ISSN 2304-4470

ПЕДАГОГІКА ВИЩОЇ ТА СЕРЕДНЬОЇ ШКОЛИ

ВИПУСК 51’2018

КРИВОРІЗЬКИЙ ДЕРЖАВНИЙ ПЕДАГОГІЧНИЙ УНІВЕРСИТЕТ
VERITAS CREATIO LIBERTAS
1930

КРИВИЙ РІГ 2018

ISSN 2304–4470

Міністерство освіти і науки України
Криворізький державний педагогічний університет

ПЕДАГОГІКА ВИЩОЇ ТА СЕРЕДНЬОЇ ШКОЛИ

ЗБІРНИК НАУКОВИХ ПРАЦЬ

Головний редактор — доктор педагогічних наук,
професор Віта Гаманюк

Збірник засновано 2000 року

Випуск 51

Кривий Ріг
2018

УДК 378(082)

ЗАСНОВНИК І ВИДАВЕЦЬ:
КРИВОРІЗЬКИЙ ДЕРЖАВНИЙ ПЕДАГОГІЧНИЙ УНІВЕРСИТЕТ

Рекомендовано до друку рішенням Вченої ради
Криворізького державного педагогічного університету
(протокол № 6 від 13 грудня 2018 р.)

Збірник наукових праць «Педагогіка вищої та середньої школи» містить матеріали, присвячені висвітленню теоретико-практичних проблем педагогіки вищої та загальноосвітньої школи, становлення і розвитку освітньої парадигми, інтеграції психолого-педагогічних чинників в організацію навчально-виховного процесу.

Випуск підготовлено за матеріалами першого міжнародного семінару «Доповнена реальність в освіті» (Кривий Ріг, Україна, 2 жовтня 2018 року). Оригінальна онлайн публікація — у 2257 томі CEUR Workshop Proceedings (CEUR-WS.org, ISSN 1613–0073).

Contents

Pavlo P. Nechypurenko and Vladimir N. Soloviev
Using ICT as the Tools of Forming the Senior Pupils' Research Competencies in the Profile Chemistry Learning of Elective Course "Basics of Quantitative Chemical Analysis" **7**

Pavlo P. Nechypurenko, Tetiana V. Starova, Tetiana V. Selivanova, Anna O. Tomilina and Aleksandr D. Uchitel
Use of Augmented Reality in Chemistry Education **25**

Olena V. Komarova and Albert A. Azaryan
Computer Simulation of Biological Processes at the High School . **37**

Tetiana V. Hruntova, Yuliia V. Yechkalo, Andrii M. Striuk and Andrey V. Pikilnyak
Augmented Reality Tools in Physics Training at Higher Technical Educational Institutions **47**

Olexandr V. Merzlykin, Iryna Yu. Topolova and Vitaliy V. Tron
Developing of Key Competencies by Means of Augmented Reality at CLIL Lessons **58**

Viktoriia L. Buzko, Alla V. Bonk and Vitaliy V. Tron
Implementation of Gamification and Elements of Augmented Reality During the Binary Lessons in a Secondary School **74**

Mariya P. Shyshkina
The Problems of Personnel Training for STEM Education in the Modern Innovative Learning and Research Environment **84**

Yevhenii B. Shapovalov, Zhanna I. Bilyk, Artem I. Atamas, Viktor B. Shapovalov and Aleksandr D. Uchitel
The Potential of Using Google Expeditions and Google Lens Tools under STEM-education in Ukraine **90**

Viktor B. Shapovalov, Artem I. Atamas, Zhanna I. Bilyk, Yevhenii B. Shapovalov and Aleksandr D. Uchitel
Structuring Augmented Reality Information on the stemua.science **102**

Natalya O. Zinonos, Elena V. Vihrova and Andrey V. Pikilnyak
Prospects of Using the Augmented Reality for Training Foreign Students at the Preparatory Departments of Universities in Ukraine **115**

Vladyslav Ye. Velychko, Elena H. Fedorenko and Darja A. Kassim
Conceptual Bases of Use of Free Software in the Professional Training of Pre-Service Teacher of Mathematics, Physics and Computer Science **123**

Viktoriia V. Tkachuk, Vadym P. Shchokin and Vitaliy V. Tron
The Model of Use of Mobile Information and Communication Technologies in Learning Computer Sciences to Future Professionals in Engineering Pedagogy **136**

Bogdan B. Buyak, Ivan M. Tsidylo, Victor I. Repskyi and Vitaliy P. Lyalyuk
Stages of Conceptualization and Formalization in the Design of the Model of the Neuro-Fuzzy Expert System of Professional Selection of Pupils **147**

Serhiy O. Semerikov, Illia O. Teplytskyi, Yuliia V. Yechkalo and Arnold E. Kiv
Computer Simulation of Neural Networks Using Spreadsheets: The Dawn of the Age of Camelot **159**

Yevhenii O. Modlo, Serhiy O. Semerikov and Ekaterina O. Shmeltzer
Modernization of Professional Training of Electromechanics Bachelors: ICT-based Competence Approach **192**

Olga O. Triakina, Olena O. Pavlenko, Nataliia P. Volkova and Darja A. Kassim
Usage of E-learning Tools in Self-education of Government Officers Involved in Global Trade Activities **224**

Olha V. Bondarenko, Svitlana V. Mantulenko and Andrey V. Pikilnyak
Google Classroom as a Tool of Support of Blended Learning for Geography Students **235**

Natalya V. Rashevska and Vladimir N. Soloviev
Augmented Reality and the Prospects for Applying Its in the Training of Future Engineers **247**

Vladimir S. Morkun, Serhiy O. Semerikov, Nataliya V. Morkun, Svitlana M. Hryshchenko and Arnold E. Kiv
Defining the Structure of Environmental Competence of Future Mining Engineers: ICT Approach **255**

Snizhana O. Zelinska, Albert A. Azaryan and Volodymyr A. Azaryan
Investigation of Opportunities of the Practical Application of the Augmented Reality Technologies in the Information and Educative Environment for Mining Engineers Training in the Higher Education Establishment **263**

Serhiy O. Semerikov, Vladyslav S. Pototskyi, Kateryna I. Slovak, Svitlana M. Hryshchenko and Arnold E. Kiv
Automation of the Export Data from Open Journal Systems to the Russian Science Citation Index **276**

Iryna S. Mintii and Vladimir N. Soloviev
Augmented Reality: Ukrainian Present Business and Future Education **290**

Maiia V. Popel and Mariya P. Shyshkina
The Cloud Technologies and Augmented Reality: the Prospects of Use **297**

Tamila H. Kolomoiets and Darja A. Kassim
Using the Augmented Reality to Teach of Global Reading of Preschoolers with Autism Spectrum Disorders **304**

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 7–24

УДК 373.5.016:54]:004.9

Using ICT as the Tools of Forming the Senior Pupils' Research Competencies in the Profile Chemistry Learning of Elective Course "Basics of Quantitative Chemical Analysis"

Pavlo P. Nechypurenko[0000−0001−5397−6523] **and**
Vladimir N. Soloviev[0000−0002−4945−202X]
Kryvyi Rih State Pedagogical University,
54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
{acinonyxleo, vnsoloviev2016}@gmail.com

Abstract. *Aims of the study*: to substantiate possibilities of the research competencies formation among senior pupils in terms of profile Chemistry learning by means of practical using information and communication technology while accomplishing an elective course "Basics of quantitative chemical analysis". This research *considers* the influence of various ICT tools on the formation of individual study and research competencies, in particular the system components of the research competencies among senior pupils in terms of profile Chemistry learning and the methods of their practical applying while accomplishing an elective course "Basics of quantitative chemical analysis". *Object of the study*: ICT tools for Chemistry learning. *Subject of the study*: ICT tools of research competencies formation among senior pupils in terms of profile Chemistry learning. *Methods of the study*: reviewing and analyzing scientific publications, expert evaluation, summarizing pedagogical experience. *Results of the study*: the system of research competencies formation among senior pupils is effectively provided by the correct selection of ICT tools and conditions of their applying for the certain research competence formation, which embodies system components. Our research confirms the idea that the most ICT tools are to be leading in the development of research competencies among senior pupils in profile Chemistry learning. They are successfully tested by means of their applying in the process of studying the elective course "Basics of Quantitative Chemical Analysis". They show the high effectiveness. Our study confirms that virtual chemical laboratories are the most universal and influential tools of forming the research competencies among senior pupils in profile Chemistry learning.

Keywords: ICT, profile Chemistry learning, senior pupils' research competencies, methods of using ICT as a tool of forming the senior pupils' research competencies in terms of profile Chemistry learning, computer-oriented elective course "Basics of quantitative chemical analysis".

1 Introduction

While solving the scientific problem of using the ICT as tools of forming the senior pupils' research competencies in terms of profile Chemistry learning, the following main results were obtained in past works: performing the theoretical analysis of research competencies formation among senior pupils' in terms of profile Chemistry learning [4, 5, 13]; creating the system of research competencies among senior pupils' in profile Chemistry learning [11]; defying the ICT tools for profile Chemistry learning, which will contribute to the development of pupils' research competencies (the electronic spreadsheets, the tools of educational achievements control and self-control, the tools for creating multimedia presentations, the general-purpose search systems, the learning management systems, the text editors, the cloud-oriented tools of supporting joint research and study activities, the adaptive automated Chemistry training systems, the virtual chemical laboratories, the electronic periodic systems, the tools for computer modeling of chemical processes, the Chemistry educational games, the popular science and vocational chemical information Internet resources, the Chemistry program and method complexes, the simulators and electronic workshops, the Chemistry search systems, the chemical editors) [6, 8, 9, 12, 14]; developing the ICT model of research competencies formation among senior pupils' in profile Chemistry learning and its theoretical justification [5]; developing the method components of using ICT as the tools of forming research competencies among senior pupils' in profile Chemistry learning and experimental testifying of its effectiveness [7, 10, 15].

The system of senior pupils' research competencies in profile Chemistry learning [11] includes three groups:

1. *General science competencies* are related to the mastery of universal research methods. They are necessary for the research activity in any scientific discipline (GRC–01 — the ability to formulate the research hypothesis; GRC–02 — the ability to plan the hypothesis testing; GRC–03 — the ability to realize and justify the relevance of the research; GRC–04 — the ability to evaluate the moral and social aspects of scientific research; GRC–05 — the ability to find and use the reference materials that are necessary for the research; GRC–06 — the ability to think critically, GRC–07 — the ability to analyze and formalize the research results; GRC–08 — the ability to formulate conclusions; GRC–09 — the ability to substantiate the submission of research results; to protect the own opinion; to discuss; GRC–10 — the ability to work together in the research process);

2. *Natural science competencies* are related to the research of the real natural objects and their interconnections. They are necessary for the research activities in the field of Natural Sciences (SRC–01 —

the formation of representations about the stages of the cognitive activity in Natural Sciences, the Elements of Metrology; SRC–02 — the ability to plan an experiment; SRC–03 — the ability to carry out the individual operations competently during the experiment; SRC–04 — the ability to conduct experiments in order to know the properties of bodies and substances, to identify the features of the growth, the development and the behavior of organisms; SRC–05 — the ability to adhere to the safety rules during the experiment; SRC–06 — the ability to perform the mathematical analysis of the experimental research results; SRC–07 — forming the representations of the general laws of nature and the natural sciences picture of the world, the general structure of the universe, the integrity of nature; SRC–08 — the ability to use the experimental and statistical methods and modeling the objects of live and inanimate nature; SRC–09 — the ability to distribute work in the process of experiment that the purpose of optimization);

3. *Chemical competencies*, which are related to the mastery of special chemical research methods and necessary for the research activities in different branches of Chemistry (CRC–01 — the ability to distinguish the chemical phenomena of nature from the others; CRC–02 — the ability to use chemical dishes and equipment correctly; CRC–03 — the ability to adapt the existing chemical dishes and equipment for the experiment needs; CRC–04 — the ability to compose and use devices for carrying out the experiments; CRC–05 — the ability to perform the laboratory operations correctly: heating, cooling, filtering, mixing, weighing, etc.; CRC–06 — the ability to use chemical symbols, formuli, modern Ukrainian chemical nomenclature; CRC–07 — the ability to predict the course of chemical reactions, based on the properties of the substances that are taking part in them, and the conditions of the reaction; CRC–08 — the ability to justify the relationship between the structure of matter and its properties; CRC–09 — the ability to perform the various types of chemical calculations; CRC–10 — the ability to draw conclusions about the properties of matter, based on the structure of the molecule substances; CRC–11 — the ability to draw conclusions about the structure of substances based on their properties; CRC–12 — the ability to solve the experimental problems in chemistry.

2 The Aim of the Study

Therefore, the aim of the study is to substantiate possibilities of ICT implementing in the elective course "Basics of Quantitative Chemical Analysis" in order to form research competencies among senior pupils while profile Chemistry learning, as well as to develop the individual method components of using ICT as tools of forming research competencies among the senior pupils' while their profile Chemistry learning.

3 Methods of using ICT as tools of forming the senior pupils' research competencies in the elective course "Basics of Quantitative Chemical Analysis"

Let us consider how the selected ICT tools used in the elective course "Basics of Quantitative Chemistry Analysis" form the research competencies among senior pupils while profile Chemistry learning.

Electronic spreadsheets are used within the elective course "Basics of Quantitative Chemistry Analysis" as one of the most convenient ICT tools for support and automation of study and research activities. They are used primarily for the filling, saving, recording and processing numerical or other data obtained during the experiment, or necessary for task solving. In this case electronic spreadsheets represent a symbiosis of the laboratory journal, which is the tool of data processing and its visual representation. According to the results of expert evaluation [8], the total contribution of electronic spreadsheets in the formation of research competencies system among senior pupils while profile Chemistry learning is about 6.64%.

Electronic spreadsheets are the leading ICT tools in formation of SRC–06, GRC–07, SRC–08 and CRC–09. According to expert evaluation electronic spreadsheets are the only effective tools of forming SRC–06.

The tools of educational achievements control and self-control are not a leading tools for any of research competencies. However their overall contribution to the formation of the research competencies system among senior pupils while profile Chemistry learning is quite significant and is about 5.63%. It using can considerably impact the formation of GRC–06 and CRC–09. It can be seen during precise controlling and self-controlling the personal Chemistry knowledge and skill level pupils have to make certain calculations and apply critical thinking, to obtain or select correct answers to the tasks.

Due to these ICTs in most cases precise and final control and self-control are used to evaluate pupils' educational achievements in Basics Quantitative

Chemical Analysis both in local (using the MyTest program) and remote (built into the Moodle system at http://ict-chem.ccjournals.eu test editors) mode.

Taking into account the peculiarities of the elective course "Basics Quantitative Chemical Analysis" applying tests with close-ended format tasks provides an opportunity to check the facts knowledge: the names of reagents, equipment, rules for individual chemical analysis operations related to CRC–06. Open-ended format tasks provide an opportunity to check the knowledge of the main terms, formuli and laws used in Quantitative Chemical Analysis, skills to solve the simplest calculation problems associated with CRC–09. Match-finding tasks can be used both to check the knowledge of actual material and understanding the certain laws, rules, GRC–06 and GRC–08. The tasks on establishing the correct sequence allow to check the knowledge and understanding the algorithms of chemical analytical studies, CRC–05, SRC–02, etc.

The main focus is put on the test tasks, which are based on the calculation problems. During studying the abovementioned elective course, senior pupils learn to solve several types of problems. Among them are the following: the calculation of analysis results, the magnitude of errors, the preparation of reagent solutions, the result validity etc. (research competencies GRC–07, SRC–06, CRC–09). Similar calculation problems can be transformed into open or close-ended format tasks.

The tests checking pupils' knowledge contain simple one-step calculation problems, which allow us checking the formation of these research competencies. Controlling the ability to solve complicated two or more step calculation problems in Chemistry and carrying out individual control works with further result analyzing are reasonable.

To solve the tasks of the first complexity level, the pupil has to recognize or identify certain objects or phenomena associated with the formation of the CRC–01. The most appropriate test tasks for this complexity level are close-ended format tasks, which provide one or multioption correct variant answers and the tasks of correspondence finding.

To solve tasks of the second complexity level, it is necessary to perform such operations as non-clue recollecting, solving typical tasks that include the usage of previously studied algorithms, formuli, rules, etc. We considered open-ended format tasks the most convenient ones for this complexity level. Among them are the tasks of establishing the correct sequence and appropriately built-up tasks for establishing conformity and close-ended format tasks (mostly represented by the calculation problems).

The tasks of the third complexity level include pupil heuristic activity, the ability to use critical thinking in problem solving (GRC–06) such as: the strategy of actions in non-standard situations, solving tasks, which do not explicitly contain all necessary data. For this level, the most sufficient tasks are open-ended format tasks, such as the tasks of establishing the correct sequence and correspondence finding.

The fourth complexity level includes the problem solving ability and creative tasks, which do not presuppose a prior plan of solving or do not correspond to the usual problem-solving strategies. Setting the tasks of this type and their implementation requires the formation of all research competencies components at a high level.

The tools for creating multimedia presentations are leading for the formation of GRC–07, GRC–08 and GRC–09. As for the GRC–09 the tools of developing multi-media presentations are the only leading ones. The total contribution of these tools to the formation of research competencies system among senior pupils in profile Chemistry learning is 12.76%.

The tools for creating multimedia presentations are used by pupils at the final stages of study and research especially for completing results of project implementation, presenting reports and individual works etc. The process of creating a presentation meeting all the content and structure requirements, demands from pupils to show skills of highlighting the key points; presenting the report content clearly, plainly and briefly; making conclusions; creating and executing visual aids (figures, diagrams, schemes); thinking over the report script etc.

General-purpose search systems are the main and simultaneously the only one ICT tools used for such research competences formation as GRC–05. However the total contribution of general-purpose search systems into the formation of research competencies system among senior pupils in profile Chemistry learning is quite significant — 9.39%.

Applying general-purpose search system is possible and valid at all stages of the education process within the elective course "Basics of Quantitative Chemical Analysis". The objective of using general purpose search systems is not only to provide pupils with the required data amount for more detailed and profound mastering the elective course materials, but also to develop their skills in formulating search queries, critical quality assessment of link sources, which are offered by the search system.

Learning management systems (LMS) are the leading tools of GRC–10 formation. The total contribution of these tools to the formation of research competencies among senior pupils in profile Chemistry learning is 7.66%.

We use the Moodle LMS (access mode: http://ict-chem.ccjournals.eu), which hosts the digital version of the elective course "Basics of Quantitative

Chemical Analysis". Using the Moodle LMS provides the opportunity to arrange, place and organize teaching materials. It also supports distance course studying and organizes joint work between teachers and pupils as well as pupils with each other, contributing to the formation of GRC–10 and SRC–09. The LMS serves as a special kind of organizing teaching materials and other ICT tools necessary to master the course and collaborate with users.

Text editors are the leading tools of GRC–07 and GRC–08 formation, while the total contribution of text editors to the development of research competencies system is 7.26%.

Taking into account that text creating, editing and formatting is an integral part of the pupil's study and research activities and their communication by ICT tools. Text editors have been used in all stages of the elective course "Basics of Quantitative Chemical Analysis". The particular importance of text editors acquires while making reports about the results of the research work. Consequently this tools is considered to be the leading one in the formation of general research competencies and contributes to the formation of GRC–10. The significant contribution of text editors to the formation of CRC–06 should be noted, since this research competence is also related to the need to formulate and format the texts properly.

The cloud-oriented tools of supporting joint research and study activities are specific ICT tools for research competencies formation among senior pupils in profile Chemistry learning. These tools are leading in forming the only one research competence and thus they have the lowest indicators of total contribution to the formation of the research competencies system among senior pupils in profile Chemistry learning — 4.84%. In other words the contribution of cloud-oriented tools of supporting joint research and study activities in the formation of the major research competencies, according to experts, is negligible. Nevertheless the indicators of the contribution to GRC–10 formation are the possible maximum that can be practically achieved. It proves the enormous role of these tools in the formation of the above-mentioned competences.

This research has used cloud services appropriate for organizing joint education activities presented in the way of relevant documents (text files, presentations, etc.) with an open access for sharing and editing while organizing pupils' individual work, project group work, consulting teacher work, etc.

The specific cloud-oriented tools of supporting collaborative study activities are ICTs for project management. This kind of software that is typically focused on business project management such as: event planning and task management through the procedure of identifying and decomposing project components, building a hierarchical work structure, planning of interconnected events, resource allocation for specific tasks, tasks distribution among different executors, the calculation of time required for project, constructing the schedule of task implementing and Gantt charts, task sorting, simultaneous managing of several projects. In addition, project management tools provide the ability to manage data (creating task lists, collecting data on the timing of work, warning of potential risks, workload data, project progress, indicators and their prediction), project management communications (discussing project working issues, fixing problems and requests for changes, taking into account project risks, providing access to project progress data). The above mentioned options can also be effective in profile Chemistry learning for the organizing cooperative study research work, primarily remote one.

Adaptive automated Chemistry training systems, despite the significant contribution to the general development of research competencies system among senior pupils in profile Chemistry learning, which is 12.57%, are an important tool of forming only one competence — CRC–09. It should be noted that this ICT tool has a great impact on the formation of other chemical expertise, in particular, CRC–01, CRC–06, CRC–07 and CRC–12.

Virtual chemical laboratories (VCL) are a leading tool in simultaneous forming of ten research competencies. For all of them, VCL have been recognized by experts as the only leading ICT tools. Among of these research competencies are SRC–02, SRC–04, SRC–05, CRC–03, CRC–04 and CRC–12.

The formation of four other research competencies requires the usage of not only VCL as the leading one, but also some other ICTs: SRC–03, CRC–02, CRC–05 and CRC–07. In general, the contribution of VCL to the formation of research competencies system among senior pupils in the profile Chemistry learning is the largest of all ICT tools, and it is 24.84%. Thus, VCL can be considered as the most influential and most universal ICT tools for research competencies formation among senior pupils in the profile Chemistry learning.

Studying of the elective course “Basics of Quantitative Chemical Analysis” gives VCL the variety of important roles: training before conducting field experiments and laboratory works (including the individual work and homework); modeling of processes and phenomena that make up the theoretical method basis of Quantitative Chemical Analysis, in order to find out their essence and determine their peculiarities; conducting virtual laboratory works and experiments, which obviously can not be carried out as a full-scale experiment; implementing a laboratory workshop in the form of distance learning for individual student study.

For this purpose, the complementary sets of laboratory works are created in two VCLs (Virtual Lab and ChemLab [10]). Also relevant software products in Ukrainian are localized, and a VlabEmbed plugin is created to build in the Virtual Lab into the pages of the site on the Moodle platform [6]. Taking into account the various possibilities of the Virtual Lab and the ChemLab for simulating different processes, created virtual laboratory kits are not interchangeable but complementary, giving the opportunity to increase the formation of the relevant research competencies among senior pupils in terms of performing the virtual laboratory work.

Electronic periodic systems are the leading tools for the formation of GRC–05, CRC–06 and CRC–08. The total contribution of electronic periodic systems in forming research competencies system among senior pupils in the profile Chemistry learning is 7.55%.

Electronic periodic systems are used in the process of profile Chemistry leaning as a source of reference data and a convenient means of its ordering. It is also a tool for expanding the chemical horizons, mastering the modern chemical nomenclature etc. Directly supporting the elective course "Basics of Quantitative Chemical Analysis", electronic periodic systems are used as a source of reference data. However, when revising the topic "Periodic law and periodic system of chemical elements", as well as leaning Elemental Chemistry in the 10th grade, this ICT tool is an extremely convenient one for work both during lessons, and for the organizing individual, study and research work among senior pupils.

The tools for computer modeling of chemical processes due to the methods of Molecular Mechanics and Dynamics, Quantum Chemistry, etc., are hardly used in the practice of profile Chemistry learning. They are to solve rather complex and specific chemical problems related to theoretical calculations and modeling of molecular structures, intermolecular interactions, the influence of conditions on the course of physical and physical-chemical processes, etc. Their applying is considered to be used for the study and research activity of pupils in the fields of Organic, Bioorganic and General Chemistry at a high theoretical level. The total contribution of the computer simulation of chemical processes to the formation of research competencies system among senior pupils in the profile Chemistry learning is 11.16%.

Despite the relative complexity of their use, these ICTs have been identified as the leading tools by the expert evaluation of the SRC–08, CRC–07, CRC–08, CRC–10, and CRC–11 formation. For two latter ones the tools for computer modeling of chemical processes are the only ones.

Chemistry educational games is the leading ICT tool in forming GRC–06, but the overall contribution of Chemistry training games to forming research competencies system among senior pupils in the profile Chemistry learning is quite significant and it is 8.07%.

This expert opinion correlates with the views of S. O. Terno, who believes that critical thinking is primarily aimed at solving a certain problem (difficulty) [16, p. 44], and its source may be a game. Games provide an inviting opportunity for learners to discover and develop skills and knowledge that can be used later in real life. Moreover it helps to test different solutions for problem situations and to get an idea of action effectiveness, which improves their situational assessment and critical thinking skills [1].

David E. Henderson [3] offers the pattern of a Business Chemistry game aimed to develop pupil critical thinking in the process of information searching. This game can use both conventional data sources (often scientific libraries), accessible through the general-purpose search systems, as well as specialized ones, accessible through the popular science and vocational chemical information Internet resources, chemical search systems, etc. The plot of the game is to identify, study and verify the need to develop and produce new chemical equipment for chemical analysis (spectrometric, electrochemical, voltammetric, magnetic resonance, radiographic, etc.). During the game ICTs are used, such as electronic spreadsheets (for data analysis), mindmaps (for displaying different proposals to select the best one), tools for providing instructional communication in asynchronous and synchronous modes (for group learning and research activities), tools for planning educational activities and cloud-oriented supporting tools for joint study and research activities (for planning and monitoring the stages of project implementation), the web-conferencing learning tools (for remote meetings and discussions), word processing tools and multimedia presentation creators (for a visual representation of progressing, intermediate and final study results).

For example, the subject of the Chembridge Chemistry game requires the players to have the define the oxidation state of chemical elements in compounds, and to make reasonable assumptions about the redox properties of these compounds. It also contributes to the development of critical thinking, since every game situation requires a well-balanced action approach. For instance, one of the cards denotes the TiF_3 substance. It is difficult to put the oxidation state at once (in the Fluoro atom, the oxidation state is –1, and in the Titan atom +3, respectively). But what properties will this compound obtain in chemical reactions with other substances: only oxidation, only reduction, or oxidation and reduction depending on the reaction? The course of measurements should be as follows: Titan's atom is in the intermediate oxidation state, and therefore it can be an oxidizer and a reducer, while the Fluoro atom is at its lowest oxidation state, therefore, it can only be a reducer. However, such strong oxidizers do not exist to interact with the Fluoro atom in the oxidation state –1. That is why no attention should be paid to the properties of Fluoro in this (or similar) compounds. Consequently, TiF_3 will have both oxidizing and reducing properties, depending on the chemical reaction, due to the intermediate oxidation state of the Titan atom in this compound.

It should be mentioned that the significant number of tasks in the VCL Virtual Lab is made up in the way of the game. To some extent it erases the boundary between games and VCL.

Popular science and vocational Chemistry information Internet resources are the leading ICT tools of GRC–05, GRC–06, GRC–04, SRC–01, SRC–07 formation. As for the three latter of the listed research competencies, the popular science and vocational Chemistry information Internet resources are considered the only ICT leading tool. The total contribution to the formation of research competencies system among senior pupils in the profile Chemistry learning is 12.89%.

Unlike Chemistry textbooks that have to concentrate the pupil's attention on the certain set of facts, definitions, patterns and rules, written mostly, in a rather "dry" scientific language, science popular Chemistry Internet resources usually do not have these restrictions. They pay more attention to the description of vivid or unusual facts associated with a chemical object; the history of scientific research; the practical usage of chemicals, reactions, laws; the interconnection of Chemistry with other sciences. The way of data submission in the popular science and vocational Chemistry information Internet resources is also varied in style (maybe both scientific and journalistic, as well as artistic or even colloquial), and in mode (in addition to the text and photos, there can be used animation, video material, feedback from the author or other users, etc.).

The above-mentioned content features of the science popular and vocational Chemistry Internet resources make them, according to experts, the only one effective tool of GRC–04, SRC–01 and SRC–07 development. For example, the on-line version of the journal "Chemistry and Life" (https://www.hij.ru/) provides an opportunity to read articles published in the journal. These papers encourage readers to think over ethical, moral, social and the economic problems of researching in Chemistry and other Natural Sciences and form the attitude towards them. They contain a detailed description of discoveries history in the field of Chemistry or methods of chemical research. Moreover they uncover the problems of other Natural Sciences and their interrelation with Chemistry.

The same content has the Internet magazine "Chemistry and Chemists" (http://chemistry-chemists.com/) and other similar resources.

Chemical information Internet resources often contain a large number of reference materials. In particular, on the Chemiday.com site, there is an electronic periodic system, a table of salts acids and bases water solubility, a chemical reaction database, a chemical encyclopedia, the register of edible additives, etc. However it does not claim to be full and complete as this resource constantly improves. That is why if the necessary data is not found, it can searched on other similar resources (xumuk.ru, chemport.ru, etc.).

Taking into consideration the sufficient amount of such resources on Internet, their availability, constant expansion and improvement, it is logical to assume that the most important contribution of popular science and vocational Chemistry Internet resources as ICT tools in forming components of research competencies system among senior pupils in the profile Chemistry learning falls is related to GRC–05 formation.

Critical thinking is based on the cognitive skills of analysis, interpretation, conclusion making, explanation, evaluation, monitoring and correcting of individual thinking. Therefore, critical thinking to a certain extent reproduces the process of scientific research as it identifies the problem. It also states the hypothesis, collects and analyzes relevant data, tests and eventually accepts or rejects the hypothesis, and finally makes conclusions [2].

The popular science and vocational Chemistry Internet resources allow going beyond the school curriculum, to obtain data on chemical objects through different perspectives and sources, following the research thinking or the sequence of experiments, which provide the opportunity to develop GRC–06.

For example, while studying the topic "Alkaline elements" (10th grade), pupils are recommended to read the series of articles in the journal "Chemistry and Chemists" (http://chemistry-chemists.com/Video/Na-H2O.html), devoted to the properties of metallic sodium and its experiments. In addition to the detailed description of the experiments, their photos and videos, the articles also contain additional facts which, usually are not described into the textbooks, due to their exceptional status. They often require detailed and rather complicated explanations. In particular, one of the articles describes the sodium reaction with concentrated hydrochloric acid, which proceeds surprisingly much less violent than the same reaction with water. The paper explains these results due to the formation of sodium chloride insoluble in chloride acid on the metal surface of a protective film that protects sodium from further interaction with HCl. The discussion of such rule exceptions encourages pupils to examine comprehensively the problem situation, taking into account all factors and thoroughly checking the hypothesis that is at first obviously correct, and, if necessary, reasonable correcting of this hypothesis and making final conclusions.

Chemistry program and method complexes used in studying are multi-component software tools specially created and intended directly to support the study of certain topics or sections of the school Chemistry course. That is why their overall contribution to the formation of research competencies system among senior pupils in Chemistry is high. It is about 23.54%, and comparatively inferior less only than the contribution value of VCL. Chemistry program and method complexes have been identified by experts as the only leading tool for the CRC–01 formation, as well as the leading tools for the formation of SRC–03, CRC 05, CRC–06 and CRC–09.

As a rule, the usage sphere of above-mentioned program and method complex is marked in its tittle. Its functional capabilities provide the opportunity to use it as an electronic tutorial, as well as the tools of checking the level of knowledge or a simulator etc.

The total contribution of *simulators and electronic workshops* to the formation of research competencies system among senior pupils in the profile Chemistry learning is significant and amounts to 15.72%, but these tools are considered to be the leading ones for the formation of CRC–02 and CRC–09. Also, these tools affect considerably the formation of such research competencies as CRC–01, CRC–04 and CRC–05.

In general, simulators and electronic workshops in their functional capabilities and appointments are similar to VCL, but their options are much more limited, since their functioning is based on the implementation of only one algorithm aimed at working out the correct order of actions and observations. Therefore, these tools influence the formation of practically the same research competencies as the VCL, but this list is smaller and the impact of simulators and electronic workshops on the process of forming the above-mentioned research competencies is not so significant.

Chemistry search systems, as well as general-purpose search systems are the leading ICT tools for GRC–05 only, and their overall contribution to the development of research competencies system among senior pupils is less than that of general-purpose search systems. It is only 5.25%.

Chemistry search systems are powerful Chemistry databases with not only specific keyword search (names of substances or fragment names). They also contain special codes (linear notes) that reflect the structure of molecules and using two-dimensional structure formuli of substances or their fragments (structure search and similarity search).

Chemistry search systems can differ significantly in their database content that provides their specialization. Some search systems contain important information about the chemical and physical properties of substances, the others include facts about manufacturers and prices for chemical products, the third describe the biological activity of molecules etc.

The use of Chemistry search systems in the profile Chemistry learning allows obtaining reference data, necessary for problem solving, the links of literature references, the review of physical and chemical properties, and synthesis methods, skills to work with a specific tool for chemical data search etc.

A certain disadvantage of Chemistry search systems can be defined as follows: almost all of them are monolingual and the ability to search or browse data in other languages is not supported.

Chemical editors are specific software products, and their prime value is the visualization of chemical symbols. That is why these tools are the guiding ones in the formation of CRC–06. The influence of chemical editors on the formation of other research competencies is insignificant. As evidenced by the magnitude of their overall contribution to the formation of research competencies system among senior pupils in the profile Chemistry learning it is 3,36%.

Chemical editors are used predominantly at the stage of introducing the research results. As a rule, text editors provide the ability to present the majority of chemical language peculiarities (chemical formuli, reaction equations, simple conversion schemes, etc.). However the chemical editors become the only effective tool, when it is necessary to create more complex and specific graphic objects such as: structural formuli of substances, transformation schemes of chemical compounds, images of chemical utensils and appliances, etc. While using a chemical editor, pupils not only get skills of working with such an important ICT tool for a future chemist, but also improve their own knowledge of the chemical nomenclature, the structure of substance, chemical dishes, etc.

4 Conclusions

1. According to the results of the expert assessing the expediency of using ICT tools for the formation of individual research competencies the following conclusions are made: among 17 selected ICTs, the formation of research competencies of 7 tools is specific (they are leading in the formation of only one research competence). 9 tools are multifunctional, as they are leading in the formation of two and more research competencies. Finally 1 tool is not conducive to the formation of any research competence. The most significant and effective ICT tools for the formation of the whole system of research competencies among senior pupils in the profile Chemistry learning are virtual chemical laboratories and Chemistry program and method complexes. Their relative contribution to the formation of the research competencies system is 13.87% and 13.14% respectively. The other tools show contributions from 5% to 10%. In particular, such facilities as simulators and electronic workshops receive 8.78%; popular science and vocational chemical information Internet resources get 7.20%; tools for creating multimedia presentations take 7.12%; adaptive automated Chemistry training systems in are at 7.02%; tools for computer modeling of chemical processes reach 6.23% and general-purpose search systems have 5.24%. Chemistry educational games show the lowest contribution to the development of research competencies system among senior pupils (4,51%). The following results represent the other tools: learning management systems (4,28%); electronic periodic systems (4,21%); text editors (4,05%); electronic spreadsheets (3.71%); tools of educational achievements control and self-control (3.14%); Chemistry search systems (2.93%); cloud-oriented tools of supporting joint research and study activities (2.70%) and chemical editors (1.88%). Despite the relatively low level of knowledge for developing the system of research competencies, these tools can not be excluded from a list of ICTs, as they are promising tools for the formation of at least one of the research competencies.

2. Proceeding from the fact that the formation of research competencies system among senior pupils is effective due to the correct selection of ICT tools and the conditions of their applying for the formation of each of the research competencies system components. Based on the results of research and experimental work it has become possible to develop recommendations for using ICT tools in the process of

forming the research competencies among senior pupils while their profile Chemistry learning. The majority of leading ICTs has been tested through their use in the process of studying the electives course "Basics of Quantitative Chemical Analysis". The possibility of applying some ICTs for the formation of research competencies is demonstrated by certain topics of the school Chemistry course in profile senior school.

References

1. Blanchard, E. G., Frasson, C., Lajoie, S. P.: Learning with Games. In: Seel, N. M. (ed.) Encyclopedia of the Sciences of Learning, pp. 2019–2024. Springer, New York (2012).
2. Gokhale, A. A.: Collaborative Learning and Critical Thinking In: Seel, N. M. (ed.) Encyclopedia of the Sciences of Learning, pp. 634–636. Springer, New York (2012).
3. Henderson, D. E.: A Chemical Instrumentation Game for Teaching Critical Thinking and Information Literacy in Instrumental Analysis Courses. Journal of Chemical Education. 87 (4), 412–415 (2010).
4. Nechypurenko, P. P., Semerikov, S. O., Selivanova, T. V, Shenayeva, T. O.: Information and communication tools for pupils' research competence formation at chemistry profile learning. Information Technologies and Learning Tools. 56 (6), 10–29 (2016).
5. Nechypurenko, P. P., Semerikov, S. O., Tomilina, L. I.: Teoretyko-metodychni zasady vykorystannia informatsiino-komunikatsiinykh tekhnolohii yak zasobu formuvannia doslidnytskykh kompetentnostei starshoklasnykiv u profilnomu navchanni khimii (Theoretical and methodical foundations of using ICT as a tools of forming the senior pupils' research competencies in the chemistry profile learning). Publishing Department of the SIHE "Kryvyi Rih National University", Kryvyi Rih (2018).
6. Nechypurenko, P. P., Semerikov, S. O.: VlabEmbed — the New Plugin Moodle for the Chemistry Education. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017),

Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR–WS.org), vol. 1844, pp. 319–326 (2017).

7. Nechypurenko, P. P.: Deiaki aspekty imitatsii realnykh khimichnykh protsesiv ta system u virtualnykh khimichnykh laboratoriiakh (Some aspects of simulation of real chemical processes and systems in virtual chemical laboratories). Theory and methods of e-learning. 3, 238–244 (2012).
8. Nechypurenko, P. P.: Dobir ta ekspertyza zasobiv IKT dlia formuvannia doslidnytskykh kompetentnostei uchniv u profilnomu navchanni khimii (Selection and examination of ICT tools for pupils' research competencies in the chemistry profile learning). In: Proceedings of the Fourth IV All-Ukrainian Scientific and Practical Conference of Young Scientists "Scientific Youth–2016", IITLT, Kyiv, 15 Dec 2016.
9. Nechypurenko, P. P.: MarvinJS yak zasib pidtrymky navchalno-doslidnytskoi diialnosti uchniv z khimii (MarvinJS as a tool of support of pupils' learning and research activity of chemistry). In: Proceedings of the Fourth International Scientific and Practical Conference "MoodleMoot Ukraine 2016. Theory and Practice of Using the Moodle Learning Management System", KNUBA, Kyiv, 19–20 May 2016.
10. Nechypurenko, P. P.: Pro vykorystannia kompiuternoi prohramy Chemlab (About the use of the computer program Chemlab). Biology and chemistry at school. 2, 44–47 (2007).
11. Nechypurenko, P. P.: Systema doslidnytskykh kompetentnostei uchniv starshoi shkoly u profilnomu navchanni khimii (The system of research competencies of high school students at chemistry profile learning). Bulletin of Cherkasy University. Series: Pedagogical Sciences. 7, 83–90 (2016).
12. Nechypurenko, P. P.: Systema Moodle yak zasib formuvannia doslidnytskykh kompetentnostei uchniv u profilnomu navchanni khimii (The system Moodle as a tool of formation of pupils' research competencies in the profile chemistry learning). In: Proceedings of the Third International Scientific and Practical Conference "MoodleMoot Ukraine 2015. Theory and Practice of Using the Moodle Learning Management System", KNUBA, Kyiv, 21–22 May 2015.
13. Nechypurenko, P. P.: Teaching and research activities of students in chemistry profile school as a means of formation of research competencies. New computer technologies. 14, 135–136 (2016).

14. Nechypurenko, P. P.: Virtualni khimichni laboratorii v protsesi navchannia khimii: suchasnyi stan ta perspektyvy (Virtual chemical laboratories in the teaching chemistry process: current state and prospects). Scientific journal of the National Pedagogical University named after M. P. Dragomanov. Series number 5. Pedagogical sciences: realities and perspectives. 33, 95–102 (2012).
15. Nechypurenko, P. P.: Vyvchennia osnov khimichnoho analizu zasobamy kompiuternykh tekhnolohii ta yoho mistse v ekolohichnii osviti shkoliariv (Study of the basics of chemical analysis by computer technology tools and its place in the ecological education of schoolchildren). In: Proceedings of the VII International scientific and practical conference on Problems of ecology and ecological education, Kryvyi Rih (2008)
16. Terno, S. O.: Teoriia rozvytku krytychnoho myslennia (na prykladi navchannia istorii) (The theory of the development of critical thinking (by example the history learning)). Zaporizhzhya National University, Zaporizhzhya (2011).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 25–36

УДК 373/378.016:54]:004.9

Use of Augmented Reality in Chemistry Education

Pavlo P. Nechypurenko[1[0000−0001−5397−6523]],
Tetiana V. Starova[1[0000−0001−7995−3506]],
Tetiana V. Selivanova[1[0000−0003−2635−1055]],
Anna O. Tomilina[1[0000−0002−8529−4882]] **and**
Aleksandr D. Uchitel[2[0000−0002−9969−0149]]
[1] Kryvyi Rih State Pedagogical University,54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine, 5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine
acinonyxleo@gmail.com, simaneneko@ukr.net,
{vitro090, anna.tomilina.anna}@gmail.com, o.d.uchitel@i.ua

Abstract. The purpose of this article is to analyze the current trends in the use of the augmented reality in the chemistry education and to identify the promising areas for the introduction of AR–technologies to support the chemistry education in Ukrainian educational institutions. The article is aimed at solving such problems as: the generalization and analysis of the scientific researches results on the use of the augmented reality in the chemistry education, the characteristics of the modern AR–tools in the chemistry education and the forecasting of some possible areas of the development and improvement of the Ukrainian tools of the augmented reality in the chemistry education. The object of research is the augmented reality, and the subject is the use of the augmented reality in the chemistry learning. As a result of the study, it has been found that AR–technologies are actively used in the chemistry education and their effectiveness has been proven, but there are still no Ukrainian software products in this field. Frequently AR–technologies of the chemistry education are used for 3D visualization of the structure of atoms, molecules, crystalline lattices. The study has made it possible to conclude that there is a significant demand for the chemistry education with the augmented reality that is available via the mobile devices, and accordingly the need to develop the appropriate tools to support the chemistry education at schools and universities. The most promising thing is the development of methodological recommendations for the implementation of laboratory works, textbooks, popular scientific literature on chemistry with the use of the augmented reality technologies and the creation of the simulators for working with the chemical equipment and utensils using the augmented reality.

Keywords: augmented reality, chemistry education, technology of the augmented reality (AR-technology), 3D model.

1 Introduction

The reformation of school education happening in accordance with the conception "New Ukrainian School" includes the changes into the pupils' competence set, among which some of them could be distinguished: the innovation, the information-communication and digital competences, the competences in the Natural Sciences, the techniques and technologies, the lifelong learning and etc.

The main method of providing the effectiveness of the educational reform implies the end-to-end using of information-communication technologies in the educational process and the management of the establishments and the system of education. The system application of ICT in the education has to expand essentially the teachers' possibilities, to organize the interaction between the teacher and students, to form students' technological competences that are important to our century.

The reformation of school education provides for the increase of the project, command and group pupils' activity in the educational process. According to this fact the variants of the educational organization will be varied especially by using mobile workplaces that are easily transformed for the group activity. The planning and design of the educational space will be aimed at the child's development and his/her motivation to the learning by means of ICT, the multimedia devices, the laboratory renovation for the studying natural-mathematic subjects [10].

Children today are getting used to data availability, possibility to obtain data whenever and anywhere they may need it. They are getting accustomed to the virtual reality as well. Therefore, so called SMART–education which implies the use of smartphones, tablets, interactive blackboards and other devices with internet access is becoming more popular [25, 26].

The integration of an educational process with the use of mobile devices and computers, real objects with virtual ones, acquisition of necessary data about the objects which are being studied with their three-dimensional visualization is made possible due to augmented reality [18].

According to the definition of Ronald T. Azuma, Augmented Reality (AR) is a type of the virtual environment (or virtual reality) which complements an objective reality but does not change it entirely. Augmented reality allows a user to see a real world with virtual objects being either imposed or joined with the real world [4]. Augmented reality can be potentially applied to all the senses of a person, that is, audition, olfaction, somatosensation, however, the most frequent supplement is vision.

The major features of the augmented reality are a combination of both real and virtual objects in the real environment, a real-time environmental operational practice, interactivity, equalization of the peculiarities of real and virtual objects [3].

Chemistry is considered to be a complicated science due to the use of notions which cannot become the objects of direct comprehension and as a result students have to create images, virtual objects exactly in their imagination. Not all students are able to create such objects or to create them in an appropriate way for the reality that is why means of teaching intended for intensifying visibility are of always concern in the process of chemistry teaching [20–22]. Augmented reality is considered to be one of such modern tools.

2 Exposition of Basic Material of Research

Despite a fifty year long history of the development of the conception of augmented reality, in chemistry teaching practice technologies of augmented reality (AR–technologies) have been actively used since the beginning of the 2000s. It is due both to the development of the software for creating and simulating the systems of augmented reality and the increase in the availability of mobile devices with the necessary functional specifications which has made it possible for students to use AR–technologies not only in special laboratories (as a rule, in computer labs), but in chemistry laboratories and other special chemical facilities.

A considerable amount of experience has been gained not only in terms of methods of creating and using augmented reality tools in the process of chemistry teaching but in terms of the assessment of its didactic significance, influence on the learning process, advantages and disadvantages while studying certain disciplines of chemistry as well.

In particular, Zeynep Tachgin together with the co-authors have pointed out that technologies of augmented reality are the most essential ones for studying non-perceptible notions (atom, molecule, chemical bonds etc.) and emphasized the necessity of involving experts on the scientific and methodological issues in the process of choosing the content and designers in the process of improving the quality of graphic design [30]. It has been noted that the quality of 3D–models and graphic interface of tools of chemistry teaching which use augmented reality has a positive influence on the users' level of interest in the discipline and a corresponding increase of acquiring knowledge [9].

Su Cai together with the co-authors [5] have determined the development of students' spatial thinking, their ability to imagine and interpret three-dimensional structures of molecules and crystals to be the leading direction of the use of AR–technologies in the process of chemistry teaching. The results of their study have proved a positive influence of the use of technologies of augmented reality on the level of interest in chemistry acquiring, the level of progress in the sphere of 'Composition and structure of substances', the level of spatial awareness concerning the composition of substances. However, these researches have pointed out that the visualization of certain issues of studying has negatively impacted on the comprehension of textual information and has diverted their attention from the instructions and explanations presented in a written form.

The use of augmented reality tools created on the base of freely accessible software in the learning process has made it possible for a group of Spanish researches to determine the increase in the level of interest in chemistry acquisition, the development of comprehension about the crystal structure of substances and the improvement of students' skills to interpret two- and three-dimensional schemes. The participants of the study have noted the possibility to handle three-dimensional models and to perceive them from sides and different angles to be the main advantages of technologies of augmented reality [23]. Similar results have been achieved in the study held among students in the process of organic chemistry learning [27].

Dragos Daniel Iordache together with the co-authors [11] have detected a favourable impact of the technologies of augmented reality on the effectiveness of knowledge acquisition of the notions of chemical bonds, the law of periodicity, a periodic table of chemical elements mainly due to the possibility to interact with the atom and molecule models simultaneously receiving necessary explanations.

The use of 3D–models of molecules for intensifying the effectiveness of organic chemistry [13] and biochemistry [16] teaching is of particular importance. As it provides the opportunity for students to examine the structure of molecules thoroughly and to do it from different angles and it contributes to improving the understanding of bonds between the structures of molecules and properties of the substances.

A growing interest in chemistry learning due to chemical reaction modelling via technologies of augmented reality that is by visualization tools of chemical experiments (particularly dangerous and conducted with difficulties) has been considered worth noting by a group of researches [32, 34].

Also a considerable potential of technologies of augmented reality not only in chemistry teaching but in the sphere of chemical studies such as: modelling, intermolecular interaction, mechanisms of chemical reactions, molecular design etc. has been detected [14, 19].

Therefore, the effectiveness of the use of AR–technologies as tools of intensifying the process of chemistry teaching is undeniable on condition of their methodologically appropriate use.

The generalization of the existing experience of the use of technologies of augmented reality in the process of chemistry teaching makes it possible to determine some key directions of their use:

1. visualization and granularity of the structure of objects and simulation of their interaction which are inaccessible for the direct observation;
2. additional data provision about the objects in written, visual or audio-visual forms;
3. simulation of work with different equipment in order to master and to develop skills of dealing with them.

The comparison of particular characteristics of certain supporting tools of chemistry teaching via the use of technologies of augmented reality is represented in Table 1.

Table 1. Supporting tools of chemistry teaching via the use of augmented reality

Name of tools	**Description of features**
Arloon Chemistry [1]	3D–modelling of the process of molecular or crystal creation from individual atoms
Augmented Chemical Reactions [14]	3D–visualization of molecules, their spatial dynamics and interaction, possibility to form molecules from individual fragments
Augment [15]	3D–visialization of molecules and crystal lattices
Study Marvel–Chemistry AR [29]	3D–illustrations and models in special printed educational textbooks and publications on chemistry
AR VR Molecules Editor Free [33]	3D–visualization of molecules, organic and inorganic compounds in different forms (stick, ball-and-stick, scale models etc.)
Atomic Structure AR Learning Gear [12]	Dynamic 3D–visualization of atom models, electron clouds, studies which have led to the discovery of electrons, atom structure etc.
Dáskalos Chemistry [7]	Visualization of the atom structure of all chemical elements with the possibility to look through additional data

Name of tools	Description of features
HTMoL — AR plugin [28]	3D–modelling of molecular structures with the possibility to use the computational characteristics of molecules and semiautomatic animation for reactions through linear interpolation of atom coordinated between gradual computational stages of reactions
Elements4D [6]	Availability of additional information and images of appearance of substances, possibility to model chemical reactions between them
EVToolbox [8]	Russian-language resource of modelling interactions between atoms with the creation of molecules and structure of molecules and their interaction with each other
AR Learning [31]	Modelling of certain chemical reactions and physical and chemical processes
MEL Chemistry [17]	3D–modelling and molecular animation, structure of crystal lattices, detection of substances according to the special markers

In most cases augmented reality software used as supporting tools of chemistry teaching operates in accordance with the classical pattern: selection of an image and its identification as a marker →search of a model corresponding to the marker →an imposition of the model (as a rule, it is a 3D one) on the image of the marker and its demonstration on the screen of the device.

The following things can serve as markers:

1. artificial markers (images on the plane something similar to QR–codes or other images);
2. chemical symbols;
3. real objects.

Typically only two first types of markets are used in augmented reality tools to support chemistry teaching. It is justified by the simplicity of the creation of connection between a marker and a model and a high operational stability of this system. Whereas real objects are almost of no use and do not serve as markers.

The publication of AR–books — printed books (popular scientific literature, textbooks and teaching manuals) with the elements of AR–technologies is becoming some kind of modern trend of nowadays in the use of AR–technologies. The Hungarian authors [24] have described their experience of creation AR–textbook on chemistry for secondary schools (certain sections of the syllabus for the ninth grade). The authors have conducted an experiment and the results of which have led to the conclusion about a higher level of effectiveness of the use of AR–textbooks in comparison with ordinary ones.

The group of authors from the Republic of Turkey has suggested a set of images [2] to be used for the introduction of structures of atom elements, molecular structure of water, salt, carbon (II) oxide. Suggested set of cards has been represented as a science publication on chemistry.

3 Conclusion and Estimation of Perspective ways of Development

Augmented reality tools in chemistry teaching are used on the introductory stage of new material and knowledge acquiring and on the stages of learned content retention and systematization, stages of preparations for laboratory tests, for conducting tests or modelling a process of their implementation (in case they are dangerous or their implementation is impossible due to other reasons), independent study, knowledge check and self-check.

The following should be attributed to the main advantages of the use of technologies of augmented reality in chemistry teaching:

- granularity and 3D–modelling of objects which are inaccessible for the direct observation (taking into account expensive or rare equipment) which used to be represented as spatial images and schemes;
- mobility and availability to users;
- simplicity of use and comprehension;
- the possibility to use both in formal and informal education;
- modernity which highlighted interest is explained by;
- considerable potential allowing to create different supporting tools of chemistry teaching.

Most modern AR–technologies of supporting chemistry teaching are aimed solely at the visualization of molecular and crystal structures, atom and molecular structures.

There is no known Ukrainian-language product among wide spread tools of augmented reality in chemistry teaching. Although, the use of most AR–technologies to chemistry teaching is user friendly there is still a necessity to create Ukrainian AR–technologies of high-quality for supporting chemistry teaching.

Taking into account an urgent necessity to reform and modernize the system of education in Ukraine, we consider the creation and implementation of technologies of augmented reality of chemistry teaching in the learning process on different levels: basic and specialized secondary education, different levels of technical and vocational education and higher education to be one of the key tasks of our further work.

The creation of AR–technologies of chemistry teaching, Ukrainian analogues of already known foreign tools, is being planned. It is planned to create tools which will apply possibilities of augmented reality in chemistry teaching which are of little use now. Training manuals, text books, methodical recommendations on doing chemistry laboratory works, popular scientific literature and handbooks with the support of augmented reality, 3D–modelling of molecules etc. should be named among AR–tools of the first group. As for the second group it is planned to create AR–tools of chemistry teaching which provide the opportunity for getting additional information about glassware and equipment, capturing the essence and mechanism of their functioning, modelling their application, creating tools to conduct chemical experiments from different sections of chemistry virtually, using equations of chemical reactions or chemical formulas of substances etc. as markers.

References

1. Arloon: Arloon Chemistry. https://play.google.com/store/apps/details?id=com.Arloon.Chemistry.AR (2017). Accessed 31 Dec 2017.

2. Artırılmış Gerçeklik Element Kartları: AR Bilim Kartları (Augmented Reality Element Cards: AR Science Cards). Ders Zamanı Yayınları (2017).

3. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., MacIntyre, B.: Recent Advances in Augmented Reality. IEEE Computer Graphics and Applications. 21 (6), 34–47 (2001).

4. Azuma, R. T.: A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments. 6 (4), 355–385 (1997). doi: 10.1162/pres.1997.6.4.355

5. Cai, S., Wang, X., Chiang, F.-K.: A case study of Augmented Reality simulation system application in a chemistry course. Computers in Human Behavior. 37, 31–40 (2014). doi: https://doi.org/10.1016/j.chb.2014.04.018

6. DAQRI: Elements 4D by DAQRI. https://play.google.com/store/apps/details?id=com.daqri.elements4dbydaqri&utm_source=www.apk4fun.com (2013). Accessed 31 Dec 2017.

7. Dáskalos: Dáskalos Chemistry: interactive science teacher for augmented reality. https://prefrontalcortex.de/labs/daskalos/periodicSystem.pdf (2015). Accessed 25 Dec 2017.

8. EligoVision: EV Toolbox. http://evtoolbox.ru/ (2018). Accessed 30 Jan 2018.

9. Fjeld, M., Fredriksson, J., Ejdestig, M., Duca, F., Botschi, K., Voegtli, B., Juchli, P.: Tangible user interface for chemistry education: comparative evaluation and re-design. In: CHI'07: Proceedings of the SIGCHI conference on Human factors in computing systems, San Jose, April 28 — May 3 2007, pp. 805–808 (2007). doi: 10.1145/1240624.1240745

10. Hryshchenko, M. (ed.): Nova ukrainska shkola: kontseptualni zasady reformuvannia serednoi shkoly (New Ukrainian School: Conceptual Principles for Reforming the Secondary School). Ministerstvo osvity i nauky Ukrayiny. https://mon.gov.ua/storage/app/media/zagalna%20serednya/nova-ukrainska-shkola-compressed.pdf (2016). Accessed 28 June 2017.

11. Iordache, D. D., Pribeanu, C., Balog, A.: Influence of specific AR capabilities on the learning effectiveness and efficiency. Studies in Informatics and Control. 21 (3), 233–240 (2012). doi: 10.24846/v21i3y201201

12. Larngear Technology: Atomic Structure AR Learning Gear. http://larngeartech.com/products/atomic-structure-ar-learning-gear/ (2012). Accessed 31 Dec 2017.

13. Maier, P., Klinker, G.: Augmented chemical reactions: An augmented reality tool to support chemistry teaching. In: Proceedings 2013 2nd Experiment@ International Conference (exp.at'13), University of Coimbra, Coimbra, 18–20 Sept. 2013, pp. 164–165 (2013). doi: 10.1109/ExpAt.2013.6703055

14. Maier, P., Tönnis, M., Klinker, G.: Dynamics in Tangible Chemical Reactions. World Academy of Science, Engineering and Technology International Journal of Chemical and Molecular Engineering. 3 (9), 442–448 (2009).

15. McCormack, P.: Augmented Reality. Innovative Education.org. http://www.innovativeeducation.org/blog/augmented-reality (2014). Accessed 29 Jan 2018.

16. Medina, E., Chen, Y.-C., Weghorst, S.: Understanding Biochemistry with Augmented reality. In: Montgomerie, C., Seale, J. (eds.) Proceedings of ED–MEDIA 2007 — World Conference on Educational Multimedia, Hypermedia & Telecommunications, Vancouver, 25 Jun 2007, pp. 4235–4239. Association for the Advancement of Computing in Education (AACE), Waynesville (2007).

17. MEL Science: MEL Chemistry. https://melscience.com/en/app/ (2018). Accessed 19 Jan 2018.

18. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

19. Musio, B., Mariani, F., Śliwiński, E. P., Kabeshov, M. A., Odajima, H., Ley, S. V.: Combination of Enabling Technologies to Improve and Describe the Stereoselectivity of Wolff–Staudinger Cascade Reaction. Synthesis. 48 (20), 3515–3526 (2016).

20. Nechypurenko, P. P., Semerikov, S. O., Selivanova, T. V, Shenayeva, T. O.: Information and communication tools for pupils' research competence formation at chemistry profile learning. Information Technologies and Learning Tools. 56 (6), 10–29 (2016).

21. Nechypurenko, P. P., Semerikov, S. O., Tomilina, L. I.: Teoretyko-metodychni zasady vykorystannia informatsiino-komunikatsiinykh tekhnolohii yak zasobu formuvannia doslidnytskykh kompetentnostei starshoklasnykiv u profilnomu navchanni khimii (Theoretical and methodical foundations of using ICT as a tools of forming the senior pupils' research competencies in the chemistry profile learning). Publishing Department of the SIHE "Kryvyi Rih National University", Kryvyi Rih (2018).

22. Nechypurenko, P. P., Semerikov, S. O.: VlabEmbed — the New Plugin Moodle for the Chemistry Education. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR–WS.org), vol. 1844, pp. 319–326 (2017).

23. Núñez, M., Quirós, R., Núñez, I., Carda, J. B., Camahort, E.: Collaborative Augmented Reality for Inorganic Chemistry Education. In: EE'08 Proceedings of the 5th WSEAS/IASME international conference on Engineering education, Heraklion, 22–24 July 2008, pp. 271–277. World Scientific and Engineering Academy and Society (WSEAS), Stevens Point (2008).

24. Pasaréti, O., Hajdú, H., Matuszka, T., Jámbori, A., Molnár, I., Turcsányi-Szabó M.: Augmented Reality in education. In: INFODIDACT Informatika Szakmódszertani Konferencia. http://people.inf.elte.hu/tomintt/infodidact_2011.pdf (2011). Accessed 17 Jan 2018.

25. Semerikov, S., Teplytskyi, I., Shokaliuk, S.: Mobilne navchannia: istoriia, teoriia, metodyka (Mobile learning: history, theory, methodic). Informatyka ta informatsiini tekhnolohii v navchalnykh zakladakh. 6, 72–82 (2008).

26. Semerikov, S., Teplytskyi, I., Shokaliuk, S.: Mobilne navchannia: istoriia, teoriia, metodyka (Mobile learning: history, theory, methodic). Informatyka ta informatsiini tekhnolohii v navchalnykh zakladakh. 1, 96–104 (2009).

27. Singhal, S., Bagga, S., Goyal, P., Saxena V.: Augmented Chemistry: Interactive Education System. International Journal of Computer Applications. 49 (15), 1–5 (2012). doi: 10.5120/7700-1041

28. Sliwinski, E. P., Kabeshov, M. A., Ley, S. V.: HTMoL — AR plugin: A web-based interactive 3D molecular viewer with Augmented Reality & Holographic Display. GitHub. https://github.com/es605/HTMoLAR (2018). Accessed 21 Jan 2018.

29. StudyMarvel AR: StudyMarvel — Chemistry AR. https://play.google.com/store/apps/details?id=com.StudyMarvelAR.ImmersiveChemistryAR (2016). Accessed 31 Dec 2017.

30. Taçgin, Z., Uluçay, N., Özüağ, E.: Designing and Developing an Augmented Reality Application: A Sample of Chemistry Education. Journal of the Turkish Chemical Society, Section C: Chemical Education. 1 (1), 147–164 (2016).

31. Tintisha Technologies: AR Learning. http://www.arlearning.co.uk/#about (2018). Accessed 21 Jan 2018.

32. Tuli, N., Mantri, A.: Augmented Reality as Teaching Aid: Making Chemistry Interactive. Journal of Engineering Education Transformations. Special Issue, Jan, 187–191 (2015). doi: http://dx.doi.org/10.16920/jeet%2F2015%2Fv0i0%2F59624

33. Virtual Space LLC: AR VR Molecules Editor Free. https://play.google.com/store/apps/details?id=com.vspaces.molb_free (2017). Accessed 25 Dec 2017.

34. Wojciechowski, R., Cellary, W.: Evaluation of learners' attitude toward learning in ARIES augmented reality environments. Computers & Education. 68, 570–585 (2013). doi: 10.1016/j.compedu.2013.02.014

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 37–46

УДК 373.5.016:57]:004.94

Computer Simulation of Biological Processes at the High School

Olena V. Komarova[1[0000−0002−3476−3351]] **and**
Albert A. Azaryan[2[0000−0003−0892−8332]]
[1] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
[2] State Institution of Higher Education "Kryvyi Rih National University", 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
komarova1978@ukr.net

Abstract. *Research goals*: the necessity of study in high school of the law of Hardy — Weinberg as one of the fundamental genetic laws was justified. The peculiarities of using the method of model experiment in the study of the genetic and evolutionary processes in populations with the use of computer technology. *Object of research*: computer simulation of population genetic structure. *Subject of research*: computer simulation of genetic and evolutionary processes in ideal and real populations. *Research methods*: pedagogical experiment (survey), analysis of scientific publications on the use of the high school method of modelling genetic and evolutionary processes in populations, computer simulation. *Results of the research*: a web page for processing by the pupils of the modelling results of genetic and evolutionary processes in populations was created.

Keywords: modelling, computer simulation, ideal population, the law of Hardy — Weinberg, statistical methods, evolution factor, natural selection, genetic structure of population, microevolution, diagram, graphs, the law of large numbers.

1 Introduction

1.1 The Problem Statement

Modern course of biology in high school is based on the fundamental theoretical generalizations of basic biological science — scientific theories and laws. Fundamental genetic laws, classically studied by high school students, are laws of heredity of Mendel. Given the trends of development of modern biological sciences, namely, the development of theoretical biology, the main issues which are problems of genetics, ecology, evolution, law of genetic equilibrium concentrations (the law of Hardy — Weinberg) is considered as a fundamental law, the disclosure of which to high school students is aimed at understanding by them of the mechanism of evolution in general. This law reveals the regularities of functioning of living at the population — species level, including time frames.

1.2 The State of the Art

Students' mastering of the patterns of population genetics and associated evolutionary theory is one of the most complex issues in biology course in high school. Studies of such scientists as Robert L. Hammersmith, Thomas R. Mertens [1–3], Timothy J. Maret, Steven W. Rissing [4], Carol Chapnick Mukhopadhyay, Rosemary Henze, Yolanda T. Moses [5], Pongprapan Pongsophon, Vantipa Roadrangka, Alison Campbell [6] confirm this.

We have conducted a survey among 52 high school students to ascertain their level of knowledge about the essence of law of genetic equilibrium concentrations, its value for the understanding of the factors and directions of the evolutionary process.

The tasks were as following:

1. Specify the mathematical equation of the law of Hardy — Weinberg (multiple answers are allowed):

   A) $p + q = 1$;
   B) $(p + q)^2 = 1$;
   C) $p^2 + 2pq + q^2 = 1$;
   D) $p^2 + pq + q^2 = 1$;
   E) $p + 2pq + q = 1$.

2. Specify an equation describing the genotypic structure of the population (multiple answers are allowed): (see the answers to the assignment 1).

3. Specify the equation describing allelic population structure: (see answers to the assignment 1).

4. What are the conditions of validity of the law of equilibrium gene concentrations?

Students were asked to solve three problems for the application of the law of equilibrium of gene concentrations.

The results of the survey are presented in Fig. 1–3.

Conditions of validity of the law, according to the student, were as following: population sizes are large — 29% of respondents, mating occurs at random — 24%, new mutations do not occur — 18%, all genotypes are equally fertile — 12%, generations do not overlap — 12%, there is no exchange of genes with other populations — 18%, the genes are in the autosomes and not in sex chromosomes — 18%, individuals of different genotypes are equally viable — 12%.

The obtained results allow to formulate the following conclusions: students insufficiently understood the description of the essence of the

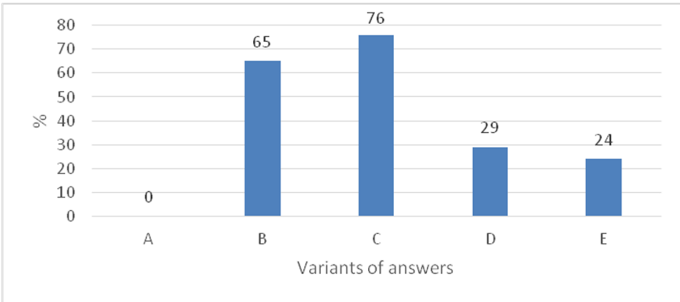


Fig. 1. The results of the response to the first task

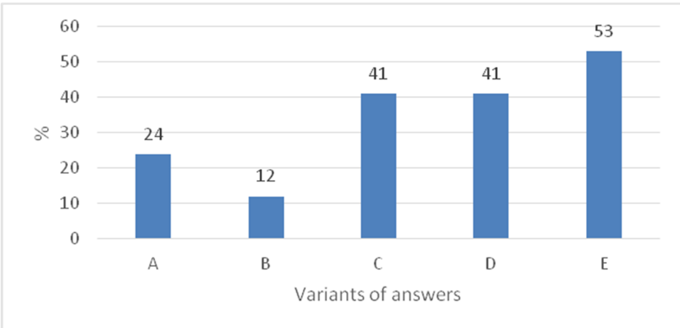


Fig. 2. The results of the response to the second task

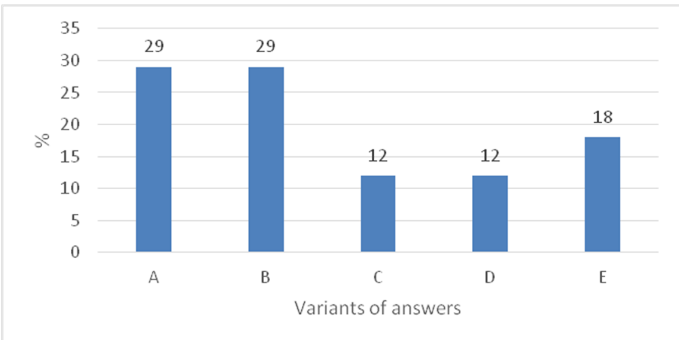


Fig. 3. The results of the response to the third task

law of Hardy — Weinberg with two equations, namely, the definition of allelic and genotype structure of the population; the students are confused about variables included in the equations; knowledge about the conditions of the law is fragmentary. None of the respondents began to address two of the proposed problems, three of the respondents solved the third task incorrectly.

The results of the survey suggest the presence of formalism in high school students' knowledge about the law of genetic equilibrium concentrations. Formal approach to training lies in the mechanical memorization of educational material without enough understanding of its content. The low level of development of knowledge about the law of genetic equilibrium concentrations is one of the reasons for the difficulties of the students in understanding of the evolutionary content for the understanding of population genetics and population human genetics in particular.

Simulation, particularly computer simulation is one of the most effective training methods for demonstrating to students of the essence of complex biological processes, including genetic and evolutionary processes in natural populations.

1.3 The Purpose of the Article

Our main goal is to create a web pages for online processing of the modelling results of genetic and evolutionary processes in populations.

2 Presenting the Main Material

2.1 The Technological Aspect of Use

Model experiment is a special form of the experiment, which is characterized by the use of existing models as special means of experimental research. The purpose of using of the method of model experiment in the study of the genetic and evolutionary processes in populations: students get convinced in practice that, in ideal populations gene frequency and the ratio of genotypes from generation to generation are preserved, in contrast to populations influenced by the genetic factors of dynamics; simulation experiments allow us to represent the primary evolutionary changes in populations; model experiments demonstrate the probabilistic nature of genetic and microevolutionary processes; model experiments contribute to the transformation of empirical knowledge of students in persistent beliefs that are an integral component of outlook.

We have developed a web page for entering, processing and presenting graphical view of modelling results of genetic and evolutionary processes in ideal populations, which are not influenced by the factors of changing its genetic structure (according to the law of Hardy — Weinberg) — http://mybio.education/mod/exp1/en/index.html (Model experiment 1. Study of the genetic structure of the ideal population) and http://mybio.education/mod/exp2/en/index.html (Model experiment 1. Study of the genetic structure of the ideal population (second option)), as well as web pages to make for entering the results of modelling of genetic and evolutionary processes in populations, which are influenced by the factors of changing its genetic structure http://mybio.education/mod/exp3/en/index.html (Model experiment 2. Study of the genetic structure of the population under the influence of natural selection), http://mybio.education/mod/exp4/en/index.html (Model experiment 3. Modelling the effect of gene flow on the genetic structure of the population), http://mybio.education/mod/exp5/en/index.html (Model experiment 4. Modelling the effect of random processes on the genetic structure of the population, modelling the drift of genes).

The developed system of online processing of simulation results can only be used if in a model experiment the number of model individuals of the population is insignificant. The population size is limited by the objective possibility of creating a corresponding number of chip patterns of the alleles of a gene. Optimum number of chips — 100. In this case, the number of individuals is equal to 50. One can take more or fewer objects. In the first case, the choice will be associated with the growth of material costs for the manufacture of model elements. In the second case, the calculated values (allele frequency) will be significantly deviate from the pre-selected frequencies, and the level of statistical significance of the obtained results will decrease.

2.2 The Ways of Implementation

Stages of modelling of the genetic structure of populations are as following:

1. Modelling of the genetic structure of an ideal population with the use of material objects. Entry of simulation results into a table on web pages
   http://mybio.education/mod/exp1/en/index.html or
   http://mybio.education/mod/exp2/en/index.html.

   Modelling of the genetic structure of an ideal population can be done using the possibilities of any of the two web pages. The difference between them lies in the methods of processing of the experimental results, namely in the methods of calculating the frequencies of genes.

In the first variant, the gene frequencies are calculated automatically by the method of extracting of the square roots of the frequencies of the homozygotes AA and AA. In the second variant the gene frequencies are automatically calculated according to the formulas: $p = (D + 0.5H)/N$, $q = (R + 0.5H)/N$, where p — frequency of dominant allele, q — frequency of recessive allele, D — number of dominant homozygotes, R — number of recessive homozygotes, H — number of heterozygotes, N — total number of members of the population. Both methods allow us to formulate the main conclusion, that in ideal populations, the ratio of frequencies of genes and genotypes remain constant from generation to generation, and the sum of their frequencies is equal to 1.

2. Modelling of population genetic structure, which is influenced by factors of change in its genetic structure — natural selection, gene flow, genetic drift. Entry of simulation results into a table on web pages
http://mybio.education/mod/exp3/en/index.html,
http://mybio.education/mod/exp4/en/index.html,
http://mybio.education/mod/exp5/en/index.html respectively.

Before usage of web pages for entering the results of the simulation, high school students work with persisted models of alleles of dealing a gene and create a genetic model of the parent population [2, 3]. These materialized models can be checkers, chips, candies, balls of different colours. The educational models of the genetic structure of the population are the findings of the experimental action with the model elements first ratio of genotypes and ratio of frequencies of genes, that is, the ratio of frequencies of genotypes and genes in the parent population.

On each of the web pages there is an instruction for the sequence of actions that must be performed concerning materialized objects, as well as actions to enter the received results in the tables for automatic calculation of genotype frequencies and allele frequencies. The rows that are highlighted in blue in tables for web pages

http://mybio.education/mod/exp1/en/index.html,
http://mybio.education/mod/exp2/en/index.html,
http://mybio.education/mod/exp3/en/index.html or
http://mybio.education/mod/exp4/en/index.html,
http://mybio.education/mod/exp5/en/index.html are filled manually by students on the basis of counting of the number of the results obtained in the course of the materialized models of alleles and genotypes. The

web pages provide automatic plotting of graphs and charts, allowing, first, to reveal the results in graphical form (Fig. 4, 5). Secondly, it allows to effectively carry out their comparative analysis and to formulate conclusions according to the algorithm of the action plan.

Fig. 4. View of graphics on the web page that were built in automatic mode http://mybio.education/mod/exp1/en/index.html#

Both diagrams show the genetic structure of populations and according to the semantic content they are identical. They differ in the way of the visibility of the results. The teacher can draw the students' attention to one variant of a diagram with a proposal to compare the genetic, genotypic structure of the population in generations. There is another, more complicated version of the analysis of the constructed diagrams. For this the students choose their own chart to analyze data and formulate conclusions.

Both variants have advantages and disadvantages. In the first variant of the diagram, numeric data of the results of the experiment are included in the corresponding segments of each column. All the data are displayed on the screen, so the student can quite easily compare the numbers.

In the second variant, the segments of each column are located one

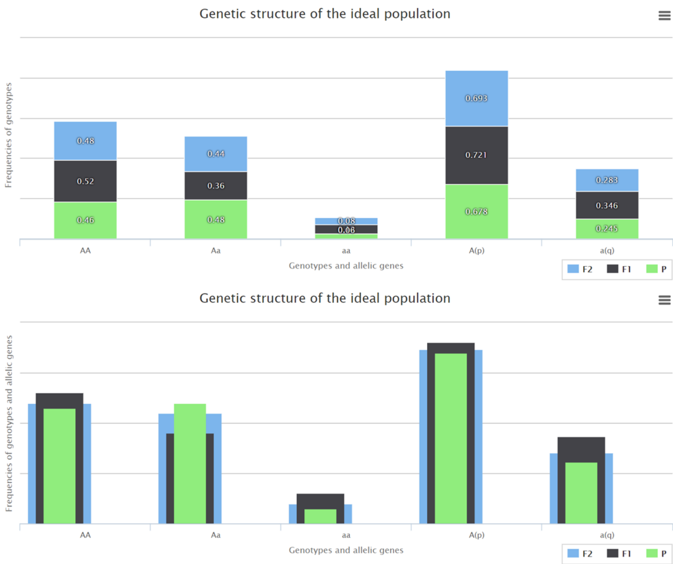


Fig. 5. View of diagrams on the web page that were built in automatic mode

behind the other, and so that the first, the most narrow segment corresponds to the parent generation and the last, the widest one corresponds to the last child generation. This way of presenting data is liked by students because, not even using numerical data it is visually easy to compare the size (height) of colored bars. Besides, when one aims the cursor at the corresponding field the necessary numerical information appears on the screen.

Analysis of the received data of the model experimentation by the students is carried out on the basis of the analysis of the built:

1) graphics of genetic and genotype structure of the population in generations;
2) one of the diagrams of the genetic structure of the population in generations;
3) graphs and diagrams that overlap.

A variety of graphic options allows to acquaint students with the methods of their statistical processing and presentation.

3 Conclusions and Outlook

Modelling of biological processes among population with the means of computer technology is an effective method to develop a series of genetic and evolutionary concepts and results in savings of time resources in the classroom. The use of computer technology as a means of modelling contributes to the formation of the concepts about the possibility of application of elementary statistical methods in biological research, understanding of the nature of statistical laws, in particular the law of large numbers.

In the discussion of the results of the model experiment performed using the developed web pages, the teacher focuses on a small size of the model population (about 50 individuals). For the experiment, one can take a smaller or larger number of individuals, but note that, on the one hand, the smaller the sample size is, the greater the error in the calculations may be. On the other hand, the feature of such studies is that under the conditions of school experimentation with the training model an ideal population for the implementation of practical actions with tangible objects — the models of alleles — it is impossible to comply with the such a condition of validity of the law of Hardy — Weinberg as a large population size. Theoretically it is possible to take this condition into account, if the move away from practical handling of material objects, replacing it with a fully automated process of determining the genetic (genotype and genetic) structure of the population. Students will enter manually data on the number of investigated parental populations and the output frequency of allelic genes in it to the model. We are its research without the use of materialized models. We have begun work in this direction and created the web page http://mybio.education/mod/exp6/en/index.html#. Its use in the teaching of biology does not require simulation with persisted models.

4 Acknowledgments

The authors are grateful to Ariyenchuk Serhiy for advice and technical support in the development and improvement of the functionality of web pages for the modelling of genetic and evolutionary processes in populations.

References

1. Hammersmith, R. L., Mertens, T. R.: Teaching the Concept of Genetic Drift Using a Simulation. The American Biology Teacher. 52 (8), 497–499 (1990).

2. Mertens, T. R.: Introducing Students to Population Genetics and the Hardy-Weinberg Principle. The American Biology Teacher. 54 (2), 103–108 (1992).
3. Mertens, T. R.: Introducing Students to Population Genetics and the Hardy-Weinberg Principle. In: Moore, R. (ed.) Biology Labs That Work: The Best of How-To-Do-Its, pp. 171–179. National Association of Biology Teachers, Reston (1994).
4. Maret, T. J., Rissing, S. W.: Exploring Genetic Drift & Natural Selection Through a Simulation Activity. The American Biology Teacher. 60 (9), 681–683 (1998).
5. Mukhopadhyay, C. C., Henze, R., Moses, Y. T.: How Real is Race? A Sourcebook on Race, Culture, and Biology (2nd Edition). AltaMira Press, Lanham (2014).
6. Pongsophon, P., Roadrangka, V., Campbell, A.: Counting Buttons: demonstrating the Hardy-Weinberg principle. Science in School. 6, 30–35 (2007).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 47–57

УДК 378.016:53]:004.9

Augmented Reality Tools in Physics Training at Higher Technical Educational Institutions

Tetiana V. Hruntova[0000-0001-6775-6361],
Yuliia V. Yechkalo[0000-0002-0164-8365],
Andrii M. Striuk[0000-0001-9240-1976] **and**
Andrey V. Pikilnyak[0000-0003-0898-4756]
State Institution of Higher Education "Kryvyi Rih National University",
11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
{tatianagru, uliaechk, andrey.n.stryuk, pikilnyak}@gmail.com

Abstract. *Research goal*: the research is aimed at theoretical substantiation of applying the augmented reality technology and its peculiarities at higher technical educational institutions. *Research objectives*: the research is to solve the problems of determining the role and place of the technology in the educational process and its possible application to physics training. *Object of research*: teaching physics to students of higher technical educational institutions. *Subject of research*: the augmented reality technology as a component of the training process at higher educational institutions. *Research methods used*: theoretical methods include analysis of scientific and methodological literature; empirical methods include studying and observation of the training process. *Research results*: analysis of scientific publications allows defining the notion of augmented reality; application of augmented reality objects during laboratory practical works on physics is suggested. *Main conclusions*. introduction of the augmented reality technology in the training process at higher technical educational institutions increases learning efficiency, facilitates students' training and cognitive activities, improves the quality of knowledge acquisition, provokes interest in a subject, promotes development of research skills and a future specialist's competent personality.

Keywords: mobile learning technology, augmented reality technology, training at university, a physics laboratory practicum.

1 Introduction

1.1 The Problem Statement

Professional competences of IT and engineering students are formed through learning both professional and fundamental subjects, physics in particular. That is why a lecturer's task is to search for new training technologies, i.e. training methods, tools, and organization forms to master the content of a subject and realize training principles aimed at forming a competent specialist and improving his/her competences.

Introduction of modern ICT is a priority of Ukraine's education development. It especially concerns the technologies aimed at improving the training process, making training material more available, enhancing educational mobility and efficiency, preparing students for professional activity and life in the information society. Mobile learning is an example of such modern technology, which is associated with the concept of mobile learning [13] and the augmented reality (AR) technology.

Modern mobile learning tools are those that call for ensuring more efficient mastering of theoretical material and practical skills [14].

Students themselves are reluctant to apply mobile devices to learning regardless of high-level technological advancements [26]. It is the educator who sets all internal and external mechanisms of learning in motion for students to acquire necessary knowledge [9]. Therefore, basic advantages of mobile learning (an unlimited access to the training content, a free choice of a place and time of learning, elimination of nonproductive time, convenience, consideration of individual peculiarities, absence of restrictions as to class schedules) [12] and increased number of software tools (mobile applications) for working with AR objects should be taken into account while organizing classes and preparing students for them [7].

1.2 Theoretical background

Issues of introducing ICT and modern learning tools in teaching physics and initial experiment work have been raised by Petro S. Atamanchuk [1], Valerii Yu. Bykov [4], Yurii M. Oryshchyn [21], Mykola I. Sadovyi [22], Valentyna D. Sharko [25], Illia O. Teplytskyi [28], Stepan P. Velychko [29], Myroslav I. Zhaldak [31], Yurii O. Zhuk [32], and other domestic researchers.

Yurii O. Zhuk indicates that relations between man and technology can be normal if they are rational and efficient [32].

Myroslav I. Zhaldak thinks that ICT application to the training process provides wide opportunities to make training creative, inquisitive and attractive with its results evoking satisfaction, the desire to work and search for new knowledge [31].

Mykola I. Shut [15], Volodymyr F. Zabolotnyi [30], Vadim A. Ilin [16], Bohdan A. Sus [27], Volodymyr P. Serhiienko [23] considered problems of data visualization in physics training at higher school.

Volodymyr F. Zabolotnyi states that active perception of visual information occurs when it is structured and accompanied by explanations. It requires special organization and deliberate methods of material presentation [30].

Augmented reality as a specific innovative environment of communication has been studied by such foreign investigators as Ronald T. Azuma [3], Reinhold R. Behringer [2], Yohan Baillot [18], Walter P. Donnelly [19], Simon Julier [17], Steven K. Feiner [6], and Blair MacIntyre [5].

In Ronald T. Azuma's opinion, augmented reality is a variation of the virtual environment (VE) or virtual reality (VR). VE technologies plunge a user into the artificially made environment in such a way that he/she cannot see the real world. As opposed to VE technologies, augmented reality enables a user to see the real world while virtual objects are superposed on or combined with the reality. That is why, the AR technology supplements the reality without replacing it entirely. This technology allows incorporating elements of virtual reality into the surrounding world. Thus, Azuma defined augmented reality as a system combining virtual and real elements, interacting online and operating in 3D [3].

The key feature of augmented reality is possible obtainment of additional information or a virtual action perceived as real by our brain as there are accesses to virtual opportunities in the real environment.

People apply augmented reality to navigation, architecture, medicine and warfare. Nowadays, there are many approaches to the AR technology application to education.

Introduction of AR technologies in education is topical as this innovative system will enhance students' motivation and increase the level of data acquisition due to diversity and interactivity of its visual presentation [24]. Any AR tools can be a training object if it is controlled and facilitates users' interaction with real objects in order to study their properties during experimental investigation [20].

1.3 The objective of the article

The objective of the article is to solve the problems of determining the role and place of the technology in the educational process and its possible application to physics training.

2 Presenting the Main Material

At physics department of Kryvyi Rih National University, possible directions of introducing the AR technology in education are under study including a laboratory practicum on physics.

Skills of experimenting and data analysis are developed during laboratory practicums when a student conducts experiments independently. This organization form of physics classes allows developing such personality traits as diligence, insistence, purposefulness, power of observation in a greater degree than other forms. It also facilitates students' constructive thinking, interest in a subject and creative approach to knowledge acquisition, thus enhancing future specialists' activity in future. Considering advantages of the laboratory practicum, a lecturer is to organize and prepare it so that the above-mentioned advantages reveal themselves in class. At the initial stage of the laboratory practicum, a lecturer should make the material interesting as in interest situations, students' fatigue falls, while efficiency of training rises [10]. Introduction of the augmented reality technology as a visualization tools of training material presentation is an important condition of learning efficiency increase at higher educational institutions.

AR objects, namely video instructions for performing laboratory works, are considered a result of adding virtual objects (extra data) to markers, which are perceived as objects of the real world. Video instructions help visualize the procedure of work performance, indicate specific features of an experiment and facilitate students' perception. These markers for video demonstrations can be schematic draughts of laboratory instructions for performing works, which can be found in classrooms, at the library or the website of physics department. Students can get ready for a laboratory work easily, even if he/she is not in the auditorium with real installations at this moment.

Students with visual thinking have difficulty in understanding and mastering training material as they are unable to comprehend and study a phenomenon without visualizing it. Students with theoretical thinking, who are able to acquire formalized knowledge, can use mobile learning tools as an additional mean for developing their visual thinking [11] and focus. Therefore, augmented reality is capable of activating all human senses, evoking interest and improving a general impression of a class.

AR objects are created by software tool Aurasma (HP Reveal), a smartphone application developed by the British company Autonomy, which is able to recognize visual images in the real world [8].

When pointing a smartphone or tablet camera at a picture-marker, a mobile device starts scanning it. On the screen, there appears a video of a lecturer demonstrating a laboratory installation, its basic components and commenting on the experiment procedure (Fig. 1). It helps visualize students' step-by-step actions, indicate peculiarities of each work, consider them and save time. AR application to physics workshops facilitates students' understanding of drawings, instructions as it supplements printed information.

As a rule, there is one lecturer for groups of up to 20 students at classes of physics laboratory workshops. His/her duties include giving a permission for students to work, consulting on performing experiments and calculation of physical values, checking obtained results, assisting in building graphs and statistical processing of results, questioning students (according to questions on laboratory work defense) and assessing them. It is a great amount of work to be done by one lecturer considering the fact that all students perform different works.

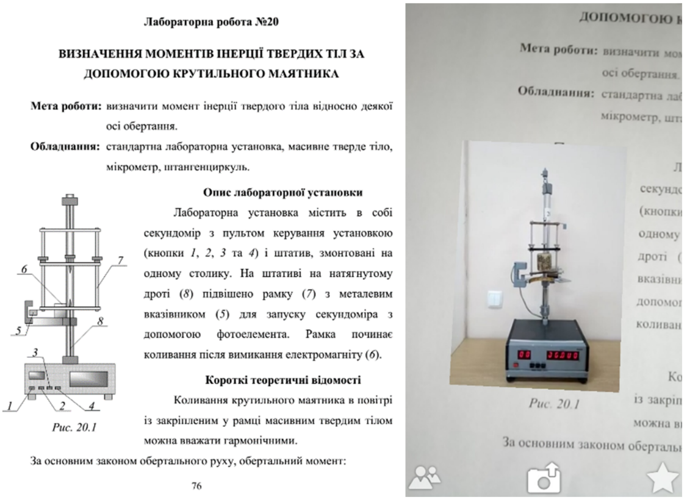


Fig. 1. Application of AR objects to methodological recommendations to physics laboratory works

Application of AR objects makes perception of procedures of experiments and theory presentation simpler, provides opportunities for students to get ready for laboratory works at home more thoroughly. Both full-time and correspondence students who do not have enough time during lecture periods can do it.

AR objects help students process information in their own pace [12]. There is an opportunity to watch a video instruction several times without disturbing a lecturer during classes. A lecturer has more time to consult other students as to their calculations, laboratory work defence, etc.

Students, who were offered to use the AR technology, got interested in applying it to performing laboratory works as an additional learning tools and liked the idea of visualizing training material through a mobile application.

Application of mobile devices (smartphones, tablets, HMD, etc.) as basic elements of the AR technology in the training process is substantiated only in case of providing sufficient capacity of mobile processors, great resolution of modern screens and built-in cameras, an access to additional facilities of the system (a gyroscope, Wi-Fi, GPS, 3D data transmission, etc.), which are available in most modern devices.

Most students have mobile devices, which can be accompanied by AR objects for providing distance learning in out-of-class periods.

3 Conclusion

Thanks to the AR technology, mobile learning tools allow making classes interesting and diverse. Mobile-oriented learning material becomes visualized and understandable, thus enhancing students' perception, understanding and acquisition of complicated notions, phenomena and laws of physics [12].

Thus, application of AR as a visualization tool at physics laboratory practicums at technical universities motivates students and allows solving the problem of learning efficiency [14] by increasing their knowledge quality and interest in a subject, developing research skills, active independent knowledge acquisition and forming a competent personality of a future specialist.

In conditions of intensive informatization of modern educational institutions, a lecturer has to work in a new way. He/she is to be a mediator in the world of multiple sources of information and help students find it and teach how to deal with it. Thus, there arises a necessity to develop a mobile-oriented tutorial on physics based on the augmented reality technology.

References

1. Atamanchuk, P., Nikolaev, O., Tkachenko, A., Kulyk, L.: Didactic Features of Modeling Professional Competence of the Physics Education Students. American Journal of Educational Research. 2 (12B), 28–32 (2014). doi: 10.12691/education-2-12B-6

2. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., MacIntyre, B.: Recent Advances in Augmented Reality. IEEE Computer Graphics and Applications. 21 (6), 34–47 (2001).

3. Azuma, R. T.: A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments. 6 (4), 355–385 (1997). doi: 10.1162/pres.1997.6.4.355

4. Bykov, V., Shyshkina, M.: Emerging technologies for personnel training for IT industry in Ukraine. In: Proceedings of ICL2014 — 2014 International Conference on Interactive Collaborative Learning, Dubai, 03–06 December 2014, pp. 945–949. IEEE, Red Hook (2014). doi: 10.1109/ICL.2014.7017903

5. Feiner, S., MacIntyre, B., Höllerer, T., Webster, A.: A touring machine: Prototyping 3D mobile augmented reality systems for exploring the urban environment. Personal Technologies. 1 (4), 208–217 (1997). doi: 10.1007/BF01682023

6. Feiner, S., Macintyre, B., Seligmann, D.: Knowledge-based augmented reality. Communications of the ACM. 36 (7), 53–62 (1993). doi: 10.1145/159544.159587

7. Golitcyna, I. N., Polovnikova, N. L: Mobilnoe obuchenie kak novaia tekhnologiia v obrazovanii (Mobile learning as a new technology in education). Obrazovatelnye tekhnologii i obshchestvo. 14 (1), 241–252. http://ifets.ieee.org/russian/depository/v14_i1/pdf/1r.pdf (2011). Accessed 14 Feb 2017.

8. HP Reveal. https://www.hpreveal.com (2018). Accessed 16 Jan 2018.

9. Hruntova, T., Povar, S.: Pryiomy aktyvizatsii samostiinoi piznavalnoi diialnosti studentiv na zaniattiakh fizychnoho laboratornoho praktykumu yak neobkhidnoi umovy v formuvanni kompetentnoi osobystosti maibutnoho fakhivtsia (Methods of activating the independent cognitive activity of students on the lessons of physical laboratory practice as a prerequisite for the formation of a competent person of a future specialist). In: Proceedings of the 3rd scientific and practical conference on Scientific activity as a way of forming professional competences of a future specialist, Sumy, 5–6 Dec 2012, pp. 26–28 (2012).

10. Hruntova, T.: Udoskonalennia metodyky laboratornoho praktykumu yak instrumentu dlia rozvytku kompetentnostei maibutnoho inzhenera, shliakhom vykorystannia stymuliv aktyvizatsii piznavalnoi diialnosti (Improvement of the methodology of the laboratory practice as a tool for the development of competencies of the future engineer, through the use of incentives for activating cognitive activity). In: Proceedings of the 2nd scientific and practical conference on Scientific activity as a way of forming professional competences of a future specialist, Sumy, 1–2 Dec 2011, pp. 26–28 (2011).

11. Hruntova, T. V.: Aktyvizatsiia navchalno-piznavalnoi diialnosti maibutnikh fakhivtsiv zasobamy mobilnoho navchannia (Activation of training-cognitive activity of future specialists by means of mobile learning). Naukovi zapysky, Seriia: Problemy metodyky fizyko-metematychnoi i tekhnolohichnoi osvity. 11 (2), 162–168 (2017).

12. Hruntova, T. V.: Ispolzovanie kompiuternykh tekhnologii v organizatcii samostoiatelnoi raboty studentov po fizike kak zalog formirovaniia tvorcheskoi kompetentnoi lichnosti budushchego spetcialista (Use of computer technologies in the organization of independent work of students in physics as a pledge of the formation of a creative competent personality of a future specialist). In: Proceedings of the 5th international scientific and practical conference on Scientific search in the modern world, Makhachkala, 31 Jan 2014, pp. 187–189. Aprobatciia, Makhachkala (2014).

13. Hruntova, T. V.: Mobilne navchannia fizyky — suchasna tekhnolohiia realizatsii pryntsypiv navchannia u formuvanni kompetentnoi osobystosti maibutnoho fakhivtsia (Mobile training of physics — the modern technology of the implementation of the principles of training in the formation of a competent person of the future specialist). In: Proceedings of the 2nd Ukrainian scientific and practical Internet-conference on Professional training of a specialist in the context of the needs of the modern labor market, Vinnytsia, 28 Feb 2017, pp. 150–153 (2017).

14. Hruntova, T. V.: Zasoby mobilnoho navchannia fizyky u formuvanni praktychnykh umin maibutnikh fakhivtsiv z informatsiinykh tekhnolohii (Mobile learning tools of physics in forming of practical skills of future professionals). New computer technology. 15, 176–179 (2017).

15. Hurzhii, A. M., Zhuikov, V. Ya., Orlov, A. T., Spivak, V. M., Bohdan, O. V., Shut, M. I., Blahodarenko, L. Yu., Rokytskyi, M. O., Annenkov, V. P., Hrechko, S. M., Havinskyi, A. S: Vykladannia fizyky z vykorystanniam vitchyznianoi elektronnoi tsyfrovoi laboratorii, stvorenoi na osnovi IKT (Teaching Physics with the use of domestic ICT-based electronic digital laboratory). Theory and methods of e-learning. 4, 69–78 (2013).

16. Ilin, V. A., Kudriavtcev, V. V.: Radioastronomiia: metody, instrumentalnaia baza, fundamentalnye otkrytiia (Radio astronomy:

methods, instrumental base, fundamental discoveries). Fizika v shkole. 7, 4–16 (2014).

17. Julier, S., Baillot, Y., Brown, D., Lanzagorta, M.: Information Filtering for Mobile Augmented Reality. IEEE Computer Graphics and Applications. 22 (5), 12–15 (2002). doi: 10.1109/MCG.2002.1028721

18. Livingston, M. A., Rosenblum, L. J., Brown, D. G., Schmidt, G. S., Julier, S. J., Baillot, Y., Swan II, J. E., Ai, Z., Maassel, P.: Military Applications of Augmented Reality. In: Furht, B.: (ed.) Handbook of Augmented Reality, pp. 671–706. Springer, New York (2011). doi: 10.1007/978-1-4614-0064-6_31

19. Meisner, J., Donnelly, W. P., Roosen, R.: Augmented reality technology. US Patent 6,625,299 B1, 23 Sept 2003.

20. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

21. Oryshchyn, Yu. M.: Pro rozrobku novykh tekhnolohii navchannia fizyky (On the development of new technologies for teaching physics). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu im. Ivana Ohiienka, Seriia: Pedahohichna. 9, 37–39 (2003).

22. Sadovyi, M.: Experimental studying of wave and corpuscular properties of light. Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 8 (1), 126–130 (2015).

23. Serhiienko, V. P., Bodnenko, T. V.: Kompetentnisnyi pidkhid u navchanni fizyky maibutnikh fakhivtsiv kompiuternykh system (Competent approach in studying physics future specialists of computer systems). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu im. Ivana Ohiienka, Seriia: Pedahohichna. 21, 231–233 (2015).

24. Shabeliuk, O. V.: Vykorystannia tekhnolohii dopovnenoi realnosti v dystantsiinomu osvitnomu protsesi (Using the technology of the augmented reality in the distance education process). Visnyk Kyivskoho natsionalnoho universytetu imeni Tarasa Shevchenka, Seriia fizyko-matematychni nauky. 2, 215–218 (2014).

25. Sharko, V.: Pidhotovka maibutnikh vchyteliv do kompiuterno-oriientovanoho navchannia fizyky (Training future teachers to computer-based learning physics). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 5 (1), 184–188 (2014).
26. Striuk, M. I., Semerikov, S. O., Striuk, A. M.: Mobility: a systems approach. Information Technologies and Learning Tools. 49 (5), 37–70 (2015).
27. Sus, B. A., Sus, B. B.: Samostiina navchalna diialnist studentiv yak vazhlyvyi mekhanizm formuvannia kompetentnosti maibutnikh fakhivtsiv v umovakh kompiuteryzatsii navchalnoho protsesu (Independent educational activity of the students, as an important factor in forming of specialists' competency while educational process is getting computerized). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu im. Ivana Ohiienka, Seriia: Pedahohichna. 22, 231–233 (2016).
28. Teplytskyi, I., Semerikov S.: Neobmezheni mozhlyvosti ta mozhlyvi obmezhennia zastosuvan kompiutera u fizychnomu laboratornomu eksperymenti (Unlimited possibilities and possible limitations of computer applications in a physical laboratory experiment). Fizyka ta astronomiia v shkoli. 2, 47–49 (2004).
29. Velichko, S., Tkachenko, V.: Poiednannia navchalnoho eksperymentu iz suchasnymy zasobamy informatsiino-komunikatsiinykh tekhnolohii na prykladi analizu kolyvalnoho rukhu tiahartsia na pruzhyni (Association Of Educational Experiment And Of Modern Means Of Information And Communication Technologies At The Example Of The Analysis Of The Oscillating Motion Of The Spring With The Load). Physical and Mathematical Education. 1 (15), 158–162 (2018). doi: 10.31110/2413-1571-2018-015-1-028
30. Zabolotnyi, V. F., Myslitska, N. A.: Realizatsiia tekhnolohii vizualizatsii na lektsiinykh zaniattiakh z fizyky (Implementation of visualization technology at lecture sessions in physics). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu im. Ivana Ohiienka, Seriia: Pedahohichna. 20, 84–86 (2014).
31. Zhaldak, M. I., Nabochuk, Yu. K., Semeshchuk, I. L.: Kompiuter na urokakh fizyky (Computer at Physics lessons). Tetis, Rivne (2004).
32. Zhuk, Yu.: Fenomen rozpodilu skladu laboratornoho obladnannia dlia navchalnoho eksperymentu z fizyky u serednii shkoli (The phenomenon of distribution of the composition of laboratory equipment for a

training experiment on physics in high school). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 4 (2), 116–120 (2013).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 58–73

УДК 004.9:[378.16:81'243]

Developing of Key Competencies by Means of Augmented Reality at CLIL Lessons

Olexandr V. Merzlykin[1[0000−0003−2601−5713]], **Iryna Yu. Topolova**[1] **and Vitaliy V. Tron**[2[0000−0002−6149−5794]]

[1] Kryvyi Rih Educational Complex No 129 "Gymnasium-Lyceum of Academic Approach",
39, Penzenska St., Kryvyi Rih, 50048, Ukraine
{merzlykin, topolova}@physics.ccjournals.eu

[2] State Institution of Higher Education "Kryvyi Rih National University",
11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
vtron@ukr.net

Abstract. Using of new learning and IC technologies is necessary for effective learning of modern students. Their specific educational needs are: using of mobile ICTs, collaboration, challenging tasks and entertainment. Appropriate learning environment should be created to satisfy all these demands. It ought to deal with cloud-based technologies (for 24/7 access, individual and group work according to a personal schedule), augmented reality (for creating of firm links between real and virtual objects), content and language integrated learning (for immersion in an additional language and creation challenging groups and personal tasks in language and non-language subjects). Using these technologies in complex provides social and ICT mobility and creates positive conditions for developing 9 of 10 key competencies. The paper deals with the features, problems and benefits of technologies' implementation in secondary schools. To sum up, in spite of all difficulties, this environment helps students to get some practical experience in using foreign languages and understanding abstract nature concepts; to develop language and research competencies and to remain motivated (and self-motivated) in learning Science and English.

Keywords: Augmented Reality, Science Learning, Key Competencies, Generation Z, Content and Language Integrated Learning (CLIL).

1 Introduction

Current secondary school students are members of so-called "Generation Z" cohort. This term is based on Strauss–Howe generational theory. It is often criticized as sim-plified and pop-sociological. However, we can use the terms as markers for social statistics study. Most of "Zeds" have been using ICT since a young age. Technologies and social network are the essential parts of their world. Consequently, using ICT in education is not an option but a necessity. The most helpful educational technologies for "Zeds" are smartboards, digital textbooks, websites, online videos and game-based learning systems. “Zeds” also prefer studying with friends. Their favorite educational activities are class discussions and working through problems or concepts [1, pp. 6–8]. That is why we have to create learning environment which contains ICT, supports online learning and provides wide opportunities for students’ collaboration and effective education. A possible solution lies in using cloud-based technologies (for example, based on Google Classroom — G Suit learning management system [13]).

2 ICT Component of Learning Environment

2.1 Traditional Cloud-based ICTs

The cloud-based ICTs can be widely used in science learning at secondary schools. We use project management software, virtual labs, virtual simulators, electronic organizers, content analysis tools, electronic lab notebooks, media editors, programming languages and libraries, physical process modeling software, presentation programs; computer algebra systems; statistical packages, spreadsheets and word processors for various purposes [10]. This software is used both in a classroom and at home. Thereby, students operate with virtual objects as well as with real ones. Unfortunately, the links between these objects are not obvious in classic systems and students often do not match real objects with their virtual representations. This problem can be solved with augmented reality (AR) using.

2.2 Using Augmented Reality in Science Learning

The technology of augmented reality attracted the attention of a wide audience in the summer of 2016, when Niantic and Nintendo launched Pokémon Go computer game. However, the history of the augmented reality successful application has at least 25 years [16]. The ideas about using this technology in education were expressed by Ivan E. Sutherland [17], who was the developer of the first systems of virtual and augmented reality. He wrote about the country of miracles, which is opened to the users of these systems, and he focused on their benefits while assimilating the abstract concepts of modern science (in particular, the fields and interactions of elementary particles) [18, p. 507].

That is, the ideas of augmented reality application in education have appeared even before the first augmented reality system was created. In addition to visualizing abstract concepts and objects, that cannot be perceived directly, the importance of augmented reality for training specialists, who work with unique, dangerous or very expensive equipment (astronauts, doctors, pilots, welders, etc.), is obvious. The only factor, that restrained the development of augmented reality learning environments for decades, was the advancement of computer technologies. Nowadays this issue is not so acute due to the proliferation of mobile devices [14, p. 95].

Jean-Marc Cieutat, Olivier Hugues, and Nehla Ghouaiel define AR as the combination of physical spaces with digital spaces in semantically linked contexts for which the objects of associations lie in the real world [3, p. 32]. According to Gartner hype cycle analysis (see Fig. 1) AR is a mature technology and it will reach the plateau of productivity in 5–10 years [19]. Thus, in the near future the number (and quality) of augmented reality software and hardware is supposed to be increased. Augmented reality is implemented in Ukraine slower than in some countries [11, p. 32], but its popularity in our country is currently growing (according to Gartner reports for 2010–2011). However, sustainable development of appropriate means abroad is likely to lead to accelerated, compared to Fig. 1, speed of augmented reality by hype cycle in Ukraine. Consequently, the forecast of augmented reality reaching the plateau of productivity in Ukraine within the next 10–15 years seems to be real.

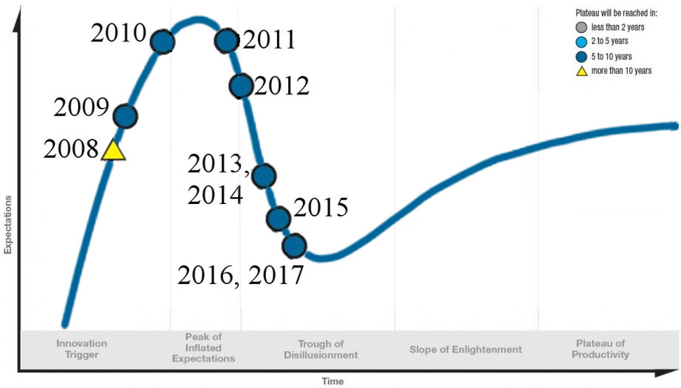


Fig. 1. The trajectory of AR at the Gartner hype cycle since its first appearance in Gartner reports till now

Undoubtedly, the increasing number of augmented reality applications for mobile devices contributes to this process. The use of this software in education provides an opportunity to accommodate the vast majority of subjects of the educational process both in high and secondary schools: our experience shows that the proportion of the students who are able to use mobile Internet devices in the classroom is not less than 90%. In addition, augmented reality applications for mobile devices can naturally be a part of the mobile learning environment [20, p. 46], which benefits are thoroughly compared with classical ones in [8].

Stanley Pierre-Louis in his testimony before the U. S. Senate Committee on Commerce, Science & Transportation of United States Senate said that "the applications of these technologies [AR and mixed reality] to education are endless" [6, p. 7] and pointed some of these applications. In this paper we will review some possibilities of using AR in learning Science subjects at secondary schools.

Mark Billinghurst and Andreas Dünser [2] note that augmented reality is able to expand traditional learning models. The authors emphasize that augmented reality facilitates the understanding of complex phenomena, provides unique visual and interactive experience, that combines real and virtual data, and helps to interact with digital content.

What is more, the use of augmented reality promotes new forms of collaboration, educational cooperation and motivates students to work actively both in the classroom and remotely. According to the authors [2], augmented reality allows creating a unique educational environment, but at the same time they note that possibilities of augmented reality and its application should be studied in more detail.

Phil Diegmann, Manuel Schmidt-Kraepelin, Sven van den Eynden, and Dirk Basten [5] have studied the experience of using augmented reality in education. They have analyzed and systematized the use of augmented reality in 25 publications according to directions of its usage and training benefits (table 1). Each cell of the table contains the relative number of publications which describe the benefits of using augmented reality in this area.

Thus, using augmented reality:

- facilitates the understanding of complex phenomena with the help of unique visual and interactive experience, that combines real and virtual data;
- promotes the effective demonstration of abstract concepts;
- motivates students to learn, making educational process more effective and interesting;
- supports the development of new forms of cooperation and sharing of educational experience;
- involves students in active learning in the classroom as well as remotely.

Table 1. Benefits of using augmented reality in education

Directions	**Benefits**			
	Discovery-based Learning	**Objects Modeling**	**Skills Training**	**AR gaming**
Motivation	28%	16%	4%	4%
Attention and Concentration	16%	0%	0%	0%
Satisfaction of Learning Needs	4%	8%	4%	4%
Student-centered Learning	8%	0%	0%	0%
Collaborative Learning	4%	8%	0%	0%
Details in Data Presentation	0%	0%	4%	0%
Accessibility Information	0%	0%	4%	4%
Interactivity	4%	0%	0%	0%
Learning Curve	24%	16%	24%	4%
Creativity in Learning	8%	0%	0%	0%
Spatial Abilities	0%	8%	4%	0%
Memory	4%	0%	8%	0%
Reduced costs	0%	4%	4%	0%

To sum up, the main benefits of using AR are linked to opportunities for studying objects and phenomena, which are inaccessible for direct cognition, but can be observed by the meanings of AR. It can be very useful in learning abstract Maths and Science concepts. Moreover, AR shows the links between real and virtual objects. For example, students can see that constant chaotic moving of molecules is not a "thing-in-itself", but the nature of the gas. Moreover, AR can be a good example of developing technology by itself and show accelerating progress in the modern world. At schools AR can form some "digital" habits, which can be useful in future life. Using AR in a classroom makes it possible to learn in personal-oriented environment. It helps students to provide their own learning (and self-learning) styles.

According to The State Standard of the Basic and Complete Secondary Education key competencies are [7]:

- native language competency;
- foreign language competency;
- mathematical competency;
- competencies in science;
- digital competency;
- lifelong learning;
- social and civic competencies;
- sense of initiative and entrepreneurship;
- cultural awareness;
- ecological competencies and health care.

Every competency consists of four components: cognitive (related knowledge and intellection), praxeological (needed skills and experience), axiological (personal values and motivation to develop competency), social and behavioral (personal habits and abilities in communication and cooperation in providing main activity of the competency) [12, p. 58]. The benefits of using AR in secondary education (in regard to key competencies) are given in the Table 2. If a competency is not presented in the table, it means that it is hard to distinguish the influence of AR on its forming.

The most essential drawbacks of using AR are connected with deficient studies of its influence on users' health and a lack of privacy and security [15]. We should say that the last problem is mainly caused by irresponsible using of AR; it is not AR itself. That is why it is especially important to teach students basics of AR using (including safety regulations). One of the difficulties, which we face applying AR at Ukrainian secondary school, is their English interface. We can overcome this drawback by developing foreign language competency.

Table 2. Advantages of using AR at science lessons (in regard to key competencies)

Competency	**Component of Competency**			
	Cognitive	**Skills and Experience**	**Values**	**Social and Behavioral**
Mathematical Competency	supporting of abstract mathematical concepts learning	scaffolding of basic math skills (for example geometry imagination)	giving an additional example how mathematical equations come to life	making better conditions to provide own learning style
Competencies in Science	supporting of abstract concepts learning; improving links between nature objects and phenomena (including inaccessible for direct cognition)	making possible to operate with objects, which are inaccessible for direct cognition	demonstrating variety of science implementation; motivating for science learning due to making abstract concepts not abstract ones	making better conditions to provide own learning style
Digital Competency	widening outlook; getting knowledge about AR	acquiring skills and getting experience in mastering subjectively new technologies	demonstrating the importance of digital literacy in the modern world	mastering new ways of digital communication (including learning one)
Lifelong Learning	demonstrating infinite technological progress	getting new learning habits	demonstrating both entertaining and useful learning potential	mastering new ways of learning communication and self-development

Competency	**Component of Competency**			
	Cognitive	**Skills and Experience**	**Values**	**Social and Behavioral**
Sense of Initiative and Entrepreneurship	gaining knowledge about effective ways of organizing information and developing flexible thinking	acquiring skills and getting experience of applying the same technology in different fields	giving an opportunity to adapt to constantly changing situations (using an example of AR)	mastering new effective ways of communication
Cultural Awareness	mastering new effective ways of gaining cultural knowledge	improving praxeological component of technical awareness as a necessary part of personal cultural awareness	helping to understand the importance of cultural awareness by making cross-cultural links more obvious	giving more opportunities for creating own style of self-development
Ecological Competencies and Health Care	making better conditions for understanding the complexity of ecological and medicine processes	acquiring skills and getting experience of health care by themselves (using sport facilities with AR)	demonstrating the importance of health care and saving the environment due to understanding links between nature phenomena and human activities	making better conditions to create own health care programme using sport facilities with AR

3 CLIL Approach In Education

3.1 CLIL Definition

English teaching is still based on traditional education with textbooks as a main resource. The textbooks are mainly focused on grammar material and stereotypical cultural views. This way of teaching does not encourage students to learn language. New methods and approaches should be used to motivate students and to adapt to their learning needs and styles. Content and Language Integrated Learning (CLIL) is considered to be one of such approaches [9]. CLIL is a dual-focused educational approach in which an additional language is used for the learning and teaching of content and language with the objective of promoting both content and language mastery to pre-defined levels [9, pp. 2, 65].

3.2 Risks and Benefits of CLIL Approach

According to Do Coyle, Bernardette Holmes, and Lid King there are four dimensions (4 Cs) which form a conceptual CLIL framework: content, cognition, communication and culture [4]. The authors define five key characteristics which have been drawn from experience of working with successful CLIL.

1. Choosing appropriate content
   - CLIL is about new learning. In a CLIL lesson the learner is discovering new knowledge, developing new or existing skills and deepening understanding;
   - lessons must integrate subject area content and language content;
   - content planning involves choosing relevant contexts for learning which are appropriate to the learners' age, ability and interests and provide meaningful interaction with and through the language.

2. Developing intercultural understanding
   - CLIL actively seeks to promote intercultural understanding by planning and providing rich opportunities to investigate and reflect on different cultures, traditions and values;
   - This approach not only involves learning content through another language, but also often involves learning content through another cultural lens.

3. Using language to learn/learning to use language
    - CLIL involves rich input. Learners are expected to interact with language which is accessible to their existing linguistic level but which promotes linguistic progression;
    - learning new content through language often requires learners to find information from spoken and written text which is at a higher level than the learners' current productive capability;
    - CLIL accelerates the development of language learning strategies to support learners in working out the meaning of what they hear and read and using prior knowledge to predict content.

4. Making meanings that matter
    - There is an expectation that CLIL will involve interaction in the target language within and beyond the classroom;
    - learners will have opportunities to use language for authentic communication;
    - CLIL provides motivating contexts for communication which encourage students to use language to express thoughts, ideas and feelings which matter to them.

5. Progression
    - In a sequence of learning there will be evidence of scaffolding in both language using and interaction with content;
    - learners will progress in language and in the content subject;
    - learners will develop higher order thinking skills, demonstrating their ability to make observations, analyze, generalize and apply their skills to fresh contexts.

CLIL develops a positive attitude to learning by means of diverse educational activities. For instance, students get more language practice including not only dependent on classical language based activities (speaking, reading, writing, listening), but doing experiments, solving problems, dealing with laboratory assignments etc. This can increase students' motivation to learn and can enable them to progress more quickly. CLIL approach allows to be more flexible and employable at the labour market, provides learning mobility and helps to adapt more quickly to constant changes in our increasingly interconnected world. At CLIL lessons students are aware that knowledge and skills are applicable to a wide range of fields. They gain a healthy appreciation of skills and become more motivated to improve them.

CLIL approach involves cooperation and mutual assistance. It provides collaborative environment for both language and science subject learning in a practical way. Students are helpful in assisting each other when getting either into language or science problems. Such situation promotes partnership and cooperation. Advantages of CLIL approach (in regard to key competencies [7]) are reflected in the table 3.

Table 3. Advantages of CLIL science lessons approach in key competencies forming

Competency	**Component of Competency**			
	Cognitive	**Skills and Experience**	**Values**	**Social and Behavioral**
Competencies in Science	learning terms in a foreign language; providing a wider variety of learning objects and original scientific sources	learning culture-based science rules (e. g. mnemonics)	understanding the importance of studying science for learning mobility	empowering social interaction in learning science
Mathematical Competency	learning specific terms in a foreign language	learning culture-based math rules (e. g. mnemonics)	realizing an importance of studying math for learning mobility	empowering social interaction in learning math
Social and Civic Competencies	developing better cross-cultural understanding	shaping tolerance and respect to other cultures; increasing values of cultural peculiarities	demonstrating different cultures impact on science	appreciating pluralism; broadening social experience

Competency	**Component of Competency**			
	Cognitive	**Skills and Experience**	**Values**	**Social and Behavioral**
Foreign Language Competency	widening cross-subject vocabulary	creating real learning situations; providing more language practice	realizing the necessity of languages to access science sources; using languages for real practical purposes	providing mutual assistance in learning languages; making the social environment more accessible
Lifelong Learning	giving opportunities to work with various learning resources; providing cross-subject links	acquiring skills of "mining" knowledge in different languages	increasing awareness of developing in different fields; presenting teachers' examples of development in various spheres	forming collaboration habits due to mutual assistance in learning both language and science
Sense of Initiative and Entrepreneurship	providing a wider range of resources	broadening teamwork experience (including leadership qualities)	demonstrating importance of personal input in common success	providing mutual assistance while learning both language and science
Cultural Awareness	widening outlook	widening a range of multilinguistic activities	recognizing the importance of different knowledge spheres	raising cultural awareness; enhancing ability for cultural reflection

The implementation of CLIL approach in secondary school educational process allows us to distinguish such backgrounds of CLIL lessons as:

- proper level of students' language skills;
- parents' and students' demands for social mobility;
- the teachers' readiness to introduce CLIL lessons;
- social competency of all educational process participants.

While introducing CLIL lessons we face such difficulties as:

- curriculum coordination;
- consuming a lot of time to prepare a CLIL lesson;
- a lack of appropriate materials and resources.

Despite all challenges and problems, CLIL approach has its advantages. Taking into consideration both recent researches [4, 9] and our practical experience we can conclude that CLIL lessons:

- are more interesting and motivating;
- are time-saving (both subjects are learnt together);
- help students to feel confident;
- promote communication and understanding;
- contribute to personal and cultural development;
- provide educational diversity;
- increase mobility.

4 Conclusions

To conclude, nowadays both new learning and IC technologies are required to satisfy "Zeds" demands. For instance, all reviewed technologies provide individual learning strategies: AR and cloud-based learning environment help students to work according to their personal style, CLIL approach helps students to feel confident either in language or non-language subjects. Cloud-based learning environment gives students and teachers great opportunities for communication and cooperation via online tools, and CLIL approach is based on their teamwork and collaboration.

Although AR and CLIL are supposed to be relatively new technologies, in fact, they are sufficiently mature and can be used at school. The using of both AR and CLIL in cloud-based science learning environment helps to form and develop 9 of 10 key competencies (except native language competency). Cloud-based technologies provide online and offline access to learning materials and give more opportunities for individual and group work. Augmented reality helps to create the firm links between real and virtual objects. Moreover, it is very beneficial for studying abstract mathematical and science concepts. Content and language integrated learning creates conditions for efficient group and individual work in language and science learning.

We should mention that implementation of these technologies is reasonable only under certain conditions. AR using requires gadgets and appropriate level of teachers' digital literacy. Conversely, CLIL implies the proper level of foreign language competency and readiness of all participants of education process to introduce this approach. The main difficulties, we face applying these technologies in science learning, are connected with organization of educational process not with teaching or learning. To sum up, cloud-based, AR and CLIL technologies together create rich learning and teaching environment for effective and interesting education of modern students.

References

1. Barnes & Noble College: Getting to Know Gen Z — Exploring Middle and High Schoolers' Expectations for Higher Education. https://next.bncollege.com/wp-content/uploads/2015/10/Gen-Z-Research-Report-Final.pdf (2015). Accessed 15 Jan 2018.
2. Billinghurst, M., Duenser, A.: Augmented Reality in the Classroom. Computer. 45 (7), 56–63 (2012). doi: 10.1109/MC.2012.111
3. Cieutat, J.-M., Hugues, O., Ghouaiel, N.: Active Learning based on the use of Augmented Reality Outline of Possible Applications: Serious Games, Scientific Experiments, Confronting Studies with Creation, Training for Carrying out Technical Skills. International Journal of Computer Applications. 46 (20), 31–36 (2012).
4. Coyle, D., Holmes, B., King, L.: Towards an Integrated Curriculum — CLIL National Statement and Guidelines. The Languages Company. http://www.rachelhawkes.com/PandT/CLIL/CLILnationalstatement andguidelines.pdf (2009). Accessed 15 Jan 2018.
5. Diegmann P., Schmidt-Kraepelin M., Van den Eynden S., Basten D.: Benefits of Augmented Reality in Educational Environments — A Systematic Literature Review. In: Thomas, O., Teuteberg,

F. (eds.) Proceedings the 12th International Conference on Wirtschaftsinformatik, Osnabrück, 4–6 March 2015, pp. 1542–1556. http://aisel.aisnet.org/wi2015/103/ (2015). Accessed 10 Jan 2018.

6. Exploring augmented reality : hearing before the Committee on Commerce, Science, and Transportation, United States Senate, One Hundred Fourteenth Congress, second session, November 16, 2016. U. S. Government Publishing Office, Washington (2017).
7. Kabinet Ministriv Ukrainy: Derzhavnyi standart bazovoi i povnoi zahalnoi serednoi osvity (The State Standard of the Basic and Complete Secondary Education). Zakonodavstvo Ukrainy. http://zakon3.rada.gov.ua/laws/show/1392-2011-%D0%BF (2011). Accessed 25 Dec 2017.
8. Kislova, M. A., Semerikov, S. O., Slovak, K. I.: Rozvytok mobilnoho navchalnoho seredovyshcha yak problema teorii i metodyky vykorystannia informatsiino-komunikatsiinykh tekhnolohii v osviti (Development of mobile learning environment as a problem of the theory and methods of use of information and communication technologies in education). Information Technologies and Learning Tools. 42 (4), 1–19 (2014).
9. Marsh, D.: CLIL/EMILE — the European dimension: actions, trends and foresight potential. University of Jyväskylä, Jyväskylä (2002).
10. Merzlykin, O. V., Merzlykin, P. V.: Zasoby informatsiino-komunikatsiinykh tekhnolohii pidtrymky navchalnykh doslidzhen u profilnomu navchanni fizyky (The tools of information and communication technologies for learning researches support in profile physics learning). Information Technologies and Learning Tools. 48 (4), 58–87 (2015).
11. Merzlykin, O. V., Semerikov, S. O.: Perspektyvni khmarni tekhnolohii v osviti (Prospective Cloud Technologies in Education). In: Proceedings of the scientific and practical workshop on Cloud Technologies in Modern University, Cherkasy, 24 Mar 2015, pp. 31–33. ChDTU, Cherkasy (2015).
12. Merzlykin, O. V.: Khmarni tekhnolohii yak zasib formuvannia doslidnytskykh kompetentnostei starshoklasnykiv u protsesi profilnoho navchannia fizyky (Cloud technologies as tools of high school students' research competencies forming in profile physics learning). Thesis for the degree of candidate of pedagogical science, Institute of Information Technologies and Learning Tools of the NAPS of Ukraine (2017).

13. Merzlykin, O. V.: Mozhlyvosti vykorystannia Google Classroom dlia realizatsii khmarnoho seredovyshcha pidtrymky navchalnykh doslidzhen z fizyky (The possibilities of using Google Classroom for implementing cloud environment of support physics learning researches). In: Proceeding of the 2nd Ukrainian scientific and practical conference of young scientists "Scientific Youth–2014", pp. 110–112. Institute of Information Technologies and Learning Tools of the NAES of Ukraine, Kyiv (2014).
14. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).
15. Roesner, F., Kohno, T., Molnar, D.: Security and Privacy for Augmented Reality Systems. Communications of The ACM. 57 (4), 88–96 (2014). doi: 10.1145/2580723.2580730
16. Rosenberg, L. B.: The Use of Virtual Fixtures As Perceptual Overlays to Enhance Operator Performance in Remote Environments: Interim Report for The Period June 1992 to July 1992. Wright-Patterson Air Force Base, Ohio (1992).
17. Semerikov, S. O., Striuk, A. M., Slovak, K. I., Rashevska, N. V., Yechkalo, Yu. V.: Liudyna z kompiuternym oblychchiam (do 80-richchia Aivena Edvarda Sazerlenda) (A man with a computer face (to the 80th anniversary of Ivan Edward Sutherland)). New computer technology. 16, 9–24 (2018).
18. Sutherland, I. E.: The Ultimate Display. In: Proceedings of the IFIP Congress 1965. New York City, 24–29 May 1965, vol. 2, pp. 506–508. Macmillan and Co., London (1965).
19. Technology Research & Insight for IT Professionals | Gartner Inc. https://www.gartner.com/technology/it_professionals.jsp (2018). Accessed 26 Jan 2018.
20. Teplytskyi, I. O., Semerikov, S. O., Polishchuk, O. P.: Model mobilnoho navchannia v serednii ta vyshchii shkoli (The model of mobile learning in middle and high school). In: Proceedings of the 3rd Ukrainian scientific and methodical workshop on Computer Simulation in Education, Kryvyi Rih, 24 Apr 2008, pp. 45–46. KDPU, Kryvyi Rih (2008).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 74–83

УДК 373.5.016:53]:004.9

Implementation of Gamification and Elements of Augmented Reality During the Binary Lessons in a Secondary School

Viktoriia L. Buzko[1[0000−0001−9358−8365]],
Alla V. Bonk[1[0000−0001−9867−4107]] and
Vitaliy V. Tron[2[0000−0002−6149−5794]]

[1] Municipal Establishment "Teaching-Educational Association No. 6 "Specialized Secondary School of I–III Grades, Aesthetic Upbringing Centre "Nathnenia" Kirovohrad City Council Kirovohrad Region", 39/63, Velyka Perspectyvna St., Kropyvnytskyi, 25006, Ukraine
vika.buzko@gmail.com, alla@school6kr.org.ua
[2] State Institution of Higher Education "Kryvyi Rih National University", 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
vtron@ukr.net

Abstract. The *purpose of the research* is to consider the possibilities of gamification and elements of augmented reality in the secondary school during the binary lessons in Physics and English. The *objective of the research* is to give examples of conducting binary lessons by means of gaming and elements of augmented reality. The *object of the research* is the process of teaching Physics and English in a secondary school. The *subject of the research* is the use of gamification and the elements of augmented reality when conducting binary lessons in a secondary school. The article considers the possibility of introducing the elements of augmented reality and gamification in a secondary school during the binary lessons. Examples of binary lessons for the secondary school students using gamification and augmented reality elements are given. The introduction of various types of educational activities during the binary lessons is analyzed. The *results of the research* indicate that gamification and the introduction of the elements of augmented reality in the process of studying in a secondary school contribute to the formation and development of cognitive interest of students in Physics and English; it will promote the application of scientific and technical knowledge in real life.

Keywords: binary lessons, gamification, augmented reality, studying in a secondary school, Physics, cognitive interest, basic school.

1 Introduction

One of the effective means of forming students' cognitive interest in science in general education is the implementation of integrated lessons.

The problem of organizing the educational process on an integration basis was the subject of researches conducted by Iryna M. Kozlovska [8], Yaroslav M. Sobko [15], Vladimir T. Fomenko [7], Tetiana D. Yakymovych [18] and others; the integration of natural science knowledge was analyzed in the works of Iurii I. Dik [6], Vira R. Ilchenko [9], Mykhailo T. Martyniuk [11], Vasilii G. Razumovskii [14], Illia O. Teplytskyi [16] and others. Integral pedagogical technology as a model of learning was developed in the works of Oksana Ya. Marynovska [12].

2 Exposition of Basic Material of Research

Integrated lessons should be conducted periodically so that students could see the correlation between the school subjects and understand that the knowledge gained from studying one subject allows you to understand the processes that are being studied in other subjects better. These lessons are relevant and effective regardless of whether the students are learning new or generalizing already learnt material. During the integrated lessons multidimensional objects are considered, which are subjects of studying for various school disciplines [4, 5].

In the process of studying at a secondary school the integrated technology is implemented in the following ways: conducting lessons using interdisciplinary connections; implementation of integrated lessons; conducting binary lessons [1].

Binary lessons, as a rule, allow you to integrate knowledge from different fields to solve one problem, make it possible to apply your knowledge in practice. Such lessons are often conducted by two teachers.

Our experience shows that in the process of studying in a comprehensive school it is reasonable to have integrated lessons in physics, biology, chemistry, mathematics, foreign languages [17].

The purpose of a binary lesson is to create conditions for the motivated practical application of knowledge, skills and abilities, to give students the opportunity to see the results of their own learning in two different educational disciplines and get positive emotions from the process of gaining knowledge.

Here are some examples of binary lessons that we think is reasonable to have at a secondary school:

1. “Diffusion in Nature and Science” — a binary lesson in Physics and English (Grade 7) [1].
2. “Science and Technical Progress. Light Phenomena in Nature and in Technology” — a binary lesson in Physics and English (Grade 9).

3. “Magnetic Field in Nature and Technology” — a binary lesson in Physics and Biology (Grade 9) [4].
4. “Resistance-moving System” — a binary lesson in Biology and Physics (Grade 9) [5].
5. “Environmental Problems of Nuclear Energy” — a binary lesson in Physics and English language (Grade 9).

In order that pupils work effectively during the binary lessons, it is necessary to implement gamification and elements of augmented reality.

The game for children and young people is a usual form of communication, when they feel themselves most comfortable. Discussions in form of a game avoid obstacles such as insufficient knowledge, inability to argue reasonably for their opinion [2].

During the lesson in the 7th grade (“Diffusion in nature and science”), it is a good idea to work with the interactive whiteboard, such as SMART Board, at the warming-up stage and during the actualization of students’ skills and abilities, for example, the task to define the physical phenomena (exercise “Physical Football”, Fig. 1).

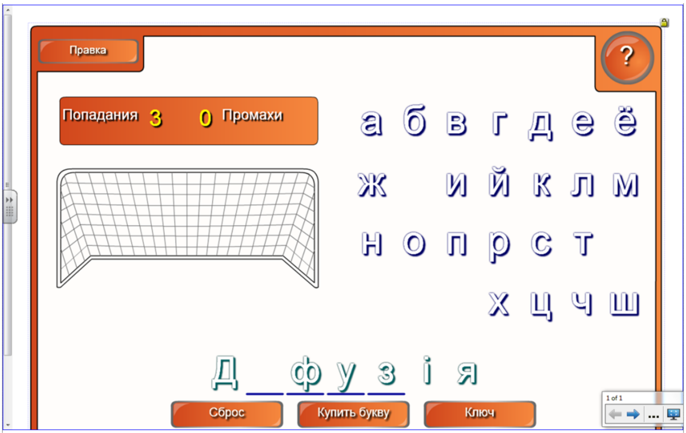


Fig. 1. Exercise “Physical football”

After the announcing of the theme of the lesson students are encouraged to explain the task encoded using QR codes and thus split them into teams (Fig. 2).

QR codes can be used in game quests to offer game tasks at one or more stages of the corresponding activities, in educational crossword puzzles [3].

Fig. 2. QR codes for dividing students into teams

During the main part of the lesson students carry out experimental tasks: one group of students carries out experimental tasks with the help of devices, and the other group of students is encouraged to watch the video after scanning the QR-code [1].

Students of the 7th grade are encouraged to read the task in English, carry out the experiment, and then explain the results in English as well. An example of the task "Wilful Potato".

Experiment # 2. "Wilful Potato"

Purpose: to observe the phenomenon of osmosis.

Equipment: potato cubes, a glass of weak salt solution, a glass of clean water, a glass of concentrated salt solution, a knife, sugar, a board, a saucer.

1. You have three glasses with different liquids, they contain almost identical cubes of potato.
2. One or two hours later, we can see that the cubes began to differ: the first of them (the one that was in weak salt solution) remained the same size, the second (it was in strong salt solution) shrank and became much smaller, and the third, on the contrary, plumped up.

At the beginning of the lesson "Science and Technical Progress. Light Phenomena in Nature and in Technology", the teacher of English and the teacher of Physics announced the theme and the objectives of the lesson. The aim of this lesson in Physics is to test and consolidate students' knowledge on the topic "Light Phenomena", the purpose of the English lesson is to activate and test students' skills in different types of language activities in English.

During the warming-up activities students were offered some tasks in both English and Ukrainian. There were tasks using Kahoot [10], SMART Board. With great interest students solve puzzles (Fig. 3); guess riddles in English concerning light phenomena in Physics (Fig. 4).

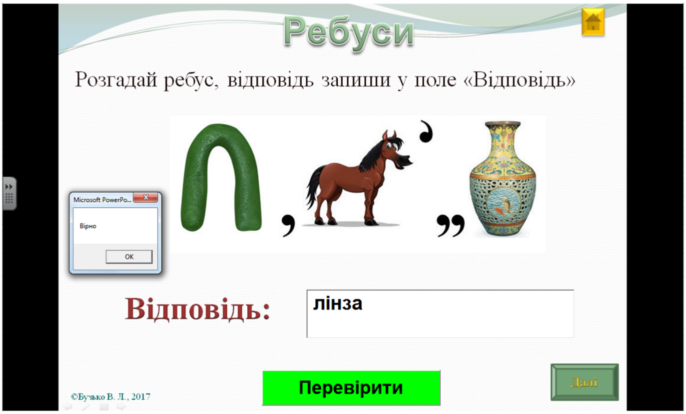


Fig. 3. An example of a puzzle

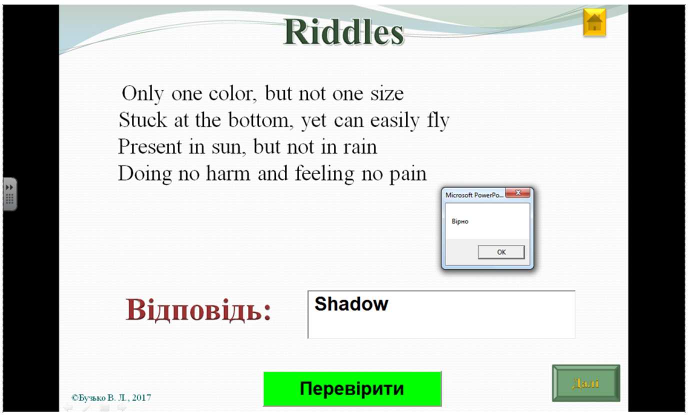


Fig. 4. An example of a riddle

The main part of the lesson was dedicated to performing experimental tasks in Physics. Students were divided into four groups beforehand, performing laboratory work they studied the laws of Physics and light phenomena, for this purpose, the method of active learning was introduced: the experimental task is given to the students, having read the task students work out the possible results of the experiment, and subsequently check it during the experiment.

Fig. 5. The work with a marker

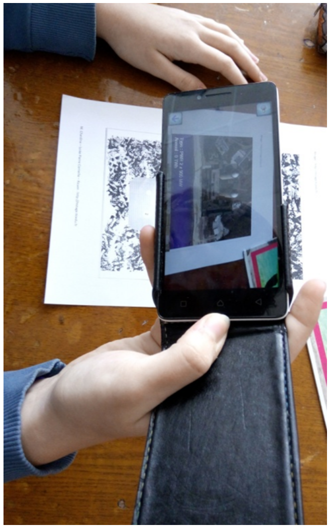


Fig. 6. The elements of the augmented reality at the lesson of Physics

During the course of this lesson, the students are encouraged to ascertain experimentally the validity of the following laws:

- The law of refraction (Snell's law of refraction) — the law of refraction of light (the law of Snelius),
- Dispersion of light,
- The law of reflection,
- The law of rectilinear spread of light.

During the lesson "Environmental Problems of Nuclear Energy" (Grade 9) it is reasonable to use the elements of the augmented reality [13] (Fig. 5). To do this, before the lesson, the students are encouraged to download the "Augmented Nuclear plants" free application (Fig. 6). The markers printed on paper are distributed to the students.

We offer the following tasks to the ninth-graders:

1. Describe the nuclear power plants on each card, explain how the nuclear power plant works.
2. Try to find out on what conditions you can build a nuclear power plant.
3. Two power plants are not atomic power plants, find them. Explain how they affect the environment.

3 Conclusion

Our experience of conducting binary lessons gives grounds to draw the following conclusions. Binary lessons are an effective means of increasing the motivation of studying natural sciences as they create conditions for the practical application of knowledge; develop students' skills in self-education, since a significant part of the training is carried out by students on their own and after classes; develop analytical abilities and ingenuity; form convergent thinking; at binary lessons we transfer skills in new spheres, which helps to find a solution to the problem under the new conditions; have significant educational potential; the positive atmosphere of such a lesson allows us to solve communicative tasks and contributes to the formation of a fully-developed student's personality. The realization of integration between subjects is possible only under the condition of a positive climate in the team of teachers, their fruitful cooperation on the basis of mutual understanding and respect and the knowledge of the programs of other natural sciences.

It is important to integrate English with other subjects in high school for the career-guidance purposes. It is important to note that the introduction of gamification and augmented reality in education in the secondary school allows the participants of the game to go beyond the content and the forms of the presentation of educational material introduced by the teacher; in the process of performing such tasks students develop their communicative skills; gamification and elements of augmented reality contribute to the formation and development of students' cognitive interest, motivate their self-educational activities.

References

1. Buzko, V., Bonk, A.: Implementation of binary lessons as a STEM-education in the process of education in a secondary school. In: Proceedings of the 2nd International scientific and practical workshop on STEM-education — problems and prospects, KLA NAU, Kropyvnytskyi, 25–26 Oct 2017, pp. 19–21 (2017).
2. Buzko, V. L., Echkalo, Yu. V.: Heimifikatsiia yak zasib formuvannia piznavalnoho interesu u navchanni fizyky (Gamification as a mean of forming of cognitive interest in physics teaching). New computer technology. 15, 171–175 (2017).
3. Buzko, V. L., Echkalo, Yu. V.: Mozhlyvosti vykorystannia QR-kodiv u navchanni fizyky (The possibility of use of QR-codes in teaching physics). Naukovi zapysky, Seriia: Problemy metodyky fizyko-metematychnoi i tekhnolohichnoi osvity. 10 (1), 112–118 (2016).
4. Buzko, V. L., Usachova, A. O.: Tekhnolohiia provedennia binarnykh urokiv z fizyky i biolohii u zahalnoosvitnii shkoli (Technologies of implementation of binary lessons in physics and biology in the secondary school). Naukovi zapysky, Seriia: Problemy metodyky fizyko-metematychnoi i tekhnolohichnoi osvity. 7 (3), 116–121 (2015).
5. Buzko, V. L., Velychko, S. P.: Zaprovadzhennia intehralnoi pedahohichnoi tekhnolohii yak zasobu realizatsii doprofilnoi pidhotovky v zahalnoosvitnii shkoli (Introducing of the integral pedagogical technology as a means of implementing pre-school preparation in a secondary school). Naukovi zapysky, Seriia: Problemy metodyky fizyko-metematychnoi i tekhnolohichnoi osvity. 6 (2), 48–54 (2014)
6. Dik, Iu. I., Pinskii, A. A., Usanov, V. V.: Integratciia uchebnykh predmetov (Integration of subjects). Sovetskaia pedagogika. 9, 42–47 (1987).
7. Fomenko, V. T.: Igra svobodnykh, sushchnostnykh sil uchitelia i uchashchikhsia v usloviiakh mezhpredmetnoi integratcii (The game of free, essential forces of the teacher and students in the context of inter-subject integration). Russian Psychological Journal. 14 (1), 231–236 (2017).
8. Honcharenko, S. U., Kozlovska, I. M. Teoretychni osnovy dydaktychnoi intehratsii u profesiinii serednii shkoli (The theoretical basis of didactic integration in professional high school). Pedahohika i psykholohiia. 2, 9–18 (1997).

9. Ilchenko, V. R.: Perekrestki fiziki, khimii i biologii (Crossroads of physics, chemistry and biology). Prosveshchenie, Moscow (1986).
10. Kahoot!: Kahoot! | Learning Games | Making learning awesome. https://getkahoot.com (2018). Accessed 15 Jan 2018.
11. Martyniuk, M. T., Bondarenko, S. I., Braslavska, O. V., Brit, N. M., Valiuk, V. F., Hnatiuk, O. V., et al.: Intehratyvnyi funktsionalno-haluzevyi pidkhid yak chynnyk prohnozuvannia i pobudovy modelei pedahohichnoi pryrodnycho-naukovoi osvity (Integrative functional and sectoral approach as a factor for forecasting and constructing models of pedagogical science and education). FOP Zhovtyi O. O., Uman (2013).
12. Marynovska, O. Ya.: Intehralna tekhnolohiia navchannia: vid teorii do praktyky (Integral learning technology: from theory to practice). Pochatkova osvita. 32 (608), 3–5 (2011).
13. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).
14. Razumovskii, V. G., Tarasova L. V.: Razvitie obshchego obrazovaniia: integratciia i gumanitarizatciia (Development of general education: integration and humanitarization). Sovetskaia pedagogika. 7, 3–10 (1988).
15. Sobko, Ya. M.: Teoretyko-metodychni osnovy vprovadzhennia intehratyvnykh kursiv u profesiino-tekhnichnii osviti (Theoretical-methodical basis of implementation of integrative courses in professional and technical education). Norma, Lviv (2014).
16. Teplytskyi, I. O., Semerikov, S. O.: Na perekhresti ekolohii, matematyky, informatyky y fizyky (At the intersection of ecology, mathematics, computer science and physics). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu. Seriia pedahohichna. 18, 34–37 (2012).
17. Velychko, S. P., Buzko, V. L.: Binarnyi urok z fizyky ta biolohii yak zasib formuvannia piznavalnoho interesu uchniv osnovnoi shkoly (The binary lesson with physics and biology as means of forming cognitive interest of basic school pupils). Pedahohichni nauky. 66, 116–122 (2014).

18. Yakymovych, T. D.: Intehratsiia teoretychnoho i vyrobnychoho navchannia v protsesi profesiinoi pidhotovky fakhivtsiv (na materiali elektronnoi promyslovosti) (Integration of theoretical and production training in the process of professional training of specialists (on the material of the electronic industry)). Dissertation, Institute of Pedagogy and Psychology of Professional Education of the Academy of Pedagogical Sciences of Ukraine (2001).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 84–89

УДК 378:[37.091.39:004.9]–051

The Problems of Personnel Training for STEM Education in the Modern Innovative Learning and Research Environment

Mariya P. Shyshkina[0000−0001−5569−2700]
Institute of Information Technologies and Learning Tools of NAES of Ukraine, 9, M. Berlynskoho St., Kyiv, 04060, Ukraine
shyshkina@iitlt.gov.ua

Abstract. The *aim of the article* is to describe the problems of personnel training that arise in view of extension of the STEM approach to education, development of innovative technologies, in particular, virtualization, augmented reality, the use of ICT outsourcing in educational systems design. The *object of research* is the process of formation and development of the educational and scientific environment of educational institution. The *subject of the study* is the formation and development of the cloud-based learning and research environment for STEM education. The *methods of research* are: the analysis of publications on the problem; generalization of domestic and foreign experience; theoretical analysis, system analysis, systematization and generalization of research facts and laws for the development and design of the model of the cloud-based learning environment, substantiation of the main conclusions. The *results of the research* are the next: the concepts and the model of the cloud-based environment of STEM education is substantiated, the problems of personnel training at the present stage are outlined.

Keywords: learning environment, cloud technologies, augmented reality, pedagogical personnel.

1 Introduction

Nowadays it is impossible to introduce the innovative ICT into the learning process and management of pedagogical systems without paying attention to the organization of teachers training in educational institutions especially in view of the current need of a large amount of highly skilled IT personnel for information society development. To train teachers that would be involved in the process of informatization of the modern educational environment it is necessary to develop new approaches related to the education at different level and profile of training [7].

There is a significant need in ICT-qualified specialists in the field of public administration of education, educational management, training and retraining of teaching staff. Without sufficient knowledge of the current developments of educational ICT services the graduates will have problems with adaptation at their workplace due to the lack of awareness of the real issues and working conditions of innovative ICT use, as well as the lack of ideas on the practical implementation of innovations in the educational process, low level of emerging educational techniques introduction [6, 7].

It is unlikely that the present state of scientific, educational and management personnel training is quite satisfactory for the needs of innovative development of ICT for learning both regarding the required number of qualified specialists and the content and quality of training. Therefore there is a need for the development of new models and approaches to personnel training in view of the modernization of ICT infrastructure and the integration of learning resources at different levels of education, management and research [6, 7].

2 Results and Discussion

The process of creation and content elaboration of electronic learning resources requires fundamental basic knowledge in the field of computer and educational technologies. Instead, approaches to training today are usually not enough focused on innovations that has taken place in recent years and on the real needs for such training [7]. Certain approach to these problems solving can be based on the mechanism of outsourcing of ICT services provision with the use of appropriate cloud computing services [1]. Outsourcing plays a significant role in improving the technical level of ICT systems of educational institutions, as well as the efficiency of their processing and development. It is a market mechanism enforcing the introduction of the latest advances in ICT, aimed at more flexible and prompt response to the needs of the user [1]. In view of the challenges of educational institution innovative ICT infrastructure formation it would be possible to solve some of the above-mentioned problems [6].

Under *the learning and research environment* of the educational institution the environment of the learning and research activities of its participants (students, listeners, teachers, methodologists, scientists, administrative, managerial and auxiliary staff) is meant, where the necessary, sufficient and safe conditions for its implementation are created.

The cloud-based learning and research environment of educational institution is the environment of the learning and research activities of the participants, where the virtualized computer-technological (corporate or hybrid) infrastructure is purposefully created to provide its computer-processing functions.

The cloud-based approaches to the formation of the educational environment have promising application in the field of STEM education (Science, Technology, Engineering, Mathematics). The research in this area is aimed at achieving of a new quality of learning by means of more powerful, flexible, scalable infrastructure solutions that can be used to integrate a variety of educational components based on emerging technologies into the learning and research environment. Thus, the concept of the cloud-based environment of STEM-education appears to be valuable.

Among the functions of the cloud-based environment are: support for various processes of learning and research activities within an educational institution, supply of educational resources and services based on a unite platform.

This leads to the concept of cloud-based learning technology namely the computer-oriented part of learning technology aimed at solving of certain didactic tasks. It reflects the model of learning structure (as a set of relationships among the participants of the learning process, the elements of content and other components of the computer-based environment) the use of computer-based learning tools, information and communication networks and electronic resources, mainly and fundamentally based on cloud computing [7].

Recently in the field of STEM education the following ICT trends [4] have been developed, such as new interfaces, screenless displays, 3D technologies, augmented reality [2], “emotional” computing, wearable technologies (devices) and others. All these areas are united under the common name of “new opportunities” (new enabling technologies) [3, 5].

If we consider STEM-education tools and services in terms of the cloud-based learning and research environment services types, it is possible to distinguish the following elements that are its most important structural units:

- the personalized (remote) STEM education laboratories, which contains the tools for the management of various specialized software, devices and equipment through the network;
- the subject-oriented collections, libraries, learning resources depositories, containing sets of different programs and data for educational purposes;
- the specialized corporate cloud software, in particular, those services of modeling, programming, computing, designing, solving of educational tasks that are available for a corporate range of users — for example, employees and students of an educational institution;

- the services of scientific and educational information networks that can provide access to various data, electronic resources and network tools for scientific and educational purposes, provided to the participants of a public network (Fig. 1).

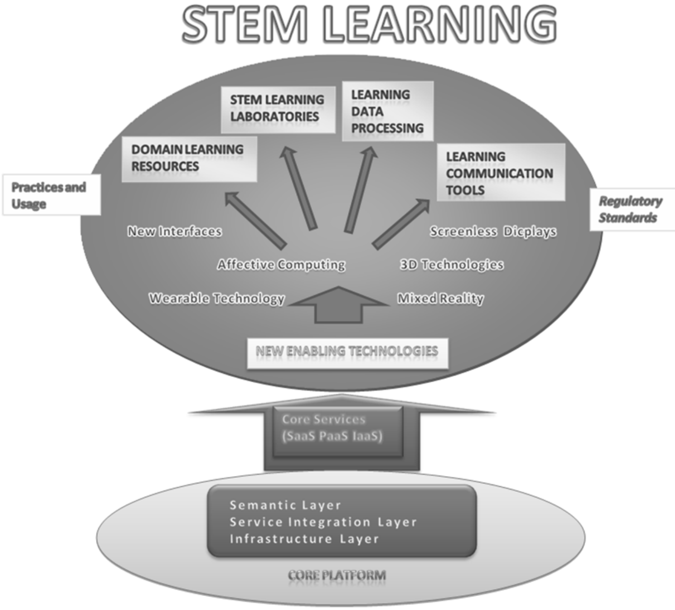


Fig. 1. The model of the cloud-based learning and research environment of STEM-education

Among the computer-based tools for creating, combining and reusing of content, services, applications and data in STEM learning process there are such as simulation tools; embedded network objects; platforms and networks for the organization of joint activities; communication tools in the learning process and others. In [1] the following components are distinguished:

- the environment for learning objects testing and experimentation ("residence" learning experience), for example, using 3D-modeling, imaging technology, augmented and virtual reality, adaptive / personalized environments);
- the learning support services (e.g., data processing, training analytics for tracking and evaluating dynamically the real-time student's achievements) [3].

3 Conclusion

Thus, the problems of STEM-education personnel training in modern innovative environment are in much concern along with the need for wider implementation of ICT-outsourcing in the design of educational systems and the development deployment of innovative technologies, including virtualization, augmented reality and others in the processes of teachers training.

References

1. Bykov, V., Shyshkina, M.: Emerging technologies for personnel training for IT industry in Ukraine. In: Proceedings of ICL2014 — 2014 International Conference on Interactive Collaborative Learning, Dubai, 03–06 December 2014, pp. 945–949. IEEE, Red Hook (2014). doi: 10.1109/ICL.2014.7017903
2. Diegmann P., Schmidt-Kraepelin M., Van den Eynden S., Basten D.: Benefits of Augmented Reality in Educational Environments — A Systematic Literature Review. In: Thomas, O., Teuteberg, F. (eds.) Proceedings the 12th International Conference on Wirtschaftsinformatik, Osnabrück, 4–6 March 2015, pp. 1542–1556. http://aisel.aisnet.org/wi2015/103/ (2015). Accessed 10 Jan 2018.
3. Johnson, L., Adams Becker, S., Estrada, V., Martín, S.: Technology Outlook for STEM+ Education 2013–2018: An NMC Horizon Project Sector Analysis. The New Media Consortium, Austin (2013).
4. Merzlykin, O. V., Semerikov, S. O.: Perspektyvni khmarni tekhnolohii v osviti (Prospective Cloud Technologies in Education). In: Proceedings of the scientific and practical workshop on Cloud Technologies in Modern University, Cherkasy, 24 Mar 2015, pp. 31–33. ChDTU, Cherkasy (2015).
5. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).
6. Shyshkina, M.: Emerging Technologies for Training of ICT-Skilled Educational Personnel. In: Ermolayev, V., Mayr, H. C., Nikitchenko, M., Spivakovsky, A., Zholtkevych, G. (ed.) Information and Communication Technologies in Education, Research, and Industrial Applications.

ICTERI 2013. Communications in Computer and Information Science, vol. 412. Springer, Cham (2013). doi: 10.1007/978-3-319-03998-5_14

7. Shyshkina, M.: Holistic Approach to Training of ICT Skilled Educational Personnel. In: Ermolayev, V. (ed.) ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer. CEUR Workshop Proceedings. 1000, 436–445. http://ceur-ws.org/Vol-1000/ICTERI-2013-p-436-445-MRDL.pdf (2013).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 90–101

УДК 004.9:37.091.39(477)

The Potential of Using Google Expeditions and Google Lens Tools under STEM-education in Ukraine

Yevhenii B. Shapovalov[1[0000−0003−3732−9486]],
Zhanna I. Bilyk[1[0000−0002−2092−5241]],
Artem I. Atamas[1[0000−0002−8709−3208]],
Viktor B. Shapovalov[1[0000−0001−6315−649X]] and
Aleksandr D. Uchitel[2[0000−0002−9969−0149]]
[1] National Center "Junior Academy of Sciences of Ukraine",
38/44, Dehtiarivska St., Kyiv, 04119, Ukraine
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine,
5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine
gws0731512025@gmail.com, o.d.uchitel@i.ua

Abstract. The expediency of using the augmented reality in the case of using of STEM-education in Ukraine is shown. The features of the augmented reality and its classification are described. The possibilities of using the Google Expeditions and Google Lens as platforms of the augmented reality is analyzed. A comparison, analysis, synthesis, induction and deduction was carried out to study the potential of using augmented reality platforms in the educational process. Main characteristics of Google Expeditions and Google Lens are described. There determined that augmented reality tools can improve students motivation to learn and correspond to trends of STEM-education. However, there problems of using of augmented reality platforms, such as the lack of awareness of this system by teachers, the lack of guidance, the absence of the Ukrainian-language interface and responding of educational programs of the Ministry of Education and Science of Ukraine. There proposed to involve methodical and pedagogical specialists to development of methodical provision of the tools of augmented reality.

Keywords: augmented reality, Google Expeditions, Google Lens, STEM-approach of education.

1 Introduction

Development of the country is depends of the education level of country. That why methods used for education of the students is provide impact on the all humanity development. There a lot of the positive educational innovation is already implemented worldwide.

2 Literature Review and Problem Statement

However, modern society requires the innovation methods including to increase the students motivation. The motivation factor is agreed with scientific results [8]. In the research was analyzed the motivation of students during the augmented reality (AR) education [16]. There was determined that 64.7% pupils was enjoyed the AR-education and 35.3% ware strongly enjoyed. There was no negative effect on the student's motivation.

There is described the interactive methods of education previously. This methods can be divided to the regular and periodic. The regular methods of the digital motivation of the students developed weakly in Ukraine. However, it based on the including of the interactive boards and using of the web-pages on classes. Project "The Future" [6], web-page "For the lesson" [17] and web-page of the virtual STEM-center of Junior Academy of Sciences of Ukraine (stemua.sciece) is one of most widely-used resources [13].

However, the periodic events aimed to improve motivation of students are more often used in the education system of Ukraine. However, there is no so much digitized education events. One of them is an open natural demonstration, based on the using of search skills of student that is important competence of modern people. Students are use the Google Search to research proposed question.

There is an increasing of scientific articles devoted to the AR digitalization of the classes' quantity. Thus, there was published 15 articles in the 2015, compare to 1 in 2011. The maximum articles quantity was observed in the 2014th with indicator of 18 [10].

Some scientific articles was devoted to analyze of the AR (VR)-approaches in the classes [18]. However, the aim of the article is to analyze the possibility to implement interactive augmented reality methods to the education system of Ukraine.

There was proposed to use the SamRohn 360 VR, BlakewayGigapixel, AirPano Arial Panoramaand 360 World Tours, World Tour 360, and World in 360, YouTube, Sites in 3D Virtual Tours, You Visit 360, Vatican, Kid World Citizen, Google Expeditions, Google Streets and InCell VR to use in the educational process [18].

Using of the argument reality in teaching is possibility to visualize information. Visualization of educational materials provide improving level of mastering of educational information by students [2]. Main advantage of instruments of AR is lower level of negative effects comparing to virtual reality. However, modern tendency of Ukrainian education declamation providing of STEM-approaches of educational which including using of informational technologies [21].

AR is approach to visualization of information, which include elements of virtual reality in the reality. Scheme of the augmented reality is shown on Fig. 1.

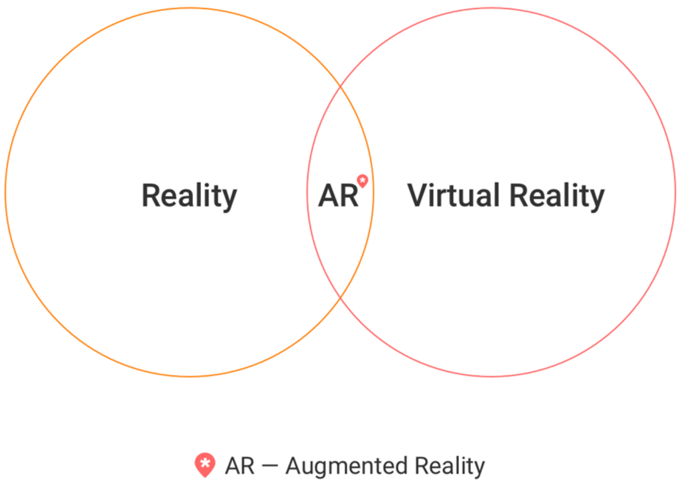


Fig. 1. Scheme of the augmented reality

The result Lee Steven O. Zantua [24] prove that there is positive effect on the motivation of pupils. The research show that students want to learn the subject using the VR (AR). All responses based on the wants of student to use AR is positive. However, there was some problems with Google Cardboard. The most excited point of using VR (AR) for children's is possibility to "travel to the different countries" without plane. The main disadvantages are eyes hurting, the problem of lack of moving freedom and it's uncomfortable according to the children's opinion [24].

According to "The Future" project supported by Ministry of education and science of Ukraine (doc. num. № 1/9–436, 09.08.2017) AR is divided to marker, no marker, projection and VIO [6]. Lack of the possibility to exchanging methodological material is one of the limiting factors for the implementation of the AR in education. Thus, it is relevant to develop a platform for the placement of techniques and methods, in particular, the AR. The advantage of the first solution is its flexibility as one can choose any relevant combinations of the simulation environments, yet, their integration level is usually insufficient. The closed character of the second solution and its binding to a certain software platform make it relevant to be applied to solving various practical tasks and irrelevant for neural network simulation training as a network becomes a black box for a user. The fourth solution is partially platform-dependent as a neural network becomes a grey box for a user. The final solution is totally mobile and offers an opportunity to regard the model as a white box, thus making it the most relevant for initial mastering of neural network simulation methods.

3 The Aim and Objectives of the Study

The aim of the article of is to describe the possibility of using of the most relevant AR instruments for education. They are Google Expedition and Google Lens.

To accomplish the set goal, the following tasks are to be solved:

1. Learn the advanced pedagogical experience of using the Google Expedition and Google Lens in the world;
2. Compare prospects of application of using the Google Expedition and Google Lens.

4 Pedagogical experience of using the Google Expedition and Google Lens

Let's consider more features of functioning of both tools. Google Expedition AR is Google main instrument based on AR which imposes virtual objects on the reality fixed by phone (table) camera. This way, Google Expedition AR is include marker and projection AR. It's already widely using in the educational systems of USA mainly in Elementary School [2, 4, 8, 24].

However, the potential of Google Expedition is not limited by using in the Elementary School. This technology can be used for visualizing of anatomy, astronomy and other environmental sciences. The example of using AR in education is present on Fig. 2.

Google Expeditions enables teachers to bring students on virtual trips to places like museums, underwater, and outer space. Expeditions are collections of linked virtual reality (VR) content and supporting materials that can be used alongside existing curriculum.

These trips are collections of virtual reality panoramas — 360° panoramas and 3D images — annotated with details, points of interest, and questions that make them easy to integrate into curriculum already used in schools.

Fig. 2. Example of using AR in education

Google is working with a number of partners, including: WNET, PBS, Houghton Mifflin Harcourt, the American Museum of Natural History, the Planetary Society, David Attenborough with production company Alchemy VR and many of the Google Arts & Culture museum partners to create custom educational content that spans the universe. With over 300 Expeditions currently available, the content touches on a wide range of subjects including historical landmarks, natural wonders, college campuses, careers and more [1].

Google Expeditions has already serviced over 2 million students [15]. Expanding into augmented reality will allow teachers to further engage their students by not only letting them view the subjects from every angle, but by letting them interact and share the experience with each other as they do. Allowing students to gather around an object or scene more closely mirrors an open classroom environment, having significant benefits of each student holding a Google Cardboard over their eyes. Manual of using

Google Expedition during lessons are actively developed by progressive teachers from the UK and the United States [22].

Using of Google Expedition may improve the size understanding of the natural phenomena. For example, the anatomy learning can be upgraded this case due to possibility of size understanding. Studying human anatomy with virtual reality gives students a better grasp of the relative size of the different organs and parts which is better to memorize it [4].

In the contrast of widely used and well-known Google Expeditions AR's applications, there exist Google Lens which is innovated of education. The technology was presented in 2017 on the Google I/O conference [7]. Lens recognizes the image and its show the relevant information about it. The approach is integrated to the Google Photo and Google Assistant. This instrument use Artificial Intelligence for the best work and it self-development. This way, Google Lens is concerns to the marker AR.

So, the main potential of the instrument is to learn the historical and cultural features under traveling. However, our opinion that there is much bigger potential to use it for the biological and other environmental researches.

The approach is simplify the research process. The example of Google Lens using in the biological research is present on the Fig. 3.

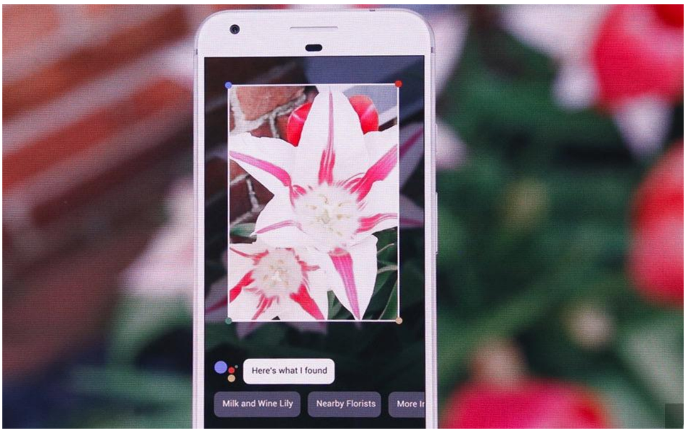


Fig. 3. The example of Google Lens using in the biological research

The instruments can be used on the classes and during self-educational process. The studying programs of Ukraine is recite including of the research works based on the research method. The research method consist of background, construction, research and analysis part. Detailed information of the research method is described in our previous works and sciencebuddies.org web-page. One of the limiting parts of providing the research work is actual research process. The problem of providing the research is lack of equipment. Both approaches described previously can simplifies the requirements for the research process due to possibility personal self-phone using.

Table 1. The main positive aspects of the represented methods

	Google Expedition	**Google Lens**
Motivation	Due to IT using, and it's interactivity	Provided by possibility to use personal phones any time to research
Interactivity	Provided by possibility of the Google Expedition to visualize natural phenomena	Interaction with any objects
Knowledge increasing	Due to the information visualization	Due to the possibility of research any object any time
Other advantages	Simplification of the linking between other people and interact with their surroundings, improving of the teamwork, introduction of facilitator's role, possibility to study of the low-spatial ability learners, size understanding, better memorizing, possibility to simulate the dangerous situations, providing STEM-education	

However, increasing of the student's motivation is one of the problem of the modern education. Nowadays there is digitization process which led to concentration of the children attention to the digital visualized information and that why there is the problem of the motivation of students. Both, Lens and Expedition can improve the motivation level of students due to its interactivity. However there is noted that the main advantage of augmented reality is simplification of the linking between other people and interact with their surroundings [14] and provide improving of the teamwork. The important AR advantage is that role of teacher is changed to the facilitator's role who helps the students explore and learn and its increase enjoy of the education due to the students control learning process [3, 5, 23]. The pupils are concentrated on the education process ignoring the distractions [9, 10].

Studding of the low-spatial ability learners is facilitates due the lack of the extraneous cognitive overloading [12]. The AR can simulate the dangerous situations to be ready for them [19].

However, the AR is important component of the STEM-education. The engineering aspect can be provided by possibility to test the prototype in the virtual environment before create it [20]. The science aspect can be achieved by the testing of the theories and hypotheses in the virtual environment [11]. The main positive aspects of the represented methods are presented in the Table 1.

Table 2. The analysis of implementation of Google Lens and Google Expedition AR

	Google Expedition	**Google Lens**
Abstract	AR instrument	Image analyzing system
Approaches in education	Physics, chemistry, biology, geography, history, architecture	Biology, history, architecture, mineralogy, geology, engineering
Pedagogical aspects	Lack of teachers awareness of this instruments, lack of the methodical achievements and there absence of Ministry of science and education recommendation about it	
Technical problems	There is no official Google office in Ukraine (or it's weak communication) and lack of equipment	High equipment cost of the Lens supported stuff, there some mistakes of under working
Other problems	There is necessary to be careful with AR-devices due possibility of damage the device during which might damage electronic components, problems GPS errors effect on the accurate of markerless AR programs	

Using of these AR approaches depends on the few factors. The potential analysis of implementation of Google Lens and Google Expedition AR is presented in the Table 2.

The AR-equipment can be devoted to chip and expensive. The simplest example of the simple AR-equipment is Google Cardboard with cost of

15$. However, there exist the Google daydream with 99$ of cost, Microsoft HoloLens with cost of 3000$ and google glasses with cost of 800$.Thus, the STEMUA platform allows teachers to develop methodological material and deposit it to the platform. Methodical materials are automatically systematized in the database of the platform, and the materials are foreseen mainly in Ukrainian, which meets the requirements of the Ministry of Education and Science. Consequently, the platform is able to meet the teachers' methodological needs regarding the use of AR in the classes.

5 Conclusions

1. Google Lens and Google Expedition can enhance students' motivation to learn and correspond to trends in STEM education.
2. The use of these tools is limited by a number of factors, such as the lack of knowledge of this system from teachers, the lack of guidance on the use of this system, the absence of prevailing the majority of the Ukrainian-language interface and the absence of stamp Ministry of Education and Science of Ukraine.
3. The indicated problems can be solved by involving methodical-pedagogical workers in the development of methodical provision of the instruments of the complemented reality.
4. We offer to provide classes with short-time using of the Google Expeditions and Google Lens due to its advantages kind simplification of the linking between other people and interact with their surroundings, improving of the teamwork, introduction of facilitator's role, possibility to study of the low-spatial ability learners, size understanding, better memorizing, possibility to simulate the dangerous situations, providing STEM-education.
5. Long time using can affect negatively due to the yes hurting, the problem of lack of moving freedom and it's uncomfortable.

References

1. About Google Expeditions. Aquila Education. https://www.aquilaeducation.com/google-expeditions-kits (2017). Accessed 31 Jan 2018.
2. Akçayır, M., Akçayır, G.: Advantages and challenges associated with augmented reality for education: A systematic review of the literature. Educational Research Review. 20, 1–11 (2016), doi: 10.1016/j.edurev.2016.11.002

3. Antonietti, A., Imperio, E., Rasi, C., Sacco, M.: Virtual reality and hypermedia in learning to use a turning lathe. Journal of Computer Assisted Learning. 17 (2), 142–155 (2001). doi: 10.1046/j.0266-4909.2001.00167.x
4. Boyles, B.: Virtual Reality and Augmented Reality in Education. United States Military Academy. https://www.usma.edu/cfe/Literature/Boyles_17.pdf (2017). Accessed 31 Dec 2017.
5. Dede, C.: Planning for Neomillennial Learning Styles. EDUCAUSE Quarterly. 28 (1), 7–12 (2005).
6. Dopovnena realnist, abo AR-tekhnolohii (Augmented Reality, or AR-technology). The Future. http://thefuture.news/lessons/ua/ar (2018). Accessed 31 Jan 2018.
7. Google Lens. Wikipedia. https://en.wikipedia.org/wiki/Google_Lens (2018). Accessed 13 Jan 2018.
8. Hazlewood, A.: Virtual Reality and Augmented Reality. A practical guide: Turning smartphones into exciting learning tools. http://www.soccon.net.nz/2017/wp-content/uploads/2016/11/Aleisha-Hazlewood.pdf (2016). Accessed 25 Dec 2017.
9. Hussein, M., Nätterdal, C.: The Benefits of Virtual Reality in Education: A Comparison Study. Bachelor of Science Thesis in Software Engineering and Management, University of Gothenburg. https://gupea.ub.gu.se/bitstream/2077/39977/1/gupea_2077_39977_1.pdf (2015). Accessed 25 Dec 2017.
10. Ibáñez, M. B., Di Serio, A., Villarán, D., Delgado Kloos, C.: Experimenting with electromagnetism using augmented reality: Impact on flow student experience and educational effectiveness. Computers & Education. 71, 1–13 (2014). doi: 10.1016/j.compedu.2013.09.004
11. Kinateder, M., Ronchi, E., Nilsson, D., Kobes, M., Müller, M., Pauli, P., Mülberger, A.: Virtual Reality for Fire Evacuation Research. In: Krasuski, A., Rein, G. (eds.) Federated Conference on Computer Science and Information Systems, vol. 2, pp. 313–321). IEEE — Institute of Electrical and Electronics Engineers Inc. (2014). doi: 10.15439/2014F94
12. Lee, E. A.-L., Wong, K. W.: Learning with desktop virtual reality: Low spatial ability learners are more positively affected. Computers & Education. 79, 49–58 (2014). doi: 10.1016/j.compedu.2014.07.010

13. Mala akademiia nauk Ukrainy: Virtualnyi STEM-tsentr Maloi akademii nauk Ukrainy (Virtual STEM-Center of the Junior Academy of Sciences of Ukraine). http://stemua.science (2018). Accessed 27 Jan 2018.

14. Martín-Gutiérrez, J., Fabiani, P., Benesova, W., Dolores Meneses, M., Mora, C. E.: Augmented reality to promote collaborative and autonomous learning in higher education. Computers in Human Behavior. 51 (B), 752–761 (2015). doi: 10.1016/j.chb.2014.11.093

15. Melnick, K.: Google Brings AR Into The Classroom With 'Expeditions AR' Program. VRScout. https://vrscout.com/news/google-expeditions-ar-program/ (2017). Accessed 13 Jan 2018.

16. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

17. Osvitnii proekt "Na Urok": Zhurnal "Na Urok" (The magazine "For the lesson"). https://naurok.com.ua (2018). Accessed 13 Jan 2018.

18. Pilgrim, J. M., Pilgrim, J.: The Use of Virtual Reality Tools in the Reading-Language Arts Classroom. Texas Journal of Literacy Education. 4 (2), 90–97 (2016).

19. Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., Jovanović, K.: Virtual laboratories for education in science, technology, and engineering: A review. Computers & Education. 95 (C), 309–327 (2016). doi: 10.1016/j.compedu.2016.02.002

20. Sala, N.: Applications of Virtual Reality Technologies in Architecture and in Engineering. International Journal of Space Technology Management and Innovation. 3 (2), 78–88 (2013). doi: 10.4018/ijstmi.2013070104

21. Shapovalov, V. B., Shapovalov, Ye. B., Atamas, A. I, Bilyk, Zh. I.: Informatsiini ontolohichni instrumenty dlia zabezpechennia doslidnytskoho pidkhodu v STEM-navchanni (Information ontological tools to provide a research approach in STEM-education). In: Proccedings of the 10th International Scientific and Practical Conference on Gifted children — the intellectual potential of the state, Chornomorsk, 3–10 July 2017, pp. 366–371 (2017).

22. Wylie, J.: Google Expeditions: Lesson Ideas & Support for Schools. Owlcation. https://owlcation.com/academia/Google-Expeditions-Help-Support-for-Schools (2016). Accessed 29 Dec 2017.
23. Youngblut, C.: Educational Uses of Virtual Reality Technology. Institute for Defense Analyses, Alexandria (1998).
24. Zantua, L. S. O.: Utilization of Virtual Reality Content in Grade 6 Social Studies Using Affordable Virtual Reality Technology. Asia Pacific Journal of Multidisciplinary Research. 5 (2), 1–10 (2017).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 102–114

УДК 004.9:37.091.39

Structuring Augmented Reality Information on the stemua.science

Viktor B. Shapovalov[1[0000−0001−6315−649X]],
Artem I. Atamas[1[0000−0002−8709−3208]],
Zhanna I. Bilyk[1[0000−0002−2092−5241]],
Yevhenii B. Shapovalov[1[0000−0003−3732−9486]] **and**
Aleksandr D. Uchitel[2[0000−0002−9969−0149]]
[1] National Center "Junior Academy of Sciences of Ukraine",
38/44, Dehtiarivska St., Kyiv, 04119, Ukraine
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine,
5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine
gws0731512025@gmail.com, o.d.uchitel@i.ua

Abstract. It is demonstrated that one of the conditions for successful scientific and pedagogical work is exchanging of methodical materials, including with using of augmented reality. We propose to classify approaches of placing methodical materials on closed, open and open-moderated types. One of the important benefits of a closed type is the high quality of the methodical material, but it's limited by amount of material and the lack of exchange opportunities that are problems, and there are no open-moderated resources in the Ukrainian language. The aim of this article is to analyze approaches of systematization of methodical material with using of augmented reality and recommend using of STEMUA for systematization of them. It is shown that STEMUA allows teachers to develop methodical material and place it on this platform. The platform automatically organizes methodical material in the database. Consequently, the platform is satisfying the methodical needs of Ukrainian teachers for material with using of complementary reality in the teaching. It is recommended for teachers and methodists to provide development and methodical materials with using of augmented reality and add them to the platform database.

Keywords: augmented reality, systematization, methodical materials, STEM-approach of education, steamua.science.

1 Introduction

The development of educational and methodical technologies leads to the problem of systematization of methodical information. One of the modern and relevant type of information is augmented reality's (AR) developments [5]. Thus, that is necessary to develop instrument to popularize it and manage deposited information. Necessary is justified by grooving of interest to them due its interactivity which is important to understanding of materials [6].

AR is one of the important component of STEM-approach in classes. Important for the providing STEM-approach is based on the research and engineering methods.

The scientific method includes ways to study phenomena, systematization, adjustments of new and previously acquired knowledge. The findings are made using the rules and principles of reasoning based on empirical (observed and measurable) data about the object. It's possible to research the reality using the Artificial Intelligence in the AR which can analyze the information and give some answers about object of the research to the user. Other hand, the AR can visualize the details or processes which is important to engineering method.

Scientific and engineering methods are the basis of any STEM-approach in education independently of the field of cognition. Both methods have been worked out for a considerable time and are now recognized by the international scientific community as the main means for carrying out scientific and research activities [1].

2 Literature Review and Problem Statement

However, today there is a problem of promoting and expanding the scope of the research approach. One of the reasons is the lack of information support systems for research. In other words, there is a problem with the information provision of the ways of conducting research work related to the school program and the methods that will be used to perform these works. There is a very few already worked systems based on the support such activities.

In the general approaches of deposition of methodical developments can be divided into few types: closed, open and open with moderation. Closed type of information deposit involves placing materials on online resources for only a specific group of people. At the same time, the open's provides free placement of materials without additional control. Both approaches have their advantages and disadvantages. An analysis of the advantages and disadvantages of opened, opened with moderation and closed type of placement of methodical information is presented in Table 1.

There are a lot of the systems of the open type. However, we will not pay attention on them due to lack of the control of the quality.

An example of such a system is the site http://www.sciencebuddies.org/ (Fig. 1). However, main flow of the system is English interface which can't be used in the Ukrainian teaching. Website is designed for the student research work selection [6]. The detailed analysis of its interface and features of its operation was described in our previous works [1, 2, 7]. However, the site cannot provide the systematization of the AR materials due to the absence of separation of it. The general view of the sciencebuddies.org resource is presented on the Fig. 1.

Table 1. An analysis of the advantages and disadvantages of opened, opened with moderation and closed type of placement of methodical information

	Open	**Open with moderation**	**Closed**
Examples	An open group in social networks	Website sciencebuddies.org	Most sites ("The Future", closed group in social networks)
Main advantage	A lot of the materials	A lot of quality materials	Quality control the material
Main disadvantage	Lack of quality control of the material	Necessity of moderation	Limited amount of material

Despite the shortcomings of the closed type, it is worth pointing out that there is a platform "The Future" based on closed type of systems [3]. Main advantage of the system is Ukrainian interface and Ministry of Education and Science of Ukraine recommendation. However, "The Future" have limited amount of information and can't provide the possibility to design methodical materials of whole-Ukraine's teachers due to its closed type.

There is already known the method and tool for automatic systematization of the dynamic scientific and educational resources of the global electronic information space [number of state registration of the scientific topic 0115U000324 of Ukraine], which involves the selection of input data of information sections and the implementation of structuring the set of documents for each section separately, and for them together with Using Data Mining, Text Mining, Web Mining, and Knowledge Discovery in Databases. But it's cannot be used to organize knowledge in the educational space due to interface problems based on the old-functional instruments. However, the platform's disadvantages and the lack of support for the integration of the educational resources of the participants in the educational process.

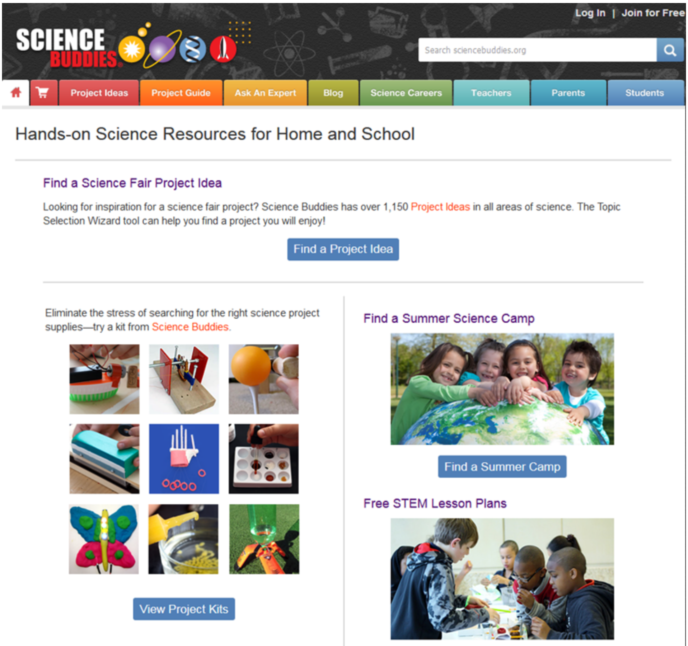


Fig. 1. The general view of the sciencebuddies.org resource

Lack of the possibility to exchanging methodical material is one of the limiting factors for the implementation of the AR in education. Thus, it is relevant to develop a platform for the placement of techniques and methods, in particular, the AR. The advantage of the first solution is its flexibility as one can choose any relevant combinations of the simulation environments, yet, their integration level is usually insufficient. The closed character of the second solution and its binding to a certain software platform make it relevant to be applied to solving various practical tasks and irrelevant for neural network simulation training as a network becomes a black box for a user. The fourth solution is partially platform-dependent as a neural network becomes a grey box for a user. The final solution is totally mobile and offers an opportunity to regard the model as a white box, thus making it the most relevant for initial mastering of neural network simulation methods.

3 The Aim and Objectives of the Study

Thus, there is the problem of storage of the methodical materials based on the AR and that is relevant to create that system which based on the open with moderation type of systems with Ukrainian interface. We propose to use the stemua.science system (further — STEMUA) to provide informational management of the AR materials [4]. Our task was to invention the method of a functional for the dissemination and exchange of educational resources, provide a user-friendly interface for the introduction of information and visualization of it in the web interface and to ensure the systematization of the information received. This approach will allow the widespread dissemination of the virtual educational environment and, respectively, improved indexing of information. The object of study was systematization of the AR materials.

4 Development and operations of the STEMUA platform

The task was solved by creation of a new script for the template for the wordpress's the platform and for access to the editorial board of information on the wide range of educators. The participants of the creation of educational material are classified into administrators and users. Users can add their own materials and adjust them, and administrators of the information environment control the quality STEMUA content. Such an approach allows us to engage the general public in creating of educational materials.

STEMUA is the educational platform designed to provide methodical support of any activities based on the STEM-approach of education. The platform based on the TODOS instruments [8, 9]. Main page of STEMUA is present on the Fig. 2.

The site was designed to use it as a multi-agent in the ontology.inhost.com.ua system. The feature of the site is the writing of information in the form intended for reading ontology.inhost.com.ua system.

The site consists of 3 main parts:

1. Methodical cabinet;
2. Research work;
3. Methodology.

Methodical cabinet contains the theoretical foundations of STEM-education. The articles presented in this section are prepared by specialists in the field of STEM-education, in particular, employees of the NAES of Ukraine (e.g., Institute of Gifted Child).

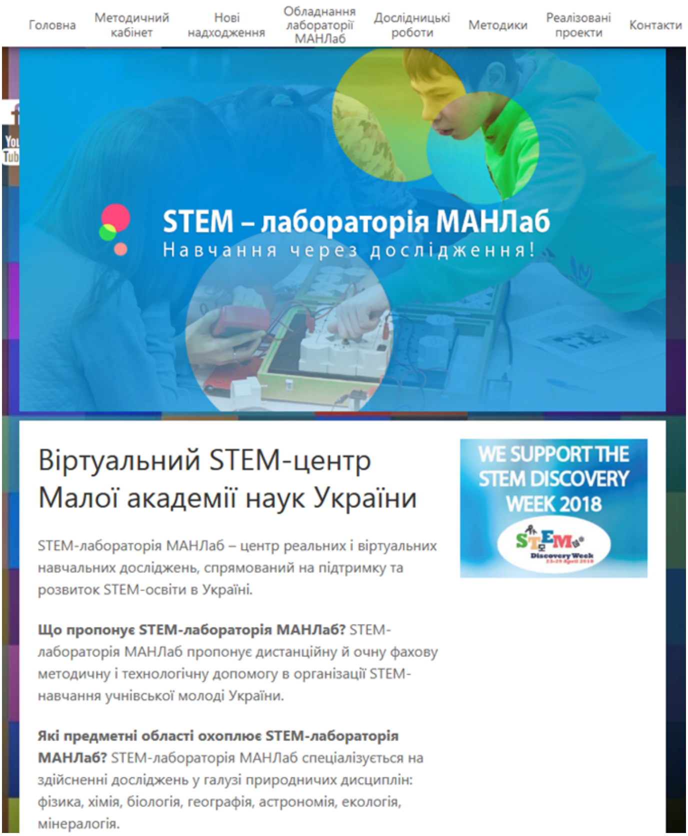


Fig. 2. Main page of STEMUA

The structure of STEMUA is consist of includes the following components:

1. Classifier of scientific instruments of technology TODOS;
2. Methodical part;
3. Catalog of research methods;
4. Catalog of techniques;
5. A tool for creating new teaching materials.

Classifier of scientific instruments based on the TODOS technology is devoted to searching and separation of the science equipment and methodical materials. Classifier of scientific instruments of technology TODOS is present in Fig. 3.

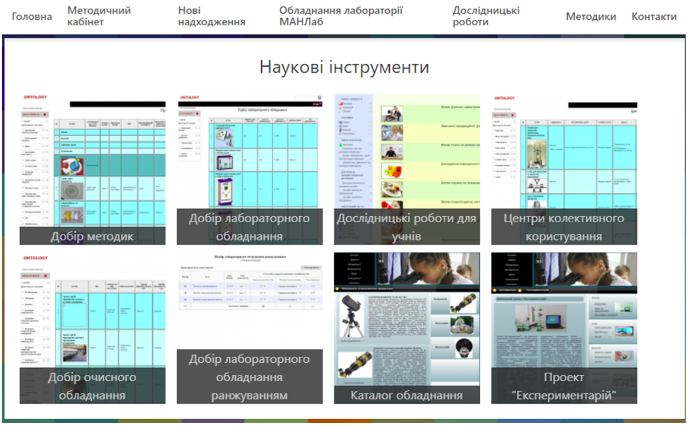


Fig. 3. Classifier of scientific instruments of technology TODOS

Methodical part is designed for information acquaintance with methodical aspects of STEM-approach in education, main concepts of education material creation using the platform and modern educational trends. The Fig. 4 is present general form of the methodical part.

The directory of research papers is a dynamically generated list of materials published on the site. Each user can add here his own research methods to share it with society. The general form of catalog of research papers is shown in the Fig. 5.

There is the mechanism of work's separation designed on the site. Both, research methods and techniques, are contain separation parameters of the educational developments. To input this parameters, there is developed the special input fields and they are:

- The author's photo and name;
- Title of the material;
- Resume material;
- A group of tags that represent the characteristics of the material;
- Material itself.

However, there will be located AR filter to faster separation the AR's developments. The catalog of techniques, also, is a dynamic list of materials with mechanisms for filtration of objects (Fig. 6).

Fig. 4. General form of the methodical part

The new material creation is provided by function "Add research work" and "Add technique" located on the user's panel. There is necessary to be registered using the Facebook, Google+ or user can create new profile to use these functions. The user's panel will be displayed after successful registration (Fig. 7).

Consider the algorithm of creating content on an example of creating a research work. The constructor of research work of technique is opens by picking the relative function on the site (Fig. 8).

The constructor contains 6 input fields and 5 fields for selecting the characteristics of the material.

The material input fields are designed simplest way to duplicate well-known Microsoft Word text editor tools. This approach is provide simple formatting of the text and even in the case of text copying from MS Word document it will be automatic formatted.

Firstly, the author of the material should to input main text of the work which consist of following parts:

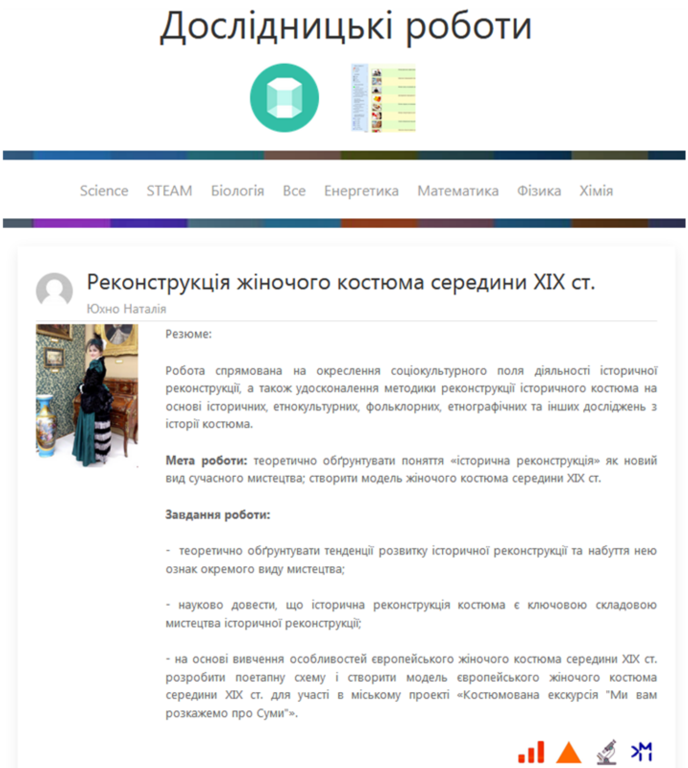


Fig. 5. The general form of catalog of research papers

- Resume;
- Preliminary information;
- Equipment;
- Experimental procedure;
- Analysis of the data;
- Areas of development (not required field).

There is necessary to input classificatory information based on the following parameters:

- Direction;
- Complexity;
- Safety;

Fig. 6. View the catalog of techniques

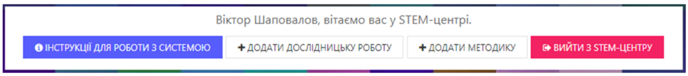


Fig. 7. View the user's panel

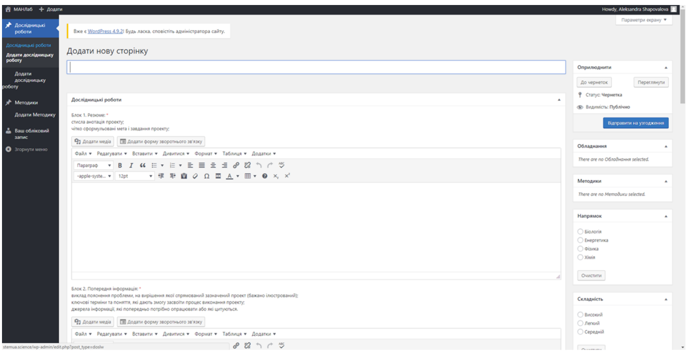


Fig. 8. The work's creating panel

- Availability of used materials;
- Work's duration.

Additionally, it may be possible to add the parameter method with the use of AR, which will allow to sort and select methodical augmented reality materials.

One of the visualized type of the systematization type is ontology integrated to the STEMUA platform. The Ukrainian platform for ontology, developed at National Center "Junior Academy of Sciences of Ukraine", is able to perform the necessary functions and possesses a ranking tool (Fig. 9).

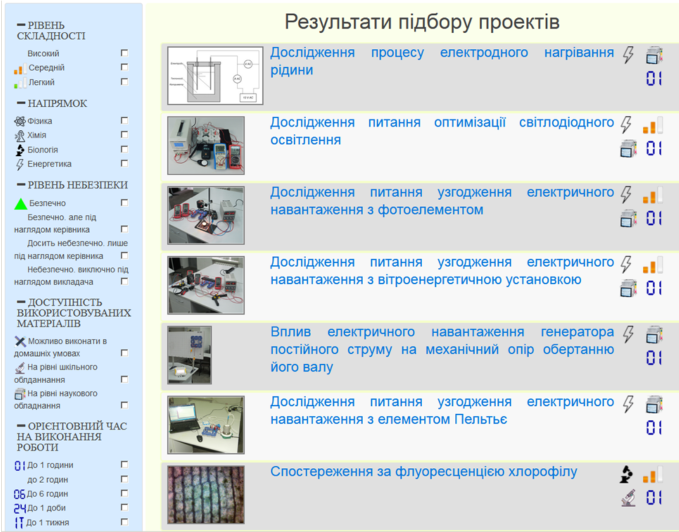


Fig. 9. Ranging platform for research work

Created the template for the WordPress site construction platform and the provision of access to editing and creating information for a wide range of participants in the educational process allows us to provide an easy-to-use interface for information entry and visualization in the web interface and to ensure the systematization of the information received.

Thus, the STEMUA platform allows teachers to develop methodical material and deposit it to the platform. Methodical materials are automatically systematized in the database of the platform, and the materials are foreseen mainly in Ukrainian, which meets the requirements of the Ministry of Education and Science. Consequently, the platform is able to meet the teachers' methodical needs regarding the use of AR in the classes.

5 Conclusions

The level of using of the AR-based methods is depends on the possibility to deposit and separate the information. There is no any instrument to separate and manage the educational AR-oriented content. We propose to use the STEMUA system to provide informational management of the AR-based materials. The task of separate and manage the educational AR-oriented content was solved by creation of a new script for the template for the WordPress platform and for access to the editorial board of information on the wide range of educators. The participants of the creation of educational material are classified into administrators and users. Users can add their own materials and adjust them, and administrators of the information environment control the quality STEMUA content. Such an approach allows us to engage the general public in creating of educational materials. The proposed method provide easy separation of AR-material from the whole array and gives the possibility to input that information to the educational environment.

References

1. Chernetskyi, I. S., Atamas, A. I., Shapovalov, Ye. B., Shapovalov, V. B.: Vykorystannia ontolohii pidboru pry provedenni naukovykh robit (Using of selection ontologies for scientific work). Naukovi zapysky Maloi akademii nauk Ukrainy, Seriia: Pedahohichni nauky. 7, 28–36 (2016).

2. Chernetskyi, I. S., Pashchenko, Ye. Yu., Atamas, A. I., Shapovalov, Ye. B.: Vykorystannia informatsiinykh instrumentiv dlia strukturyzatsii ta vizualizatsii naukovykh znan pry provedenni poperednoho doslidzhennia (The use of information tools for structuring and visualizing scientific knowledge). Naukovi zapysky Maloi akademii nauk Ukrainy, Seriia: Pedahohichni nauky. 7, 20–28 (2016).

3. Dopovnena realnist, abo AR-tekhnolohii (Augmented Reality, or AR-technology). The Future. http://thefuture.news/lessons/ua/ar (2018). Accessed 31 Jan 2018.

4. Mala akademiia nauk Ukrainy: Virtualnyi STEM-tsentr Maloi akademii nauk Ukrainy (Virtual STEM-Center of the Junior Academy of Sciences of Ukraine). http://stemua.science (2018). Accessed 27 Jan 2018.

5. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

6. Mosunova, O. G., Rybinskaia, E. A.: Vliianie sredstv vizualizatcii na effektivnost obrazovatelnogo protcessa (Effect of vizualization on the effectiveness of training). In: Proceedings of the 7th International Scientific and Practical Conference on New information technologies in education, Rossiiskii gosudarstvennyi professionalno-pedagogicheskii universitet, Ekaterinburg, 11–14 March 2014, pp. 178–182 (2014).
7. Shapovalov, V. B., Shapovalov, Ye. B., Atamas, A. I., Bilyk, Zh. I.: Informatsiini ontolohichni instrumenty dlia zabezpechennia doslidnytskoho pidkhodu v STEM-navchanni (Information ontological tools to provide a research approach in STEM-education). In: Proccedings of the 10th International Scientific and Practical Conference on Gifted children — the intellectual potential of the state, Chornomorsk, 3–10 July 2017, pp. 366–371 (2017).
8. Strizhak, A. E., Trofimchuk, A. N., Tcurika, L. Iu.: Transdistciplinarnye ontologii — informatcionnaia platforma provedeniia ekologicheskikh ekspertiz (Transdisciplinary Ontologies — Information Platform for Organizing Environmental Expertise). Ekolohichna bezpeka ta pryrodokorystuvannia. 16, 128–137 (2014).
9. Stryzhak, O. Ie.: Znannia-oriientovni instrumenty pidtrymky diialnosti eksperta (Knowledge-oriented tools for supporting the expert activities). Ekolohichna bezpeka ta pryrodokorystuvannia. 13, 114–134 (2013).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 115–122

УДК [378.147:004.9]–054.6(477)

Prospects of Using the Augmented Reality for Training Foreign Students at the Preparatory Departments of Universities in Ukraine

Natalya O. Zinonos[1[0000−0003−2159−1295]],
Elena V. Vihrova[2[0000−0003−3046−0801]] **and**
Andrey V. Pikilnyak[1[0000−0003−0898−4756]]
[1] State Institution of Higher Education "Kryvyi Rih National University"
11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
zinonos@i.ua, pikilnyak@gmail.com
[2] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave.,
Kryvyi Rih, 50086, Ukraine
elvihrova65@gmail.com

Abstract. *The purpose of the study* is to highlight the potential and the prospects of using the augmented reality in the mathematical education for foreign students at the preparatory departments of universities. *Objectives of the study*: to determine the peculiarities of the virtualization of the training of foreign students at the preparatory departments of universities, as well as the possibilities of using the technology of complementary reality in the teaching of mathematics. *Object of research*: a virtually oriented educational environment of foreign students at the preparatory departments of universities. *Subject of research*: virtualization of learning with the augmented reality of mathematical education of foreign students at the preparatory departments of universities. *Used research methods*: theoretical — analysis of scientific and methodological literature; empirical-study, observation of the educational process. *Results of the research*: on the basis of the analysis of scientific publications, the notion of virtualization of education and the virtually oriented educational environment of foreign students at the preparatory departments of higher educational institutions is described. The main *conclusions* and *recommendations*: 1) the article outlines the possibilities and prospects of using the augmented reality in the mathematical education for foreign students at the preparatory departments of universities; 2) the considering the various targets of mobile applications, which are used in solving mathematical problems, as well as analysis of the characteristics of various practical achievements of using the augmented reality in the mathematical preparation for foreign students at the preparatory departments of universities, it is planned to devote a separate work.

Keywords: foreign students, augmented reality, a virtually oriented learning environment, mathematics training.

1 Problem statement

The training of foreign students at the preparatory departments of national universities is preceded by a diligent, purposeful work of both students and future teachers, aimed at successful adaptation of students to the new environment of the country's future education [11]. Studying abroad is like turning over a new leaf in an unknown world. However, conditions of entry vary significantly between individual countries and universities. It is entirely natural that a young person who is planning to graduate in another country will try to learn as much as possible about the conditions of residence and education in that country. The following forms and methods are used in preparing for study visit:

- communication with those who have been in the country for some time or with a tourist trip, or have been trained before;
- viewing of printed sources, cinema, video materials, which give an idea of the country of the future education;
- remote communication through forums and social networks with residents of this country and selected institution of future education;
- acquaintance with the Internet-representations of a higher education institution in which the person is planning to study;
- initial mastery of the language and backgrounds of the culture of the country of future education.

Studying at the preparatory departments for foreign students of the national universities, especially at the initial stage, have a number of characteristics, among which:

- immersion in a neutral or unfriendly language and social environment;
- fundamental differences in the organization of the learning process in their native country and Ukraine;
- problems when transferring previous experience of educational activity into a new educational environment;
- significant differences in the partial teaching methods.

2 Discussion and results

All of this influences on quality of teaching foreign students at the preparatory departments of national universities and needs to find ways to increase the level of preliminary students' preparedness to study in a new environment. The use of modern information technology opens up new opportunities for raising this level. To the means aimed at increasing the level of preliminary preparedness of foreign students to study, which should provide a higher education institution can be attributed:

- two (many) language of the Internet representation (site) of the university;
- the saturation of short and medium length of the video, such as “virtual tour” (level — institution of higher education, teacher, audience, dean’s office) in the languages of potential entrants (in Ukrainian with customized subtitles);
- distance support organization of future applicants in the study of the basics of the Ukrainian language with the students-volunteer of the Faculty of Foreign Languages, International Department et al.;
- availability of bilingual courses in educational discipline (mathematics, physics, etc.) on the site of the university (e.g., Moodle);
- development of simulators (linguistic, social-behavioral, educational).

Consequently, there is a need to supplement the educational environment of the institution of higher education with the means of information and communication technologies that extend it to a virtually oriented environment. Virtual excursions and virtual learning environment, multilingual reproduction of multimedia materials can be attributed to the means that it is expedient to use at the stage of preparation for coming to the country of future education of foreign students. These tools provide an opportunity to build a more adequate model of higher education in the country’s future student education, which will help reduce the initial disadaptation level. The technology of the translation of oral speech (audio), or the reproduction of translated text; audio guides by geographical coordinates, or certain marks (orientation in the city, institution of higher education, treatment of notation, etc.) are means that will facilitate oral communication. Tools that help bridge the differences in the organization of the learning process — is the development and use of bilingual textbooks for establishing the relationship between the content of the concept and its interpretation in different languages; situational means of visibility used in a particular context (place, time, subject of class, etc.); dynamic computer models complementing traditional teaching materials.

For hundreds of years, young people have come abroad to learn new things and find direction in life. But now, with the help of technology, the way knowledge passes from teachers to their students is changing. Virtual environments are computer-simulated environments representing real or imaginary worlds. It is important to understand how valuable knowledge can be acquired within virtual environments, and how it can be transferred to real-world situations. We describe the possibility of using augmented reality in mathematics training of foreign students. It should be noted that information technologies enable the development of innovative tools for teaching mathematics both in the audience and beyond [9]. In recent years, we have seen a significant increase in the use of mobile devices as tools in education [2, 7]. It is better to analyze the application of these modern gadgets in reference to the usual pedagogical terms: educational process, learning content, forms and technologies.

The process of training is a purposeful, consistently organized interaction between the teacher and students, mediated by the content of activities, during which the tasks of education, education and general development of students are solved. If to improve the content of the educational material the most important tasks is its systematization, updating and problematization, for the development of forms — activation of training, for the method — individualization and automation, then for the improvement of pedagogical means the most important today is recognized visualization.

Based on the research by Iryna V. Salnyk, we will define a virtually oriented learning environment as an environment in which information and communication technologies are combined with traditional teaching technologies, complementing and expanding them [6]. Virtual environment tools (the most popular is Moodle [5]) are implemented parallel with traditional lectures and workshops. According to the work of Valerii Yu. Bykov into the structure of a virtually-oriented learning environment included: subjects of training, content of training, means of training and communication tools [1]. The virtuality of a virtually-oriented learning environment is achieved with:

1. the possibility of realization of educational activity of subjects of studying by lecturers and non-auditors, directly and indirectly by means of training;
2. the ability to present the content of learning in different modalities, using channels of educational communication;
3. the use of teaching aids aimed at the implementation of the content of training and support of widespread educational communication;
4. the use of communication tools aimed at supplementing non-auditing educational activities to the level of the auditorium.

The ways of supplementing the traditional learning environment with ICT tools are:

1. inclusion in the educational process of fragments of activities that require ICT tools (work with computer models, computer learning environments, communication facilities, etc.);

2. involvement in the classroom process of persons who cannot be present in the audience personally (persons with special needs, teachers with a low level of geographical mobility, etc.);
3. the use of ICT tools, complementary to traditional teaching tools (means of complemented reality).

If in the complement of the traditional learning environment the first direction is the leading means of ICT, then this environment is called a computer-based learning environment (according to Myroslav I. Zhaldak [10]), if the second one is a mobile-oriented learning environment (according to Mariia A. Kyslova) [3], if the third one is a virtually oriented educational the medium of complemented reality.

Effective functioning of the virtual environment at the preparatory department for foreign citizens of universities is provided through the activities of the teacher and students who create mutual relationships with each other and with other elements, coexist with the traditional learning environment, expands its capabilities and creates conditions for the implementation of new technologies, forms and methods of teaching mathematics.

The technology of augmented reality is becoming increasingly popular every day and is increasingly used in various fields. The term Augmented reality was coined as an expression in 1990 by Thomas Caudell [4] at Boeing, but the idea goes back much further than that. Today, technologies of the augmented reality allow through the camera of a mobile device to read from the surrounding objects additional information — to watch videos, three-dimensional objects, etc. Increasing processes of the creation and implementation of new technologies stimulate constant change of the education system. Now it is not necessary to carry books with you, it is enough to download special programs in the smartphone and it can be readily available in an easy and accessible form. In order to successfully use the technologies of the augmented reality technology, it is necessary to prepare foreign students alike — to accustom them to the use of the service, to capture the interesting possibilities. By combining books or print documents using augmented reality technology, teachers can give foreign students access to digital content and deepen their learning in 3D space. In addition, teachers can teach foreign students individually and train distantly.

The peculiarity of teaching foreign citizens at the preparatory department for universities is that, in a rather short period of time, students must learn not only a sufficient amount of theoretical knowledge and practical skills in mathematics [8], but also create their own lexical base in a non-native language of instruction. Therefore, it is advisable to use both English and non-English mobile applications in order for foreign students to have a mathematical apparatus in the language of training. For example, use the Math 42 application. This is an indispensable mathematical program, both for the student. In real time, this application not only solves the equation that is introduced into it, but also distributes the progress of the decision, clearly explaining the solution to the example. In addition, Math 42 offers several solutions at once, helping to choose the most optimal and understandable option for the student. Also, the program has a training section, where the student can learn the material that has been studied before.

The Math 42 application can help you cope with the following mathematical operations: simplification; multiplication, reduction and addition (including fractions); division of polynomials; solving linear and square equations etc. The graphics of the program are quite nice, and a simple interface makes the program easy to use.

3 Conclusion

By using students' and teachers' feedback, and the comparison with a traditional class, we hope using augmented reality will help foreign students to solve their problems in mathematical preparation. During the educational process along with the mastery of systemic basic knowledge and key competencies form the need for mastering mathematical vocabulary as a means of communication, knowledge, self-realization and didactic adaptation of foreign students. Finally, the prospects of using augmented reality technologies for communicative-oriented learning of foreign students are in its multi-purpose and multifunctional orientation, as well as its integration into a holistic educational process.

References

1. Bykov, V., Shyshkina, M.: Emerging technologies for personnel training for IT industry in Ukraine. In: Proceedings of ICL2014 — 2014 International Conference on Interactive Collaborative Learning, Dubai, 03–06 December 2014, pp. 945–949. IEEE, Red Hook (2014). doi: 10.1109/ICL.2014.7017903
2. Horshkova, H. A., Vikhrova, O. V.: Zastosuvannia resursu «Plickers» dlia otrymannia zvorotnoho zviazku na lektsiiakh z vyshchoi

matematyky (Application of the resource “Plickers” for feedback on lectures on higher mathematics). New computer technology. 14, 110–111 (2016).

3. Kyslova, M. A., Semerikov, S. O., Slovak, K. I.: Rozvytok mobilnoho navchalnoho seredovyshcha yak problema teorii i metodyky vykorystannia informatsiino-komunikatsiinykh tekhnolohii v osviti (Development of mobile learning environment as a problem of the theory and methods of use of information and communication technologies in education). Information Technologies and Learning Tools. 42 (4), 1–19 (2014).

4. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

5. Nechypurenko, P. P., Semerikov, S. O.: VlabEmbed — the New Plugin Moodle for the Chemistry Education. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR-WS.org), vol. 1844, pp. 319–326 (2017).

6. Salnyk, I. V.: Psykholoho-pedahohichni osnovy virtualizatsii protsesu navchannia fizyky v starshii shkoli (Psychological and pedagogical bases of the virtualization teaching physics in senior school). Pedagogical process: theory and practice. 1, 92–99 (2014).

7. Semerikov, S. O., Striuk, M. I., Moiseienko, N. V.: Mobilne navchannia: istoryko-tekhnolohichnyi vymir (Mobile learning: historical and technological dimension). In: Konoval, O. A. (ed.) Teoriia i praktyka orhanizatsii samostiinoi roboty studentiv vyshchykh navchalnykh zakladiv (Theory and practice of organization of independent work of students of higher educational institutions), pp. 188–242. Knyzhkove vydavnytstvo Kyreievskoho, Kryvyi Rih (2012).

8. Vihrova, O., Zinonos, N.: Otsiniuvannia adaptyvnykh staniv studentiv-inozemtsiv na pochatku vyvchennia pryrodnycho-matematychnykh dystsyplin (The evaluation of foreign students' adaptation at the beginning of learning science and mathematics). Visnyk Cherkaskoho universytetu: Pedahohichni nauky. 7, 51–56 (2016).
9. Vikhrova, O. V., Zynonos, N. O.: Metodychni osoblyvosti navchannia matematyky inshomovnykh studentiv na pidhotovchykh fakultetakh vitchyznianykh vuziv (Methodical specifics of teaching mathematics to foreign students at the preparation departments of Ukrainian universities). Aktualni pytannia pryrodnycho-matematychnoi osvity. 1, 5–8 (2013).
10. Zhaldak, M. I.: Pedahohichnyi potentsial kompiuterno-oriientovanykh system navchannia matematyky (Pedagogical potential of computer-oriented systems of teaching mathematics). Kompiuterno-oriientovani systemy navchannia. 7, 3–16 (2003).
11. Zinonos, N. O.: Vykorystannia modeli adaptatsii studentiv dlia navchannia inozemnykh studentiv u VNZ Ukrainy (Using of the students' adaptation model for teaching foreign students). New computer technology. 15, 42–46 (2017).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 123–135

УДК 378.147:004.9]:37.011.3–051

Conceptual Bases of Use of Free Software in the Professional Training of Pre-Service Teacher of Mathematics, Physics and Computer Science

Vladyslav Ye. Velychko[1[0000−0001−9752−0907]], **Elena H. Fedorenko**[1[0000−0002−1897−874X]] **and Darja A. Kassim**[2]
[1] Donbas State Pedagogical University, 19, General Batiouk St., Sloviansk, 84116, Ukraine
{vladislav.velichko, fedorenko.elena1209}@gmail.com
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine,
5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine

Abstract. The development of education is associated primarily with the use of ICT. A significant experience is already gained in how to use educational computer systems while new forms and methods of learning based on modern information technology are being developed and used. In relation to free software, a period when the quantity should translate into quality and an indicator of such translation is development of the concept of the introduction of free software in educational activities of universities. The proposed concept, let's take Ukraine as an example, determines the main aim of introduction of free software in the training of pre-service of Mathematics, Physics and Computer Science; defines the objectives, measures, principles, the role and value of free software in the informatization process and results of its implementation.

Keywords: free software, teacher training, the concept of implementation.

1 Introduction

At all stages of development and functioning of the education process its formation was carried out using certain methods, techniques and tools. The peculiarity of the current stage of development of education is that in the arsenal of techniques and tools used in the preparation of pre-service specialists are both traditional (printed) and digital (electronic) materials. Ensuring open around the clock, access of students to electronic education today is one of the priorities of information science, education and culture of Ukraine. In this regard, the role and functions of teachers are significantly changing. It should be noted that a special role in this process is played by information and communication technologies as part of information-educational environment and include digital libraries, electronic educational resources, search engines and aggregation of information, which are based on the use of free software.

2 Results and Discussion

The content of the educational process in higher educational pedagogical institutions is determined by effective programs used to train pre-service specialists in that particular university. The content of the educational training of a university is being approved by the Council of the pedagogical university, while the choice of content, methods, means and methods of work is determined by the individual departments and teachers with consideration of specifics of each educational direction. Software products which are used and guidelines developed by university teachers taking into account specifics of preparation of pre-service teachers create the basic component of fundamental training. In the modern paradigm of education it is necessary to develop educational standards which provide content of training upgrade as well as education of the younger generation on the principles of humanization, differentiation and integration.

The main *objective* of introducing of free software in the training of pre-service teacher of Mathematics, Physics and Computer Science lays in the formation of a new citizen of the information society, who feels comfortable in society, freely operates with information through new information technologies, respect the opinion of others and has his own opinion and knows how to deliver it, is capable of self-education, self-analysis and has a motivation to obtain new knowledge and to self-improvement, while also understands the importance and inevitability of information education and society at large, giving preference to the latest information and educational technologies. In this case it refers to the use of free software for the transition to a new type of training of pre-service of Mathematics, Physics and Computer Science, which includes:

- creating optimal conditions for the acquirement of general and professional knowledge and skills and updating intellectual potential of pre-service teachers of Mathematics, Physics and Computer Science;
- promoting comprehensive and harmonious development of pre-service teacher of Mathematics, Physics and Computer Science as subjects of education process and information society;
- creating suitable conditions for the emotional and intellectual enrichment of pre-service teacher of Mathematics, Physics and

Computer Science as the basis of development and strengthening of political, social, economic, humanitarian, cultural and informational aspects of public life in the interest of the welfare of citizens, economic efficiency and country's growth.

Strategy *aims* related to the use of free software in preparation of pre-service teacher of Mathematics, Physics and Computer Science need to be determined in accordance with the benefits that its implementation provides to the educational process, which, in our opinion, are:

- free access to software and its source code;
- safety, reliability and stability of the software;
- overcoming of the digital divide;
- open standards independent from the developer;
- compliance with intellectual property rights, fight against piracy;
- ability to fully adapt to suit individual needs;
- unlimited number of simultaneous installations on multiple computers in educational institutions and at home;
- the possibility of obtaining derivative software based on the original software platform and possibility to use it for private projects;
- possibility of software localization.

To achieve these objectives it is necessary to provide the following basic *measures*:

- analysis of didactic capabilities of free software through the procedure of examination and creating repositories of the recommended software provider;
- creating methodological, psychological and technological support for the use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science;
- analysis of readiness of subjects of the educational process for the use of free software;
- changing priorities as to the use of ICT in professional fields from studying certain software to studying technologies used to process information which in turn results in fundamentalization of the training of pre-service teacher of Mathematics, Physics and Computer Science (see [6]).

Introduction of free software in the process of professional training of pre-service of Mathematics, Physics and Informatics is not an aim in itself — it is first of all a way of enhancing performance based on changing priorities of study and use of ICT in education [3]. Currently, there is no single approach to the introduction of free software in the educational process; however, a considerable attention should be paid to implementing the following key principles:

Reform of educational processes. The main prerequisite for the successful implementation of free software is the understanding that it does not just mean analysis of the possibility of its use and the creation of guidelines to this process. First of all, it is about creating a new vision and new priorities in the use of ICT. The widespread of self-education must be supported and encouraged by modern information technologies. To use them it is necessary to have free access to the software, which access in turn is possible through the use of free software. Thus, on the one hand free software is an effective platform for modern paradigm of education, on the other — an example of open science, which is the basis for on open learning.

Motivation. The introduction of free software requires motivation to change the principles of the study and use of ICT in education. To include the free software in the list of software which is used in the preparation of pre-service teacher of Mathematics, Physics and Computer Science both internal and external motivations are required, which are based on the need for proper training of future professionals in information technology and internal vision of modern state of the information technology industry. Motivation will provide the initiatives to introduce free software, adapting them to today's challenges of education in preparing pre-service teacher of Mathematics, Physics and Computer Science.

Strategic Initiatives. Taking into account the realities of austerity and financial resources as well as current needs of training of pre-service teachers of Mathematics, Physics and Computer Science, it is necessary to highlight the main priority funding projects which would be based on "protected" principle. Such projects should be characterized by a clear educational value, measured according to specific criteria.

Cooperation. It is necessary to introduce new forms of relationships between subjects of education process as well as cooperation within community of developers and users of free software. Firstly, university teachers must overcome the unwillingness of joint work with pre-service teacher of Mathematics, Physics and Computer Science towards the creation and use of electronic educational resources based on open standards and free software. On the other hand, cooperation in the use and development of free software can help the subjects of the educational process to successfully reform and speed up the implementation of free software.

The principle of open systems. Creation of information and educational environment which includes software and hardware, communication mechanisms, interfaces, data formats and protocols which are based on available and generally recognized standards ensuring cross-platform, collaboration and scale of applications and data. The software should be highly accessible to scientists as to educators. Information resources if possible should be maximally open and free to use.

The rule of law, legality, equality of all before the law. The rule of law is basically the position according to which people do not obey one another, but everyone obeys the rules which define among other things the form of direct relations with each other — through statuses or contracts. This rule of law applies to the degree of freedom of the free software called "copyleft" and to license agreements used in distribution of free software.

The freedom of intellectual and creative activity. Creativity is inherent to man in any field be it production, social communication, scientific activities and more. While performing its activities, society increasingly relies on achievement of intellectual work. In countries with high respect for science, culture and art — living standards are higher because achievements of intellectual activity dictate standard of production, culture and education, etc. Today, society must realize that the state should be interested in the development of science and education and, therefore, should support them. Such support may include direct government funding, certain tax benefits system to stimulate investment in research and development and so on. A striking example of innovative mental activity is the development and creation of software. In cases where the results of this activity are items of general use, has signs of openness and aimed at increasing and improving the heritage of humanity — then such smart, creative activity corresponds to human needs and can be used in education.

Social responsibility. The social phenomenon is a voluntary and conscious performance, use and compliance by subjects of social relations, regulations, social norms in regards to general doctrine of education development and to the implementation of specific measures of its implementation, including information education. The process of using free software must meet both legal and social norms, which is of particular importance to the educational process, particularly in education subsystem. Commitment to results of scientific, practical, creative and intellectual activity should be a significant factor in humanization of education and upbringing of socially responsible society members.

The main features of modern information society are: introduction of information to different spheres of life; concentration in the field of information and intellectual services of more than 40–50% of the population; development of general theory of information society; exponential growth of knowledge and accumulation of information; combining computer systems into a single information environment through means of communication; creating information in a digital code; extremely high development of production of technology and telecommunication technologies and means of communication requires a radical change in the field of education through information and adequate response to the demands of the information society.

According to the current Law of Ukraine on the National Informatization Program on 04.02.1998, in the current edition of 25.12.2015 was noted that informatization means a series of interrelated organizational, legal, political, socio-economic, scientific-technical, manufacturing processes aimed at creating conditions aiming to meet the information needs of citizens and society through the creation, development and use of information systems, networks, resources and information technology that are based on the use of modern computer and communications technology [6].

Computerization is driven by industry trends, including the informatization of education, by definition of Valerii Yu. Bykov, is a set of interrelated organizational, legal, socio-economic, scientific-methodological, scientific, technical, manufacturing and administrative processes aimed at meeting information, computing and telecommunication needs of subjects of the educational process. Informatization of education is associated with a wide introduction of methods and means of ICT in educational system, the creation on this basis of computer-based information and communication environment, filling this environment with electronic research, education and management of information resources enabling entities to carry out the educational process, provide access to environmental resources, to use its tools and services for solving various problems [1].

Let's define the role and place of free software in the informatization of education. The use of free software in preparation at the present level of informatization of educational activity plays a special role in preparation of pre-service teacher of Mathematics, Physics and Computer Science in the formation of a certain level of informative culture and intellectual development as well as in the formation of a scientific outlook, understanding the essence of practical orientation of informatics disciplines. The level of this training should equip pre-service teacher and make them to be able to create and implement new technologies theoretical framework of which might yet not be developed while they are still in their training.

One of the steps of informatization of educational process, improving the quality of training of pre-service teachers of Mathematics, Physics and Computer Science, enhancing teaching and learning and scientific and research activities, the disclosure of creative potential, the increasing role of self-education, according to Myroslav I. Zhaldak, is the creation and widespread adoption into teaching practice of computer-oriented methodology of teaching based on the principles of progressive and not destructive embedding of ICT in active didactic systems, a harmonious combination of traditional and computer-oriented learning technologies, involving past achievements of pedagogical science of the past, improving and enhancing their achievements through the use of the achievements in development of computer technology and communications [7, 8].

When looking at the methodological training system of Anatolii M. Pyshkalo using a systematic approach to the understanding of teaching methods, where all components of the educational process form a single system with defined internal connections, who defined methodical system of education as a set of five hierarchically related components: learning objectives, contents, methods, tools and organizational learning, which form a single integrated functional structure focused on achieving the learning objectives [7]. The described methodical system is a condition for sustainable development, stability and control of the educational process, which is impossible for teaching disciplines of informatics cycle and in view of the role and place of self-education in the educational process [2]. Similar arguments are used by Nataliia V. Morze an example of secondary school and Informatics as a school subject [1]. Considering the combination of methods, tools and organizational forms of traditional methodical teaching system all if which answer the question "how to teach?", scientists believe that this is the formation of a unified system of subsystems, called technology of education. Based on this structure of subsystem, they determine target, contents and technological components of methodical system of training [4, 5].

Society shapes the social demand to preparation of pre-service teacher and defines objectives of any educational discipline. Thus, the modern information society is characterized by high development and use of information technology and advanced technologies which guarantee the production of information resources and access to these, processes of automatization of all sectors of production and management. While formulating the learning objectives of any disciplines, particularly fundamental, characteristics and requirements of the information society must be taken into account. Learning objectives, according to Yurii V. Tryus, is the initial condition for the creation of methodical system as the most specific and well-defined element of the system [5], that is, any modification of methodical system should, according to Morze, relate to the learning objectives [1] which describes the basic principle of improvement of methodical system — commitment.

The realization of principle of focus and aim is only possible through identification and development of specific components of methodical system, and vice versa — development of content will determine the focus and aim of methodical system. Methodical system that uses free software as a means of teaching must take into account the basic principles and main trends of higher education and become basis to overcome the shortcomings of higher education and promote ways to overcome them, meet the new educational paradigm in terms of using ICTs to intensify the learning process. Methodical system of using free software should be based on a modular principle of development of curriculum subjects, to apply innovative educational technology of teaching, to widely use telecommunications and networking technologies, enable self-education and scientific and research activities, to use new methods and technology of teaching , to apply effective organizational and pedagogical forms of teaching. The result of the development of methodical system must be methodical complex suitable for use in any form of education as well as to be a component of the information and educational environment of an institution of higher education.

The main aims of the use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science are to demonstrate the essence of the scientific approach to the study of information processes and phenomena, the role of information technology in the development of scientific research and technological progress; to teach pre-service teachers techniques of how to use information technology in professional activities, methods of selection and analysis capabilities of the software; develop in students the ability to harmoniously use of ICT in education, to form skills of independent information processing and selecting appropriate technologies and tools.

The use of free software in the preparation of pre-service teacher of Mathematics, Physics and Computer Science should ensure formation of individuality of pre-service teachers, develop their intellectual abilities, analytical and synthetic thinking, information culture, mastering information technologies necessary for professional basic training and professional work, mastering techniques of information technology based on free software necessary to analyze social, economic, technical, manufacturing and information systems, search for optimal solutions to improve the efficiency of the systems, ability to choose the best ways to implement these solutions, processing and analysis of experimental results.

The results of the introduction of free software in the process of professional training of pre-service teacher of Mathematics, Physics and Computer Science, in our view are:

- development of information culture of a person, computer literacy (due to a change in priorities from studying of certain software to studying information technologies and their implementation);
- development of content, methods and means of education to international standards (due to lack of legal and financial restrictions on access to sophisticated achievements in information technology field);
- reducing the term and improving the quality of education at all levels of training of personnel (through enabling the use of information technologies anywhere and at a convenient time);
- integration of academic, research and production activities (through access to the source code of software and means to change it according to individual needs);
- improving the management of education activities (through the use of open standards for interoperability);
- opportunity to intensify the training of pre-service teachers of Mathematics, Physics and Computer Science (through fundamentalization of professional training).

An important factor of the concept of implementation of free software in the professional training of pre-service teacher of Mathematics, Physics and Computer Science is compliance with international and national standards. In view of this, special attention should be paid to standards of electronic documents that must conform to the principles of openness and accessibility. These standards include international standards for open file formats, such as OASIS Open Document Format ODF 1.0 (ISO / IEC 26300) and Office Open XML (ISO / IEC 29500). Unfortunately, the national standard GOST in this field does not exist, though, in our opinion, the existence of a national standard is needed to provide a framework of using open file formats.

The next step of standardization for Ukraine should be the definition of free software. This kind of standard was adopted in the Russian Federation (GOST R 54593–2011), which contains general provisions for free software and is based on international standard classification software (ISO / IEC TR 12182–2004) and processes lifecycle software (ISO / IEC 12207: 2016). Classification meets the standard of the types of programs and policy documents (GOST 19.101–77 operates in Ukraine) and the general requirements for policy documents (GOST 19.105–78 operates in Ukraine).

While defining goals, objectives, classification and criteria for free software, we determined that free software is created and used in order to create such market, where any service (copy, reproduction, modification, error correction, increasing the functionality, etc.) may be sold and bought in a competitive market by free-will contracting of both sides (supplier and buyer services) without appeal to a third party. This definition states the terms which define license purity of free software corresponding to known degrees of freedom. Based on the analysis in our study as to the specific tasks of free software use in Ukraine we include:

- providing import proprietary of components of information systems , reduction of dependence from monopolies, i.e. freedom of action on Ukrainian information space;
- stimulate the development of national (domestic) industry of development of software for computer systems;
- expanding opportunities for participation in development works and services for state and municipal needs and the needs of the private business sector by providing additional investment in domestic producer;
- ensuring a high level of technological independence;
- reducing number of violations related to the legal protection of software for computer systems.

Drawing from these tasks, we believe that infrastructure of development and use of free software should include:

- isolated environment of software packages (means of obtaining the source code of software binary files are directly loaded onto computer systems) and other means of collective development;
- single repository of software for computer systems and source code for various hardware and software platforms including ready distributions of basic software application and standard software solutions;
- control system of software for computer systems, providing records and the right to use and reuse of software and their components;
- infrastructure support for users and developers;

- infrastructure implementation (application) of open standards and specifications, including automation assess of compliance with standards (specifications).

Expected outcomes of introduction of free software are, above all, in the transformation of educational technology, due to:

- transition from delivering already formed knowledge and its memorization to independent information search and constructing their own knowledge;
- joint training activities of pre-service teacher in different educational situations and simulating future professional situations;
- providing educational material in a nonlinear format;
- opportunity to study independently according to individual path and in his optimum pace;
- modeling of world processes and events during educational activities;
- revitalization of intellectual and emotional processes of perception, understanding, comprehension and interpretation of educational material through the integration of verbal, graphic and audiovisual information;
- satisfactory qualification of teachers and pre-service teachers in the field of information and communication technology (equal to the level of International / European Computer Driving License);
- satisfactory qualification of graduated in the field of information and communication technology;
- quality access for teachers and students to their own internal and external e-learning and teaching resources;
- quality access for teachers and senior students to scientific electronic resources;
- automated control of their own activities for teachers and students;
- use of wholly licensed software.

The result of preparing of pre-service teacher of Mathematics, Physics and Computer Science to be able to use free software in their own training will serve as their willingness to use free software in their own teaching careers.

3 Conclusions

The proposed conceptual basis is an open system enabled by its interaction with the environment (social order, standard of professional education, etc.) and integration of knowledge of pre-service teacher of Mathematics, Physics and Computer Science in such scientific fields as philosophy, psychology, pedagogy, theory and methods of teaching mathematics, theory and methods of teaching physics; theory and methods of teaching information technology as well as fundamental disciplines in the field of preparation of Mathematics, Physics and Computer Science. Conceptual framework can be supplemented and extended depending on the conditions and characteristics of the operation and can be used in the preparation of preservice teachers to design the educational process from various disciplines based on their specifics.

The proposed conceptual basis is an integrated system. Each structural element of the proposed principles of the system is its subsystem. This concept of integrity is ensured through:

- the presence of such properties and qualities which are not inherent in its structural elements;
- coherence and mutual dependence of all structural elements of conceptual principles as structural and logical and functional links between them.

Structural and logical connection provided by relationships and relationships of structural elements with each other and with over-system (social demand, state educational standard of higher education in "Pedagogical Education"). Functional connections of structural elements are defined by concept of efficacy provide by the aggregate of the basic principles and conceptual provisions.

References

1. Bykov, V. Yu.: Suchasni zavdannia informatyzatsii osvity (Modern tasks of informatization of education). Information technology and learning tools. 15 (1) (2010).
2. Morze, N. V.: Osnovy metodychnoi pidhotovky vchytelia informatyky (Basics of methodical training of informatics' teachers). Kurs, Kyiv (2003).
3. Semerikov, S. O., Teplytskyi, I. O.: Vilne prohramne zabezpechennia yak faktor stabilizatsii vuzivskykh kursiv informatyky (Free Software

as a factor in the stabilization of university computer science courses). In: Proceedings of Ukrainian scientific and practical conference on Information technologies in education, MSPU, Melitopol, 24–26 May 2006, pp. 55–56 (2006).

4. Semerikov, S. O., Teplytskyi, I. O.: Z dosvidu vykorystannia Vilnoho prohramnoho zabezpechennia u pidhotovtsi maibutnoho vchytelia (The experience of the use of Free Software in preparing future teachers). Ridna shkola. 5, 40–41 (2003).
5. Semerikov, S. O.: Fundamentalizatsiia navchannia informatychnykh dystsyplin u vyshchii shkoli (Fundamentalization of Computer Science teaching at the high educational institutions). Mineral, Kryvyi Rih (2009).
6. Tryus, Yu. V.: Kompiuterno-oriientovani metodychni systemy navchannia matematychnykh dystsyplin u VNZ: problemy, stan i perspektyvy (Computer-oriented methodical systems of teaching mathematical disciplines in higher educational institutions: problems, state and prospects). Naukovyi chasopys NPU imeni M. P. Drahomanova, Seriia 2: Kompiuterno-oriientovani systemy navchannia. 9, 16–29 (2010).
7. Verkhovna Rada Ukrainy: Zakon Ukrayiny Pro Natsionalnu prohramu informatyzatsii (Law of Ukraine: On the National Informatization Program). Zakonodavstvo Ukrainy. http://zakon3.rada.gov.ua/laws/show/74/98-%D0%B2%D1%80 (1998). Accessed 25 Dec 2017.
8. Zhaldak, M. I.: Pedahohichnyi potentsial kompiuterno-oriientovanykh system navchannia matematyky (Pedagogical potential of computer-oriented systems of teaching mathematics). Kompiuterno-oriientovani systemy navchannia. 7, 3–16 (2003).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 136–146

УДК [378.147:004.9]:[37.011.3–051:62/64]

The Model of Use of Mobile Information and Communication Technologies in Learning Computer Sciences to Future Professionals in Engineering Pedagogy

Viktoriia V. Tkachuk[0000−0002−5879−5147],
Vadym P. Shchokin[0000−0001−9709−1831] **and**
Vitaliy V. Tron[0000−0002−6149−5794]
State Institution of Higher Education "Kryvyi Rih National University",
11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
{viktoriya.tkachuk, vadim.shcokin}gmail.com, vtron@ukr.net

Abstract. *Research goal*: the research is aimed at developing a model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy. *Object of research* is the model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy. *Results of the research*: the developed model of use of mobile ICT as tools of learning Computer Sciences to future professionals in Engineering Pedagogy is based on the competency-based, person-centered and systemic approaches considering principles of vocational education, general didactic principles, principles of Computer Science learning, and principles of mobile learning. It also takes into account current conditions and trends of mobile ICT development. The model comprises four blocks: the purpose-oriented block, the content-technological block, the diagnostic block and the result-oriented block. According to the model, the learning content of Computer Sciences consists of 5 main units: 1) Fundamentals of Computer Science; 2) Architecture of Modern Computers; 3) Fundamentals of Algorithmization and Programming; 4) Software of Computing Systems; 5) Computer Technologies in the Professional Activity of Engineer-pedagogues.

Keywords: model of use, mobile ICT, Computer Science, future professionals in Engineering Pedagogy.

1 Introduction

In the previous works of the author based on a comprehensive analysis of technological conditions for the implementation of mobile learning [1] based on the statistical analysis of the results of the expert survey were highlighted general professional and ICT competencies of the future professionals in Engineering Pedagogy, which can become a core of corresponding competency-based standard of training in Ukraine [1]. There are ICT competencies of future Engineer-pedagogues in computer technology, the advantages of use of competency matrices to diagnose their level of formation, the specific criteria for assessing each ICT competence (cognitive, operational-technological, value-motivational), three their levels (low, medium, high), the influence of the criteria on the level of formation of each ICT competence which is determined by the expert evaluation method in the article [2]. The problem of formation of ICT competencies of future Engineers-pedagogues in the learning of Computer Sciences remains open. Its solution requires the construction of a methodic of use of mobile ICT as a learning tools of Computer Sciences to future professionals in Engineering Pedagogy.

In particular, a problem of determining the content and the structure of the method of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy. The solution of this problem involves determining of systemic relations between the components of the method and the components of the ICT-based environment, implementation of educational studies and the construction of a suitable model.

2 The model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy

In order to develop a model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy, according to [3, p. 55] offered some general principles of model construction, such as the definition of the purpose and specific modeling tasks; collection and systematization of the data related to the formulated tasks; distinguishing the main factors that influence the change of trends and patterns of investigated object or phenomenon; construction of a model based on tasks, the solution of which is the main model's orientation.

In Fig. 1 there is a structural and functional model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy based on the above-mentioned principles and aimed to the formation of their ICT competencies.

Based on these factors, two main groups contributing to changes in training future professionals in Engineering Pedagogy (Computer Technology) were distinguished. First, as a result of development of the society (modernization of higher education system, demand in professional education for vocational training system, informatization of society and education, the change of the educational paradigm to competency based) and second, as a result of technology's development (e.g., mobile ICT). Taking into account the results of the first group of factors, the system of

ICT competencies of engineers-pedagogues in computer technologies was created. The second group's factors have enabled to specify the goal: the formation of the ICT competencies of the future engineers-pedagogues in computer technology in learning of Computer Science using mobile ICT. Together, the above-mentioned components form the purpose-oriented block of the model.

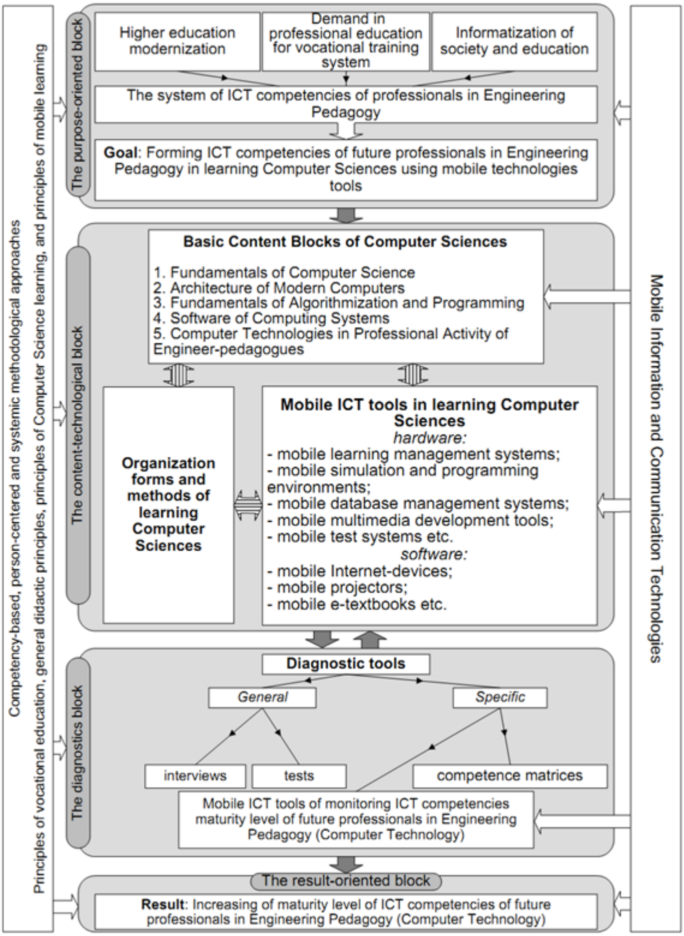


Fig. 1. Model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy

Mobile ICT, methodological approaches (competency-based, person-centered and systemic) and principles (principles of vocational education, general didactic principles, principles of Computer Science learning, and principles of mobile learning expert, person-centered and systemic), underlain to the development of the model are distinguished because they affect all the blocks of the model.

Achievement of the set purpose is in the content-technological block, which structurally corresponds to four of the five components of the methodical system of learning: content and technologies (organization forms, methods and tools) of Computer Science learning. The Computer Sciences learning content consists of five general units: “Fundamentals of Computer Science”, “Architecture of Modern Computers”, “Fundamentals of Algorithmization and Programming”, “Software of Computing Systems”, “Computer Technologies in Professional Activity of Engineers-pedagogues”. Mobile ICT tools in learning Computer Sciences include mobile learning management systems, mobile simulation and programming environments, mobile database management systems, mobile multimedia development tools, mobile test systems etc. The leading hardware mobile ICT tools in learning Computer Sciences are mobile Internet-devices, mobile projectors, and mobile electronic textbooks.

Tools of monitoring and diagnosing ICT competencies formation in diagnostic block are represented by two groups: general diagnostic tools (tests, interviews) and specific (competency matrices, mobile ICT tools of monitoring ICT competence maturity of future professionals in Engineering Pedagogy (Computer Technology)). The model components are corrected according to the results of diagnostics.

Forecast result (increasing the maturity level of ICT competencies of Engineers-pedagogues in computer technologies) represented in the result-oriented block is achieved through applying expedient method of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy.

All four blocks of the model are connected with each other both directly and through their components.

Thus, among the methodological approaches, the main influence on the components of the purpose-oriented block is provided by the competency-based (on the higher education modernization and common goal) and systematic approaches (on the structuring of ICT competencies of Engineers-pedagogues in computer technologies). Mobile ICT, in turn, influence on the informatization of society and education and the procedural goal component.

In the content-technological block, mobile ICT: (1) are reflected in the learning content; (2) are distinguished directly at the tools of Computer Sciences learning; (3) are distinguished indirectly at the organization forms and learning methods. According to the competency-based approach, the requirements for preliminary students' training and to the results of Computer Sciences learning are formulated in terms of competencies. According to the person-centered approach, the methods of Computer Sciences learning, forms of organization of educational activities of students and mobile learning tools are selected. In accordance with the principles of the system approach, the components of the block form a subsystem of the methodical system of learning Computer Sciences, which is a part of the training of Engineers-pedagogues in computer technologies. This, in turn, requires taking into account the principles of vocational education, general and specific learning principles (in particular, the principles of mobile learning and the principles of Computer Science learning).

The diagnostic block has not only direct connection, but also feedback with the content-technological block: being structurally isolated, it is procedurally implemented with it — monitoring and diagnostics of the level maturity of ICT competencies of future Engineers-pedagogues in computer technology is necessary for correction of technological components of learning during the implementation of learning content. The competency-based approach and mobile ICT have a special influence to this block. Both, they determine the leading diagnostic tools of the level of ICT competencies formation — competence matrices for monitoring students' educational activities.

The result-oriented block is totally influenced by all the methodological approaches, principles and technologies shown on the model.

3 Objectives and content of learning Computer Sciences to future professionals in Engineering Pedagogy

The objectives of Computer Science education are determined by the specifics of its contribution in solving the main tasks of the general education of the person: the formation of the foundations of the scientific ideology, which lies in understanding of the modern world, changes of nature and content of human activity in accordance with the development of new information technologies; students' thinking development, in particular theoretical, creative and a new type of thinking (operational) while learning Computer Science using of computer technology; the students' training in practical activity and life-long learning. Since it is the study of Computer Science that influences the formation of computer literacy and information culture, which makes it possible for a person to exist in the modern information society [4, p. 268].

Thus, the general purpose of teaching Computer Sciences to future professionals in Engineering Pedagogy is to form their professional ICT competencies, which specify the requirements for knowledge and skills determining the learning content as pedagogically grounded, logically arranged and textually recorded in the curriculum scientific information on the material to be studied. They are presented in a summarized form and determine the content of educational activities of teachers and cognitive activity of students aiming at mastering of all components of the learning content on the relevant level.

The learning content includes:

- theoretical (fundamental) learning elements, which is a set of basic concepts of a specific subject area of knowledge and it's interconnections;
- problems, which are determined in accordance with the theoretical material and are intended to the development of specific skills and competencies for the relevant knowledge area;
- inter-subject and intra-subject interrelationships between educational elements [4, p. 156].

According to the model, the learning content of Computer Sciences consists of 5 main units:

1. *Fundamentals of Computer Science* are represented in courses:
    - "Industrial training" (modules "Information: forms of data representation", "Solving systems of linear algebraic equations using the Jordan-Gauss method in the spreadsheet environment", "Matrix manipulation functions in spreadsheets", "Analysis of data and parameters selection in spreadsheets", "Development of the infological model and creation of the structure of the relational database");
    - "Discrete programming" (modules "Sets", "Functions", "Combinatorics", "Propositional calculus", "Logic algebra", "Graphs");
    - "Operations research" ("Optimization tasks: fundamental methods and algorithms. Convex optimization", "Linear programming", "Dynamic, discrete programming, maximum principle");

- "Data security in computer networks" (modules "Analysis of computer systems of data processing", "Symmetric cryptographic algorithms", "Cryptosystems");
- "Informatics and computer workshop" (modules "Informatics, information and information technologies", "Arithmetic basics of computing", "Logical fundamentals of computing");
- "Computer logic" ("Functions of the logic algebra: basic laws of the Boolean algebra, Boolean functions minimization, "Synthesis of combinational schemes in a given basis", "Abstract and structural synthesis of digital machines", "Synthesis of control devices", "Computer arithmetic");
- "Computer design, multimedia and Web-programming" (module "Mathematical fundamentals of computer graphics");
- "Database management systems" (module "The fundamentals of databases and knowledge bases");
- "Theory of automatic control" (modules "General characteristics of the concepts of the theory of automatic control", "Stability and quality of continuous linear automatic systems", "Correction of automatic systems", "Stability and quality of linear pulsed systems", "Stability and quality of nonlinear systems").

2. *Architecture of Modern Computers* is represented in:
   - "Industrial training" (modules "Computer system building", "Computer architecture and principles of functioning", "Basic input/output system");
   - "Computer elements and devices" (modules "Basic system devices of personal computers", "I/O devices, information storage", "Computer peripherals");
   - "Data security in computer networks" (modules "Data backup devices");
   - "Informatics and computer workshop" (module "PC hardware");
   - "Computer networks" (modules "Basic information about computer networks and data transmission", "Standardization of networks and data transmission protocols", "Standard technologies and structural organization of networks");
   - "Microprocessors and microprocessor systems" (modules "General concepts of microprocessor technology", "Types and structure of modern microprocessors", "Accompanying devices in microprocessor systems");

- "PC repair and modernization" (modules "PC components", "Peripheral devices, PC upgrades and repairs").

3. *Fundamentals of Algorithmization and Programming* are represented in courses:
    - "Algorithmic programming" (modules "Introduction to algorithms development and coding in C ++", "Windows programming");
    - "Informatics and computer workshop" (module "Algorithmization and programming fundamentals");
    - "Computer design and multimedia" (module "Visual programming in ActionScript");
    - "Microprocessors and microprocessor systems" (module "Basics of programming in Assembler");
    - "Applied and Web-programming" (modules "Applied programming in C++", "Web-programming in JavaScript and PHP");
    - "Programming technologies" (modules "Methods and technology of data organization", "Object-oriented programming", "Software testing", "Software design", "Software documentation").

4. Software of Computing Systems is represented in courses:
    - "Automated organizational management systems" (module "The fundamentals of project management");
    - "Industrial training" (modules "Operating system concept", "Shells", "Applied software", "Computer viruses and network defense", "Text processing basics", "Linguistic software", "Spreadsheets basics", "Presentations basics", "Database management systems", "Internet technologies");
    - "Computer elements and devices" (module "System and specific software");
    - "Data security in computer networks" (modules "Defense of computer systems for data processing", "Data backup", "Computer virus defense", "Information security systems in computer networks", "Defense methods for network traffic", "Tools of distributing access to information resources");
    - "Engineering and computer graphics" (module "Graphics editor");

- "Internet technologies" (modules "Internet fundamentals", "Internet services");
- "Informatics and computer workshop" (module "Operating systems", "PC software");
- "Computer documentation management" (module "Documentation management systems");
- "Computer design and multimedia" (modules "Raster graphics editors", "Vector graphics editors", "Creation of typical graphic elements for website design", "Creation of realistic animated 3D-objects");
- "Computer design, multimedia and Web-programming" (modules "Graphic software", "Publishing software");
- "Fundamentals of complex systems automated design" (modules "Fundamentals of software design", "Diagram technology", "Design methodologies and technologies");
- "Applied and Web-programming" (module "Database development based MySQL server");
- "Database management systems" (module "Relational database design");
- "System programming" (modules "Introduction to system programming", "Computer resources management").

5. *Computer Technologies in the Professional Activity of Engineer-pedagogues* are represented in courses:
   - "Automated organizational management systems" (module "Management of pedagogical projects");
   - "Production training" (modules "Keyboard simulators");
   - "IT ergonomics" (modules "Fundamentals of human-machine systems ergonomic", "IT influence on human health");
   - "Engineering and computer graphics" (module "Professional work in 2D- and 3D-graphics systems");
   - "Computer documentation management" (module "Electronic educational resources development");
   - "Computer design and multimedia" (module "Computer games development with Unity");
   - "Computer design, multimedia and Web-programming" (modules "Computer graphics in the art and business", "Computer graphics in the science and industry");

- “Computer technologies in education” (modules “Theoretical fundamentals of ICT of learning”, “ICT implementation at learning”, “Methodical fundamentals of ICT of learning”, “Prospects for the development of the ICT tools use in the education”);
- “Technical learning tools” (modules “Psychological and pedagogical basis of use of technical learning tools”, “Modern technical learning tools”, “Methodic of technical learning tools application”);
- “Educational internship” (modules “Modern methods and organization forms of future professional activity”, “Scientific and organizational work in the team and adaptation to the specialty”);
- “Technological internship” (modules “Hardware and system software”, “Applied software”, “Data processing in information systems”, “Design of text documents using modern word processors”, “Operations of data processing technological process”.

4 Conclusions

The developed model of use of mobile ICT in learning Computer Sciences to future professionals in Engineering Pedagogy comprises four blocks:

- the purpose-oriented block includes factors of changes in learning computer technologies to professionals in Engineering Pedagogy (higher education modernization, the demand in professional education for vocational training system, informatization of society and education). They determines the system of ICT competencies of professionals in Engineering Pedagogy, which is aimed at forming ICT competencies of future professionals in Engineering Pedagogy while learning Computer Sciences using mobile ICT;
- the content-technological block determines interrelated content blocks of Computer Sciences (“Fundamentals of Computer Science”, “Architecture of Modern Computers”, “Fundamentals of Algorithmization and Programming”, “Software of Computing Systems”, “Computer Technologies in Professional Activity of Engineer-pedagogues”), mobile ICT tools in learning Computer Sciences (hardware and software), organization forms and methods of learning Computer Sciences;

- the diagnostics block determines general (interviews, tests) and specific tools (competence matrices, mobile ICT tools of monitoring ICT competencies maturity of future professionals in Engineering Pedagogy (Computer Technology)) of monitoring and diagnosing ICT competencies formation;
- the result-oriented block determines the forecasting result of the model realization implying the increased maturity level of Engineer-pedagogues' ICT competencies. All blocks of the model are connected with each other both directly and through their components.

References

1. Rashevska, N., Tkachuk, V.: Technological conditions of mobile learning at high school. Metallurgical and Mining Industry. 3, 161–164 (2015).
2. Tkachuk, V. V.: Professional ICT-competencies design for the future professionals in Engineering Pedagogy. Information Technologies and Learning Tools. 53 (3), 123–141 (2016).
3. Tkachuk, V. V.: Diahnostyka rivnia sformovanosti IKT-kompetentnostei maibutnikh inzheneriv-pedahohiv kompiuternoho profiliu (Diagnostics of the level formation ICT-competencies future engineers-pedagogs of the computer profile). Scientific notes. Series: Problems of methodology of physical-mathematical and technological education. 2 (11), 205–212 (2017).
4. Savelev, A. Ia., Semushkina, L. G., Kagermanian, V. S.: Model formirovaniia spetcialista s vysshim obrazovaniem na sovremennom etape (The model of the formation of a specialist with a higher education at the present stage). Scientific and Research Institute of Higher Education, Moscow (2005).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 147–158

УДК 331.54:004.94

Stages of Conceptualization and Formalization in the Design of the Model of the Neuro-Fuzzy Expert System of Professional Selection of Pupils

Bogdan B. Buyak[1[0000−0003−1496−7573]],
Ivan M. Tsidylo[1[0000−0002−0202−348X]],
Victor I. Repskyi[1[0000−0003−4297−5335]] **and**
Vitaliy P. Lyalyuk[2[0000−0001−7793−1397]]
[1] Ternopil V. Hnatiuk National Pedagogical University,
2, M. Kryvonosa St., Ternopil, 46027, Ukraine
{buyak.bogdan, tsidylo, repskyi}@tnpu.edu.ua
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine,
5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine
vitalij.lyalyuk@gmail.com

Abstract. The article describes the problem of designing a neuro-fuzzy expert system of professional selection at the stages of conceptualization and formalization, which involves the definition of concepts, relationships and management mechanisms necessary to describe the solution of problems in the chosen subject field. The structural model of the decision making system for determining the professional selection of students for training in IT specialties is substantiated. Three subsystems are proposed as structural components for studying: psychological peculiarities, personal qualities, factual knowledge, abilities and skills of students. The quality of the system's operation is determined by the use of various techniques for acquiring knowledge on the basis of which the knowledge base of the neuro-fuzzy system and the combination of the use of fuzzy and stochastic data will be formed.

Keywords: professional orientation, professional selection, expert system, design, neuro-fuzzy modeling, conceptualization, formalization, structural model.

1 Introduction

1.1 The Problem Setting

One of the topical problems of artificial intelligence is the construction of diagnostic neuro-fuzzy expert systems, the substantiation of their structure and individual subsystems. Such systems make it possible to combine various forms of presentation and methods of processing knowledge. They are the study environment for the optimal combination of various mechanisms of knowledge processing in the process of solving the problem of effective interaction of heterogeneous information in conditions of uncertainty. The range of application of fuzzy data processing methods is expanding every year, covering areas such as the design of industrial robots and household appliances, automatic recognition of speech and images, and so on.

The social and humanitarian sphere of human activity concerning the application of intelligent technologies of automation of information processes and modeling of systems that are characterized by fuzzy and vague input values has not remained unaltered. One of the most active and perspective areas of applied research, based on the construction of information systems in terms of the theory of fuzzy sets — fuzzy simulation. The advantage of this approach is that fuzzy simulation allows you to obtain more adequate results in comparison with results based on the use of traditional analytical models and management algorithms, as well as to simulate complex systems with multiple choice and heterogeneous input data.

Professional orientation and professional selection of young people for the study of IT specialties is a complex multi-faceted process, the automation of which requires a non-standard approach and the application of artificial intelligence technologies, in particular methods and algorithms of fuzzy logic. In the process of analyzing the factors that influence the professional choice of students, in addition to the psychological and personal qualities of the individual, one must take into account the tendency to study certain disciplines, in particular, the disciplines of the professional-practical cycle of the curriculum. In addition, an external evaluation of the specialists of the chosen forecasting field of education is required as well as their independent recommendations for choosing a future profession.

1.2 Analysis of Recent Research and Publications

Problems of professional orientation and professional selection of students, in particular, practical aspects, are considered in many works by well-known teachers and scholars: Ivan D. Bekh [2], Valentyna T. Lozovetska [12], Nellia H. Nychkalo [14], Olena M. Otych [15], Olha I. Shcherbak [17], Illia O. Teplytskyi [16], Hryhorii V. Tereshchuk [21], Ivan A. Ziaziun [24] and others.

Considerable attention has been paid recently to the study of the possibility of automating the processes of vocational guidance and professional selection using a variety of information systems — Nailia R. Iangurazova [8], Baryi G. Iliasov [8], Elena B. Startceva [8], Andrei V. Shulepov [19] and others. In particular, [8] offers the construction of an expert system for the selection of not one, but several specialties when enrolling in a higher education institution. The basis of this approach is the modular principle of building the knowledge base of the expert system, as well as the advantages of applying this principle. To create an expert system, the authors analyzed and modeled the subject area using a structural approach.

Shulepov [19] on the basis of a review of expert systems on the choice of specialty when enrolling in the university offered a mathematical model of the system of assessment of own opportunities and the choice of a rational strategy in the labor market for a graduate of high school taking into account external socio-economic factors. The structure of such a system, the functional model and the data storage scheme are described.

The definition of students' success is one of the key determinants when choosing a profession, based on fuzzy logic: Andrei R. Aidinian [1], Aleksandr P. Kirpichnikov [9], Irina V. Leonova [9], Stella A. Liasheva [9], Mikhail P. Shleimovich [9], Olga L. Tcvetkova [1], Ivan M. Tsidylo [20] and others.

In the paper [9] a methodology for assessing the quality of teaching of students of higher educational institutions is proposed, which is based on the use of a two-level system built on the basis of the adaptive system of neuro-fuzzy output ANFIS implemented in the package of Fuzzy Logic Toolbox MatLab system. The system for assessing the quality of training, which allows for numerical evaluation as a summary indicator characterizing the performance of an educational institution and shows how well the learning process is conducted, is proposed in [1]. Another approach to constructing a fuzzy evaluation of the results of automated testing is proposed by us in [20]. The structure, functions and mechanisms of constructing a fuzzy system model are described. The response surface of the fuzzy system reflects the dependence of the final score on the complexity of the task and the degree of correctness of the task. Testing of the controller on the test sample has been carried out, proving the functional suitability of the developed model.

To date, the scientists have made attempts to generalize conceptual studies of the problem: the application of intellectual information technologies in practical tasks — Oleh M. Berezkyi [4], Maksim I. Dli [10], Roman Iu. Golunov [10], Vladimir V. Kruglov [10], Serhiy D. Shtovba [18], F. Wasserman [22], and others, the construction of fuzzy expert systems — George F. Luger [13], Serhiy D. Shtovba [18], etc., decision-making in situations for which both fuzzy and stochastic data should be used — Aleksei G. Beliakov [3], Olha V. Hlon [7], Volodymyr M. Dubovoy [7], Oleh O. Kovaliuk [5], Aleksandr S. Mandel [6] and other national and international scientists.

1.3 Unresolved Aspects of the Problem

The analysis of works shows the presence of a certain structure and stage of the design of neuro-fuzzy expert systems. However, little or no attention has been paid to detailing the implementation of the most important stages — conceptualization and formalization, in particular, in the process of developing a model of the system of professional selection of students.

1.4 The Purpose

The purpose of the article is to substantiate the essential features, concepts, relationships and management mechanisms necessary to describe the solution of the problem of designing a neuro-fuzzy expert system for determining the professional suitability of future students for the training of IT specialties.

2 The Results of the Research

Designing a neuro-fuzzy expert system to determine the professional suitability of students to learn future IT skills is based on the most commonly used approach using fuzzy knowledge bases and the hybrid learning algorithm ANFIS. Peculiarities of the implementation of such systems, as stated in the paper [8, p. 120] are as follows: processing of fuzzy statements, that is, when the prerequisite is fuzzy variables, and the output machine — a mechanism for obtaining data from them; the use of a matrix of fuzzy relations, when a set of factors and set of prerequisites are determined; the matrix contains fuzzy variables whose measure is represented as a real number within [0, 1], and to determine the causes of the state, the transformation of the matrix and factors into the form of equations of fuzzy relations is carried out, and then the resulting system is solved by the method of composition of the minimum-maximum; use of fuzzy excerpts.

In accordance with the stages of the development of intelligent systems, let us consider the most time-consuming stages — conceptualization and formalization, which, according to the authors [16]: "is, indeed, 'a stumbling block' at the very first stage of the development of models of intelligent systems". At these two stages, one can say, the feasibility of using one or another type of knowledge for the presentation of information is determined. At the stage of obtaining knowledge, we analyze the problem area and determine the methods of solving problems.

First of all, you need to pay attention to the development environment of the future system. The software environment for designing will be MATLAB — one of the oldest, carefully elaborated and time-tested automation systems for mathematical and scientific and technical calculations, built on the extended presentation and application of matrix operations [20]. The specific environment for the development of a neuro-fuzzy expert system is fuzzy output editor Fuzzy Inference System Editor. This editor consists of the following programs: Membership Function Editor, Rule Editor, Rule Viewer, and Surface Viewer [23, p. 18].

The problem of professional selection of students is the correspondence of psycho-physiological characteristics of a student with the requirements of the IT specialty. Based on this, the goals of the system development include: to determine the main criteria for professional review; to show their significance and validity; to simulate the work of the expert system and evaluate its effectiveness.

Accordingly, professional selection involves a system of activities that can identify people who, by their individual personal qualities, are most suitable for studying and continuing professional activities in a particular profession. Proficiency is preceded by students' inclination and abilities, quality of training, interests, and environment. The stages of professional selection include: psychological study of the profession in order to identify the requirements for a person; selection of psycho-diagnostic methods of research, including tests that most characterize those mental processes and occupational actions, concerning which the professional suitability is to be assessed; forecasting the success of training and further activities on the basis of comparison of information: a) about the requirements of the profession to the person and received psychodiagnostic data with an emphasis on the assessment of personality characteristics; b) the possibility of purposeful improvement and compensation of professionally important qualities, as well as the probability of adaptation to the profession, the possibility of emergence of extreme situations and influences.

In the final version, the system should determine the degree of professional competence of the student for further training on the IT specialty based on the prescribed criteria on the basis of the programmed knowledge. Taking into account the complexity of the task of professional selection, we divided all the input data into three subsystems: psychological peculiarities of the student, student's personal qualities, factual knowledge, abilities and skills (KAS's) in possession of the appropriate programming languages. Each of these subsystems will have separate input variables that will be responsible for the formation of this knowledge base with subsequent fuzzy logic output for a certain type of criteria. The outputs of the three subsystems that will set the condition will be inputs to the overall resultant system, the output of which will be the final result of the student's professional suitability. As a result, we obtain a hierarchical expert system that will operate as inbound variables both with fuzzy linguistic and statistical information. Thus, we have completed the stage of development of intelligent systems — conceptualization.

At the formalization stage, we fill in the system with input data to form a knowledge base. The general system will have three subsystems described above, as well as output variables that will eventually show the result. The first subsystem will be a subsystem called "psychological peculiarities of students". In each subsystem, first of all, it is necessary to provide input data or they can also be called input variables. The input data of the first subsystem include: memory, attention, imagination, thinking and temperament. We got five input variables. But this is not enough for the validity of the subsystem. Each input variable will contain its varieties, so that during the examination we will be able to determine which type of psychological features is most developed. In the language of fuzzy logic they are called fuzzy linguistic variables. For example, what kind of attention or thinking is dominant. Based on available varieties of memory, the first input variable of this subsystem will contain the following variables: figurative, verbal-logical (in content), short-term, long-term, operational (in duration), involuntary and arbitrary (by the way of memorization). The second input variable is attention. Accordingly, we introduce its types, namely: external, internal, involuntary, arbitrary, post-satisfactory. The third parameter is imagination. Its varieties, and accordingly, linguistic variables: artistic, technical, and scientific. The fourth input variable is thinking: visually-effective, visually-figurative, verbal-logical. The last, fifth input element is the student's temperament. Its varieties are as follows: choleric, sanguine, phlegmatic, melancholic.

The knowledge of the second subsystem of "student's personal qualities" is presented in the following way. The input elements of the subsystem will be: language proficiency, inclinations and abilities, overall capacity, success. We also use varieties of input elements in the form of linguistic variables, in order to classify each of them in more detail. The first input element is to speak the language, both native and foreign. Its varieties are as follows: Ukrainian, English, Russian, German, Polish. The second input element is the student's personal inclinations and abilities. Here we will include the following: educational, creative (in terms of application), theoretical and practical (by type of thinking) [11]. The third input element is the total capacity. Its varieties are as follows: depth and breadth of mind, self-discipline, self-control, activity, initiative, responsibility. The fourth element of this subsystem is the success — high, low, and average. This subsystem will output a result that describes the input variables for the general system, the level of personal qualities of the person who was tested.

The third subsystem will be a subsystem called “KAS’s” (knowledge, abilities, skills). This will be the largest subsystem and will include two more subsystems both of which will be affiliated with the IT specialty “Web programmer”. The first is the knowledge of programming languages, and the second is a software package.

Subsystem “Knowledge of programming languages”. Here it is necessary to foresee types of programming languages and the level of proficiency in them. It should be noted that in the knowledge base we will introduce the types of programming languages in two directions: client programming languages and server programming languages. The first direction will include: HTML5, XTML, CSS3, Java-Script along with the JQuery library. The server languages include: PHP, C#, ASP.NET, Java. Each input variable will provide the level of proficiency: high, sufficient, average, low, zero. It is these two areas of programming languages that play an important role, since the expert system, when deducing the result, will not only be able to show whether a professionally qualified student will study in this specialty, but will also output the result of the direction of student learning in the IT industry. Whether this will be the direction of preparation closer to web design or it will be a server programmer.

The second subsystem is a “Software product”. The input of its knowledge base will be those software products that the future web programmer should be directly proficient in. Therefore, the input variables of the subsystem will be the following software applications and packages: Notepad, Sublime Text, Php Storm, Aptana, DreamWeaver, MySQL, Microsoft Visual Studio, Photoshop (for designers). Each of the above input variables will have linguistic variables corresponding to the level of proficiency: high, sufficient, average, low, zero.

The two subsystems described above will provide a fuzzy logical output, the initial results of which will be input data for the subsystem “KAS’s” whose output values, in turn, will be input values for the general neuro-fuzzy expert system for determining the professional suitability of future students to study IT skills.

The developed structural model of the system (Fig. 1) allows for obtaining complete and visual information about the subject domain, justify the structure of knowledge bases and select and develop the means of its filling, determine the requirements for the software and hardware of the system.

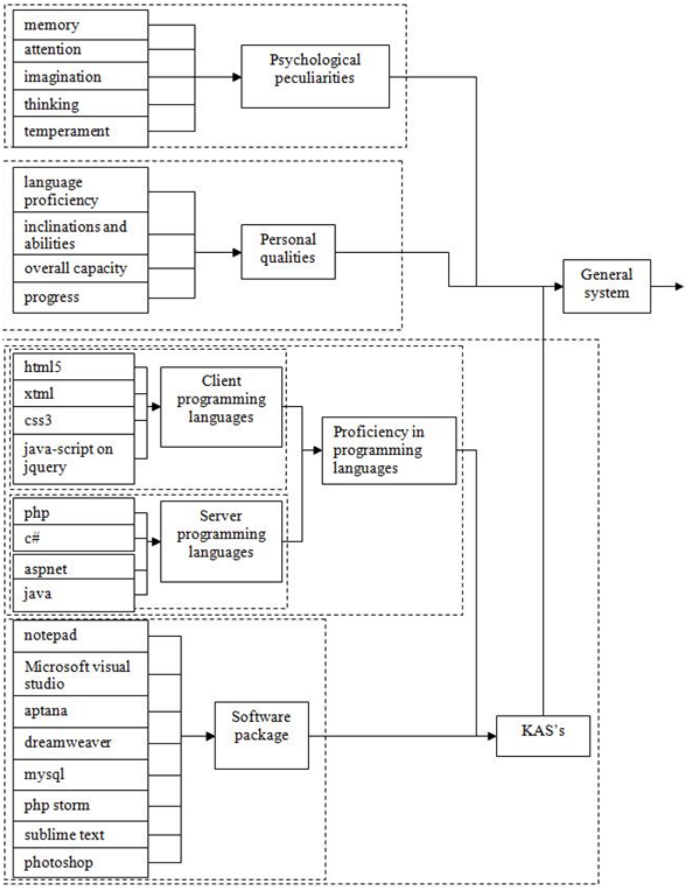


Fig. 1. Structural model of the general neuro-fuzzy expert system for determining the professional suitability

The organization of the structure of the model was made on the basis of the modular approach, which allowed us in a separate module (subsystem) to provide means and methods for obtaining, processing and preservation specific to it, the knowledge base in separate units of knowledge and their use by several subsystems in accordance with the hierarchy of acceptance processes solution to the task. The knowledge base will be formed on the basis of the creation of so-called heuristic rules that will consist of a different combination of the principle "if (condition) and (condition) then (result)", which will provide a separate result. Validity of any expert system depends on the number of heuristic rules. The more rules the expert provides, the better will be the examination and the more accurate results at the output. However, not always a greater number of rules will lead to a better result. Therefore, to optimize the system, we propose the use of the ANFIS algorithm.

3 Conclusions and Prospects for Further Research

Thus, for the automated expert assessment of the professional competence of students for the training of IT specialties, subsystems of decision-making have been allocated and their hierarchy has been determined, on the basis of which a general model is created that describes all the decision-making processes. This approach can be attributed to the IDEF methodology, which is defined and used to solve problems of modeling complex systems. Modeling of processes of professional orientation and professional definition can be attributed precisely to such systems, which allow to represent and analyze the models of activity of a diverse spectrum. As systems models we propose the following subsystems: psychological peculiarities, personal qualities, factual knowledge, skills and abilities. Hence, the width and depth of the study of processes in the system are being met. Namely, both by the use of various techniques for obtaining knowledge on the basis of which the knowledge base of the neuro-fuzzy system will be formed, and by the combination of the use of fuzzy and stochastic data.

The structural order of the inseparable, in our opinion, elements and characteristics of the student's personality reflects our vision of the automation of the process of professional orientation and professional decision. The interdisciplinary nature of the task is beyond doubt. Failure to take into account some features took place at both the conscious and unconscious levels in order to avoid overloading the created model with unnecessary data.

The prospect of further inquiries into this issue is seen in the implementation of the designed system in the MATLAB software environment, in particular in the Fuzzy Logic Toolbox, and the involvement of specialists in pedagogy, psychology, physiology, programming, atomization of information processes, etc., at the stages of conceptualization and formalization. After all, only in cooperation of experts from various industries one can get high-quality and effective software product, including a computer-aided neuro-fuzzy expert system for determining the professional suitability of students for the training in IT specialties.

References

1. Aidinian, A. R., Tcvetkova, O. L.: Metodika otcenki kachestva obucheniia studentov vuza s ispolzovaniem neiro-nechetkogo podkhoda (Methods of estimation of the quality of students' education with the use of neuro-fuzzy approach). Programmnye produkty i sistemy. 29 (4), 189–193 (2016).
2. Bekh, I. D.: Stanovlennia profesionala v suchasnykh sotsialnykh umovakh (Becoming a professional in modern social conditions). Pedahohika tolerantnosti. 3–4, 157–162 (2001).
3. Beliakov, A. G., Mandel, A. S.: Analiz dostovernosti vyvodov, formiruemykh s pomoshchiu ekspertno-statisticheskikh sistem (The analysis of reliability of the conclusions formed with the help of expert statistical systems). Ros. AN. In-t probl. upr. im. V. A. Trapeznikova, Moscow (2002).
4. Berezsky, O., Melnyk, G., Batko, Yu.: Modern Trends in Biomedical Image Analysis System Design. In: Laskovski, A. (ed.) Biomedical Engineering, Trends in Electronics, Communications and Software, pp. 461–480. InTech, Rijeka (2011).
5. Dubovoi, V. M., Kovaliuk, O. O.: Modeli pryiniattia rishen v upravlinni rozpodilenymy dynamichnymy systemamy (Models of decision-making in the management of distributed dynamic systems). UNIVERSUM-Vinnytsia, Vinnytsia (2008).
6. Granin, S. S., Mandel, A. S.: Stationary Inventory Control Policies in Supply Systems under Inflation Condition. Automation and Remote Control. 77 (8), 1453–1460 (2016).
7. Hlon, O. V., Dubovoi, V. M.: Modeliuvannia system keruvannia v umovakh nevyznachenosti (Modeling of control systems under uncertainty). UNIVERSUM-Vinnytsia, Vinnytsia (2004).
8. Iliasov, B. G., Startceva, E. B., Iangurazova, N. R.: Modulnaia struktura bazy znanii ekspertnoi sistemy "Vybor spetcialnosti pri postuplenii v vuz" (Modular structure of the knowledge base of the expert system "The choice of specialty at admission

to an institution of higher education"). Neftegazovoe delo. 2. http://ogbus.ru/authors/Ilyasov/Ilyasov_1.pdf (2006). Accessed 29 Jan 2017.

9. Kirpichnikov, A. P., Liasheva, S. A., Shleimovich, M. P., Leonova, I. V.: Proektirovanie avtomatizirovannoi sistemy obrabotki dannykh uspevaemosti studentov na osnove nechetkoi logiki (Designing an automated system for data processing of students' progress based on fuzzy logic). Vestnik Kazanskogo tekhnologicheskogo universiteta. 372–376 (2014).
10. Kruglov, V. V., Dli, M. I., Golunov, R. Iu.: Nechetkaia logika i iskusstvennye neironnye seti (Fuzzy logic and artificial neural networks). Izdatelstvo fiziko-matematicheskoi literatury, Moscow (2001).
11. Krushelnytska, Ya. V.: Fiziolohiia i psykholohiia pratsi (Physiology and psychology of labor). KNEU, Kyiv (2003).
12. Lozovetska, V. T.: Profesiine stanovlennia osobystosti v suchasnykh umovakh pratsi (Psychological and pedagogical aspects of professional formation of personality in modern working condition). Naukovyi visnyk Instytutu profesiino-tekhnichnoi osvity. 5, 20–24 (2013).
13. Luger, G. F.: Artificial Intelligence: Structures and Strategies for Complex Problem Solving (6th Edition). Pearson, London (2008).
14. Nychkalo, N.: Profesiinyi rozvytok osobystosti u konteksti neperervnosti (Professional development of the individual in the context of continuity). In: Kremen, V. H., Dmytrychenko, M. F., Nychkalo, N. H. (eds.) Kontseptualni zasady profesiinoho rozvytku osobystosti v umovakh yevrointehratsiinykh protsesiv, pp. 12–23. NTU, Kyiv (2015).
15. Otych, O.: Mystetstvo u profesiinomu rozvytku osobystosti (Art in the professional development of personality). In: Kremen, V. H., Dmytrychenko, M. F., Nychkalo, N. H. (eds.) Kontseptualni zasady profesiinoho rozvytku osobystosti v umovakh yevrointehratsiinykh protsesiv, pp. 571–582. NTU, Kyiv (2015).
16. Polishchuk, O. P., Teplytskyi, I. O., Semerikov, S. O.: Profesiina spriamovanist fundamentalizatsii informatychnoi osvity (Professional orientation of fundamentalization of informational education). Theory and methods of learning mathematics, physics, informatics. 11 (3), 122–129 (2013).
17. Shcherbak, O.: Psykholoho-pedahohichni zasady profesiinoho rozvytku i samorozvytku pedahoha profesiinoho navchannia (Psychological-

pedagogical principles of professional development and self-development of a teacher of professional training). In: Kremen, V. H., Dmytrychenko, M. F., Nychkalo, N. H. (eds.) Kontseptualni zasady profesiinoho rozvytku osobystosti v umovakh yevrointehratsiinykh protsesiv, pp. 472–481. NTU, Kyiv (2015).

18. Shtovba, S. D., Pankevich, O. D., Nagorna, A. V.: Analyzing the criteria for fuzzy classifier learning. Automatic control and computer sciences. 49 (3), 123–132 (2015). doi: 10.3103/S0146411615030098

19. Shulepov, A. V.: Postroenie ekspertnoi sistemy vybora ratcionalnoi strategii na rynke truda dlia vypusknika vuza (Constructing an expert system for selecting a rational strategy in the labor market for a graduate of the university). Vestnik kibernetiki. 8 (2009).

20. Tcidylo, I. N.: Nechetkaia otcenka rezultatov avtomatizirovannogo testirovaniia (Fuzzy evaluation of the results of automated testing). Problemy sovremennoi nauki. 11 (1), 105–114 (2014).

21. Tereshchuk, H. V.: Pedahohichna diahnostyka tsinnisnykh oriientatsii molodi v protsesi yii sotsialnoho i profesionalnoho stanovlennia (Pedagogical diagnostics of value orientations of youth in the process of its social and professional formation). Pedahohika i psykholohiia. 3 (12), 119–124 (1996).

22. Wasserman, Ph. D.: Neural computing: theory and practice. Van Nostrand Reinhold Co., New York (1989).

23. Zhernakov, S. V.: K voprosu o postroenii gibridnykh neiro-nechetkikh ekspertnykh sistem diagnostiki i kontrolia GTD (On the construction of hybrid neuro-fuzzy expert systems for diagnostics and control of GTE). In: Upravlenie v slozhnykh sistemakh, pp. 119–126. UGATU, Ufa (1999).

24. Ziaziun, I. A.: Pedahohichnyi profesionalizm u konteksti profesiinoi svidomosti (Pedagogical professionalism in the context of professional consciousness). In: Pedahoh profesiinoi shkoly, pp. 8–17. Naukovyi svit, Kyiv (2001).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 159–191

УДК 004.94:37.091.39

Computer Simulation of Neural Networks Using Spreadsheets: The Dawn of the Age of Camelot

Serhiy O. Semerikov[1][0000−0003−0789−0272], **Illia O. Teplytskyi**[1], **Yuliia V. Yechkalo**[2][0000−0002−0164−8365] **and Arnold E. Kiv**[3]

[1] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
semerikov@gmail.com

[2] State Institution of Higher Education "Kryvyi Rih National University", 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
uliaechk@gmail.com

[3] Ben-Gurion University of the Negev, Beer Sheba, Israel
kiv@bgu.ac.il

Abstract. The article substantiates the necessity to develop training methods of computer simulation of neural networks in the spreadsheet environment. The systematic review of their application to simulating artificial neural networks is performed. The authors distinguish basic approaches to solving the problem of network computer simulation training in the spreadsheet environment, joint application of spreadsheets and tools of neural network simulation, application of third-party add-ins to spreadsheets, development of macros using the embedded languages of spreadsheets; use of standard spreadsheet add-ins for non-linear optimization, creation of neural networks in the spreadsheet environment without add-ins and macros. After analyzing a collection of writings of 1890–1950, the research determines the role of the scientific journal "Bulletin of Mathematical Biophysics", its founder Nicolas Rashevsky and the scientific community around the journal in creating and developing models and methods of computational neuroscience. There are identified psychophysical basics of creating neural networks, mathematical foundations of neural computing and methods of neuroengineering (image recognition, in particular). The role of Walter Pitts in combining the descriptive and quantitative theories of training is discussed. It is shown that to acquire neural simulation competences in the spreadsheet environment, one should master the models based on the historical and genetic approach. It is indicated that there are three groups of models, which are promising in terms of developing corresponding methods — the continuous two-factor model of Rashevsky, the discrete model of McCulloch and Pitts, and the discrete-continuous models of Householder and Landahl.

Keywords: computer simulation, neural networks, spreadsheets, neural computing, neuroengineering, computational neuroscience.

1 Introduction

For the past 25 years, the authors have been developing the concept of systematic computer simulation training at schools and teachers' training universities [52]. The concept ideas have been generalized and presented in the textbook [59]. Spreadsheets are chosen to be the leading environment for computer simulation training [51, 70], their application discussed in articles [54, 61, 65, 67]. Using spreadsheet processors (autonomous [18], integrated [60] and cloud-oriented [71]) as examples, the authors demonstrate components of teaching technology of computer simulation [69] of determined and stochastic [55, 57, 66] objects and processes of various nature [58, 68].

The systematic training of simulation provides for changing [51] and integrating [56] simulation environments ranging from general (spreadsheets) to specialized subject-based ones. While teaching computer simulation of intellectual systems [49] specialized languages and programming environments [28] are traditionally used. They can be easily mastered by first-year students [1, 27]. One of the most wide-spread languages, Scheme, is offered to be applied to teaching computer simulation of classical mechanics at universities [53]. Extensive application of artificial intelligence in everyday life calls for students' early acquaintance with its models and methods including neural network-based [29] while teaching informatics at secondary schools. It conditions the need for developing training methods of computer simulation of neural networks in the general-purpose simulation environment, i.e. spreadsheets.

2 Literature Review and Problem Statement

The first description of spreadsheet application to teaching neural network simulation of visual phenomena dates back to 1985 and belongs to Thomas T. Hewett, Professor of the Department of Psychology of Drexel University [11]. In [10] there are described simple models of microelectrode recording of two neuron types of neural activity — receptors and transmitters localized in two brain-hemispheres. Thomas T. Hewett offered psychology students to independently choose coefficients of intensifying or reducing input impulses to achieve the desired output: "... the simulations can be designed in such a way that the student is able to "experiment" with a simulation-experiment both in the sense of discovering the characteristics of an unknown model and in the sense of modifying various components of a known model to see how the simulation is affected" [10, p. 343]. This approach implies simultaneous studying a neural network and understanding its functioning as psychology students conclude the laws of the neural impulse spread by applying the trial-and-error method.

In his article [4], James J. Buergermeister, Professor of Hospitality and Tourism Management of University Wisconsin-Stout, associates electronic spreadsheet application with basic principles of training technology and methods of data processing (Fig. 1). The author does not work out the methods of applying electronic spreadsheets to neural network simulation in detail, yet, the presented scheme reveals such basic steps as data obtainment, semantic coding, matching with an etalon, etc.

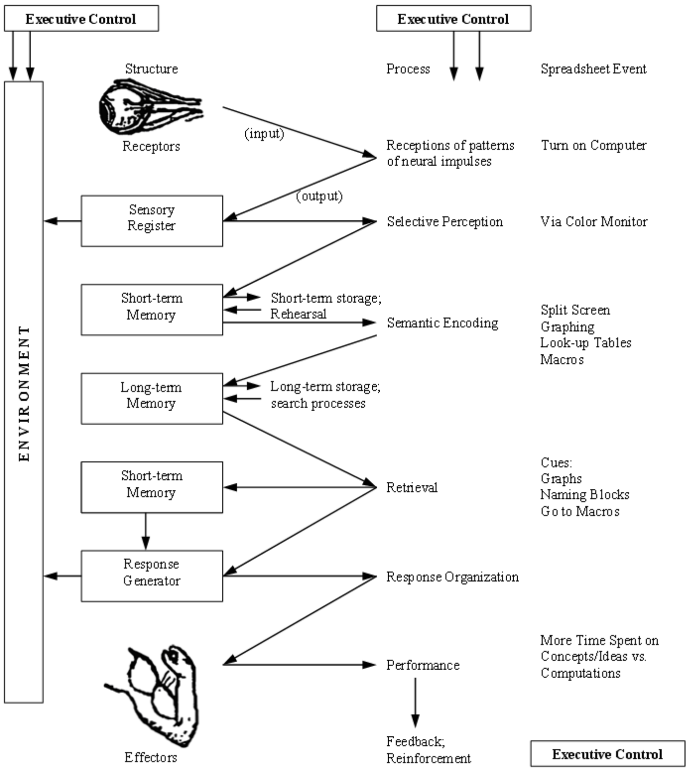


Fig. 1. The information-processing model using spreadsheet events (according to [4])

Since 1988, Murray A. Ruggiero, one of the pioneers of autotrading, has been developing Braincel, an application for Microsoft Excel 2.1C, which is a set of twenty macros to solve tasks of image recognition by artificial neural network tools [21]. At the beginning of 1991, Murray A. Ruggiero received a patent "Embedding neural networks into spreadsheet applications" [48], which describes an artificial neural network with a plurality of processing elements called neurons arranged in layers. They further include interconnections between the units of successive layers. A network has an input layer, an output layer, and one or more "hidden" layers in between, necessary to allow solutions of non-linear problems. Each unit (in some ways analogous to a biological neuron: dendrites — input layer, axon — output layer, synapses — weights [46], soma — summation function) is capable of generating an output signal which is determined by the weighted sum of input signals it receives and an activation function specific to that unit. A unit is provided with inputs, either from outside the network or from other units, and uses these to compute a linear or non-linear output. The unit's output goes either to other units in subsequent layers or to outside the network. The input signals to each unit are weighted by factors derived in a learning process.

When the weight and activation function factors have been set to correct levels, a complex stimulus pattern at the input layer successively propagates between the hidden layers, to result in a simpler output pattern. The network is "taught" by feeding it a succession of input patterns and corresponding expected output patterns. The network "learns" by measuring the difference at each output unit between the expected output pattern and the pattern that it just produced. Having done this, the internal weights and activation functions are modified by a learning algorithm to provide an output pattern which most closely approximates the expected output pattern, while minimizing the error over the spectrum of input patterns. Neural network learning is an iterative process involving multiple lessons. Neural networks have the ability to process information in the presence of noisy or incomplete data and yet still generalize to the correct solution.

In his patent, Murray A. Ruggiero details a network structure (multi-level), an activation function (sigmoidal), a coding method (polar), etc. He presents a mathematical apparatus for network training and determines a method of data exchange between a spreadsheet processor nucleus and an add-in to it. The patent author suggests storing input data in columns, maximum and minimum values for each column of input data, the number of learning patterns. Data can be normalized or reduced to the polar range $[0; 1]$ both in spreadsheets and add-ins.

In his article of 1989, Paul J. Werbos, the pioneer of the backpropagation method for artificial neural network training [64] demonstrates how to make the corresponding mathematical apparatus simpler to use it directly in the spreadsheet processor. The cycling character of training is supported by a macro that exchanges data between lines to avoid restrictions on the number of iterations because of the limited number of lines on a sheet of a separate spreadsheet. Some other authors suggest applying a similar approach of macros application [8, 73].

The authors of [22] in Chapter 2 "Neural Nets in Excel" give an example of applying the non-linear optimization tool, Microsoft Excel Solver, to forecasting stock prices using the "grey-box" concept, in which the model is evident, yet, the details of its realization are hidden.

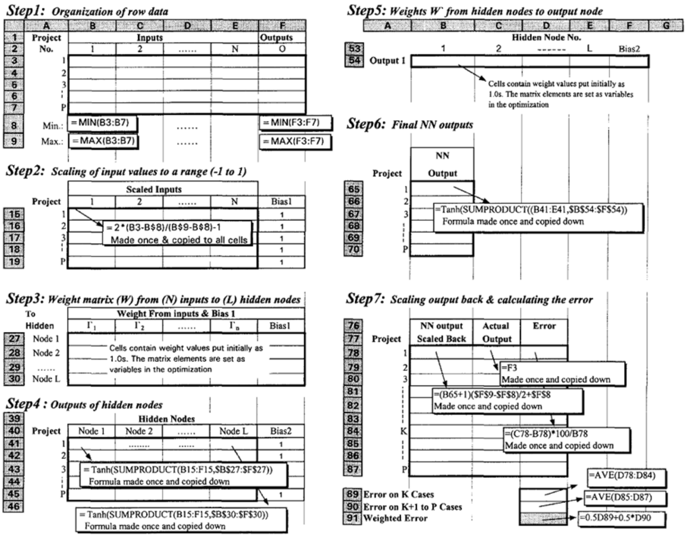


Fig. 2. Spreadsheet simulation of three-layer neural network with one output node (according to [9])

In their article of 1998 [9], Tarek Hegazy and Amr Ayed from the Department of Civil Engineering at University of Waterloo distinguish the corresponding seven steps (Fig. 2). Unlike [47], the authors suggest using bipolar data normalization (over the range of $[-1;1]$) and a hyperbolic tangent as an activation function. Three add-ins for Microsoft Excel are used to determine weighting factors — the standard Solver and third-party add-ins (NeuroShell2 and GeneHunter by Ward Systems Group).

Experiment results reveal that the best result is provided by the optimizing general-purpose tool (Solver) and not by specialized ones. In spite of the fact that "Journal of Construction Engineering and Management" does not refer to educational editions, the article [9] and the paper [3] by their structure and focus on details can be considered the first description of methodic of using spreadsheets for neural network simulation.

In their article of 2012 [46], Thomas F. Rienzo and Kuriakose K. Athappilly from Haworth College of Business at Western Michigan University consider model illustrating the process of machine learning as networks examine training data would provide another. Authors incorporate the stepwise learning processes of artificial neural network in a spreadsheet containing (1) a list or table of training data for binary input combinations, (2) rules for target outputs, (3) initial weight factors, (4) threshold values, (5) differences between target outputs and neural network transformation values, (6) learning rate factors, and (7) weight adjustment calculations. Unlike the previous ones, this model is invariant to the spreadsheet and does not call for applying any third-party add-ins.

The conducted review makes it possible to find the following solutions of the problem of computer simulation teaching to neural networks in the spreadsheet environment:

- joint application of spreadsheets and neural network tools [29], in which data is exported to the unit calculating weighting factors imported to spreadsheets and used in calculations;
- application of third-party add-ins for spreadsheets [9, 21, 36, 48], according to which structured spreadsheet data is processed in the add-in, calculation results are arranged in spreadsheet cells;
- macros development [3, 8, 64, 73] enables direct software control over neural network training and creation of a user's specialized interface;
- application of standard add-ins for optimization [9, 22, 36] calls for transparent network realization and determination of an optimization criterion (minimization of a squared deviation total of the calculated and etalon outputs of the network);
- creation of neural networks in the spreadsheet environment without add-ins and macros [46] requires transparent realization of a neural network with evident determination of each step of adjustment of its weighting factors.

The advantage of the first solution is its flexibility as one can choose any relevant combinations of the simulation environments, yet, their integration level is usually insufficient. The closed character of the second solution and its binding to a certain software platform make it relevant to be applied to solving various practical tasks and irrelevant for neural network simulation training as a network becomes a black box for a user. The fourth solution is partially platform-dependent as a neural network becomes a grey box for a user. The final solution is totally mobile and offers an opportunity to regard the model as a white box, thus making it the most relevant for initial mastering of neural network simulation methods.

3 The Aim and Objectives of the Study

The research is aimed at considering mathematical models of neural networks realized in spreadsheet environment.

To accomplish the set goal, the following tasks are to be solved:

1. to distinguish learning tools of computer simulation of neural networks in the spreadsheet environment;
2. to study mathematical models of neural networks at the beginning of the Age of Camelot [7].

4 Mathematical models of neural networks at the beginning of the Age of Camelot (1933–1947)

Russell C. Eberhart and Roy W. Dobbins [7] suggest dividing the history of artificial network development into four stages. The first stage, the Age of Camelot, starts with "The Principles of Psychology" (1890) by the American psychologist, William James, who formulates the elementary law of association: "When two elementary brain processes have been active together or in immediate succession, one of them, on re-occurring, tends to propagate its excitement into the other" [20, p. 566]. The elementary law of association (the elementary principle) is closely related to the concepts of associative memory and correlational learning. In the authors' opinion [7], William James seemed to foretell the notion of a neuron's activity being a function of the sum of its inputs, with past correlation history contributing to the weight of interconnections: "The amount of activity at any given point in the brain-cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate (1) to the number of times the excitement of each other point may have accompanied that of the point in question; (2) to the intensity of such excitements; and (3) to the absence of any rival point functionally disconnected with the first point, into which the discharges might be diverted" [20, p. 567].

William James illustrates his elementary principle by total recall example: "Suppose, for example, we begin by thinking of a certain dinner-party. The only thing which all the components of the dinner-party could combine to recall would be the first concrete occurrence which ensued upon it. All the details of this occurrence could in turn only combine to awaken the next following occurrence, and so on. If *a*, *b*, *c*, *d*, *e*, for instance, be the elementary nerve-tracts excited by the last act of the dinner-party, call this act **A**, and *l*, *m*, *n*, *o*, *p* be those of walking home through the frosty night, which we may call **B**, then the thought of **A** must awaken that of **B**, because *a*, *b*, *c*, *d*, *e*, will each and all discharge into *l* through the paths by which their original discharge took place. Similarly they will discharge into *m*, *n*, *o*, and *p*; and these latter tracts will also each reinforce the other's action because, in the experience **B**, they have already vibrated in unison. The lines in ... (Fig. 3) symbolize the summation of discharges into each of the components of **B**, and the consequent strength of the combination of influences by which **B** in its totality is awakened." [20, p. 569].

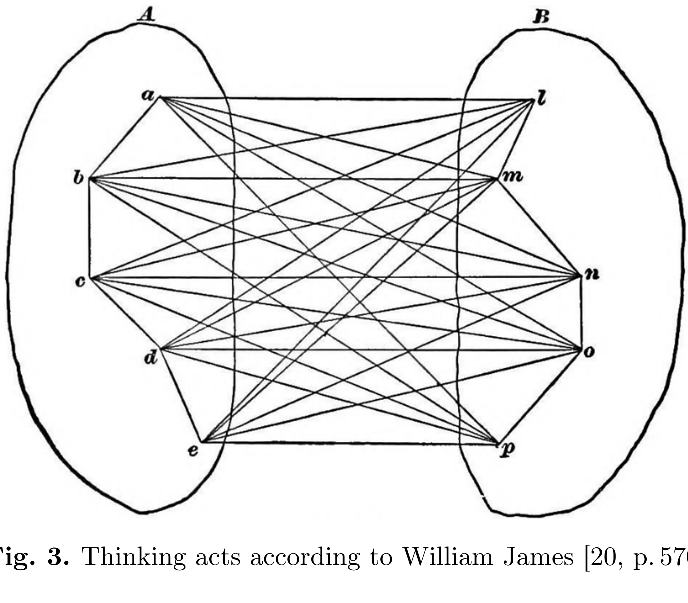


Fig. 3. Thinking acts according to William James [20, p. 570]

Fig. 3 reveals the neural network depicting connection between two conditions. Applying the elementary principle to analyzing forgetting and recall, William James creates an associative neural network (Fig. 4): "The whole process can be rudely symbolized in a diagram. Call the forgotten thing **Z**, the first facts with which we felt it was related *a*, *b*, and *c*, and the details finally operative in calling it up, *l*, *m*, and *n*. Each circle will then stand for the brain-process principally concerned in the thought of the fact lettered within it. The activity in **Z** will at first be a mere tension; but as the activities in *a*, *b*, and *c* little by little irradiate into *l*, *m*, and *n*, and as `all` these processes are somehow connected with **Z**, their combined irradiations upon **Z**, represented by the centripetal arrows, succeed in rousing **Z** also to full activity. ... `Turn now to the case of finding the unknown means to a distinctly conceived end`. The end here stands in the place of *a*, *b*, *c*, in the diagram. It is the starting-point of the irradiations of suggestion; and here, as in that case, what the voluntary attention does is only to dismiss some of the suggestions as irrelevant, and hold fast to others which are felt to be more pertinent — let these be symbolized by *l*, *m*, *n*. These latter at last accumulate sufficiently to discharge all together into **Z**, the excitement of which process is, in the mental sphere, equivalent to the solution of our problem. The only difference between this case and the last, is that in this one there need be no original sub-excitement in **Z**, cooperating from the very first. When we seek a forgotten name, we must suppose the name's centre to be in a state of active tension from the very outset, because of that peculiar feeling of `recognition` which we get at the moment of recall." [20, pp. 586–588].

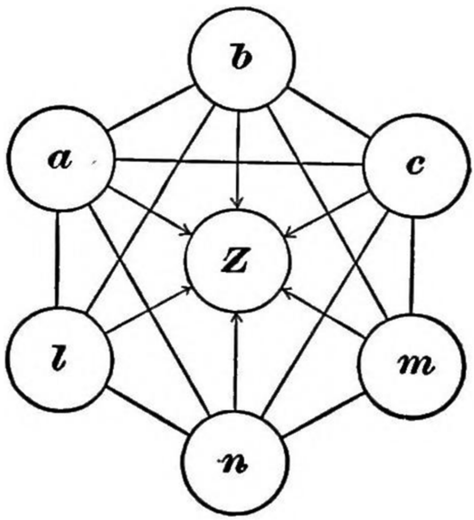


Fig. 4. The recall process according to William James [20, p. 586]

In "Psychology" (1892), an abridged re-edition of "The Principles of Psychology", William James formulates basic principles of the image recognition theory: "We know, in short, a lot `about` it, whilst as yet we have no `acquaintance` with it. Our perception that one of the objects which turn up is, at last, our `qucesitum`, is due to our recognition that its relations are identical with those we had in mind, and this may be a rather slow act of judgment. Every one knows that an object may be for some time present to his mind before its relations to other matters are perceived. Just so the relations may be there before the object is." [19, p. 275].

"The Bulletin of Mathematical Biophysics" has been an advanced platform for approbating network models and methods since the moment of its foundation by Nicolas Rashevsky in 1939 [6]. It should be no surprise as Nicolas Rashevsky invented one of the first models of the neuron [43] and started the idea of artificial neural networks. The basic idea was to use a pair of linear differential equations and a nonlinear threshold operator (1):

$$\begin{aligned} &Input := I(t) \\ &\begin{cases} \dfrac{de}{dt} = AI(t) - ae \\ \dfrac{dj}{dt} = BI(t) - bj \end{cases} \\ &Output := H(e - j - \theta) \end{aligned} \tag{1}$$

where θ is the threshold, e and j could represent excitation and inhibition or the amount or concentration of two substances within a neuron, $H(x)$ is the Heaviside operator (takes positive values to 1, and non-positive values to 0). This gives an easy way to model the all-or-none firing of a neuron — Nicolas Rashevsky showed that this simple model was able to model many of the known experimental results for the behavior of single neurons. He also made the point that networks of these model neurons could be connected to give quite complicated behavior and even serve as a model for a brain [6].

In his article of 1941, Gale J. Young ("the best theoretical engineer" of Manhattan Project [63]) [72], shows that the Nicolas Rashevsky two-factor model of nerve excitation can account for sustained inhibition or enhancement by a sequence of stimulus pulses, and for the decrease in the reinforcement period with each successive pulse of the train.

Developing Nicolas Rashevsky's ideas, his student Alston Scott Householder, who gave his name to the known linear transformation describing a reflection about a plane or hyperplane containing the origin, and a class of root-finding algorithms used for functions of one real variable with continuous derivatives up to some order, in his article of 1940 [13], suggests a parameter measuring the "strength" of the inhibitory neurons acting among the terminal synapses. In [16], he describes the activity parameter as a characteristic of the fiber which is assumed to be different from zero, but it may be either positive (when the fiber is excitatory in character) or negative (when the fiber is inhibitory in character). In Householder's articles of 1941–1942:

- Preliminary consideration is given to the steady-state activity of some simple neural structures. It is assumed as a first approximation that while acted upon by a constant stimulus, each fiber reaches a steady-state activity whose intensity is a linear function of the applied stimulus. It is shown by way of example that for a simple two-fiber circuit of inhibitory neurons knowledge of the stimuli applied to the separate fibers does not necessarily suffice to determine uniquely the activity that will result. On the other hand, there are deduced certain restrictions on the possible types of activity that may be consistent with a given pattern of applied stimulation [16].
- It is found that for a simple circuit of neurons, if this contains an odd number of inhibitory fibers, or none at all, or if the product of the activity parameters is less than unity, then the stimulus pattern always determines uniquely the steady-state activity. For circuits not of one of these types, it is possible to classify exclusively and exhaustively all possible activity patterns into three types, here called "odd", "even", and "mixed". For any pattern of odd type and any pattern of even type there always exists a stimulus pattern consistent with both, but in no other way can such an association of activity patterns be made [17].
- It is shown here that when the product of the activity parameters of the neural circuit is not exceeded by unity (algebraically) a steady state is not possible in which all fibers of the circuit are active, whereas when this product is exceeded by unity, any stimulus pattern which is consistent with such a state of complete activity is inconsistent with any state of partial activity of the circuit [14].
- Conditions under which either of two distinct activity patterns may arise from the same stimulus pattern are deduced for the case of a network which consists of N simple circuits all jointed at a common synapse. If the product of the activity parameters of all the fibers in any circuit is called the activity parameter of the circuit, or, more briefly, the circuit parameter, then the condition for the existence of

> such mutually consistent activity patterns is that there be a sum of circuit parameters which is not less than unity [15].

Thus, at the beginning of 1942, the theory of biological neural networks based on Nicolas Rashevsky's continuous two-factor model was created and intensively developed. As remembered by J. A. Anderson and E. Rosenfeld, at the boundary of two decades, Walter Pitts was introduced to Nicolas Rashevsky by Rudolf Carnap, and accepted in to his mathematical biology group [5]. In his early publication, Walter Pitts suggests "a new point of view in the theory of neuron networks is here adumbrated in its relation to the simple circuit: it is shown how these methods enable us to extend considerably and unify previous results for this case in a much simpler way" [33, p. 121]. With due consideration of Householder's articles, Walter Pitts determines the total conduction time of a fiber as the sum of its conduction time and the synaptic delay at the postliminary synapse. Walter Pitts was the first to use spreadsheet abstraction and discrete description of neural network functioning by determining a corresponding algorithm: "The excitation-pattern of [neural circuit] C may be described in a *matrix* E, of n rows and an infinite number of columns, each of whose elements e_{rs} represents the excitation at the synapse s_r during the interval $(s, s+1)$. The successive entries in the excitation matrix E may be computed recursively from those in its first column — these are the quantities λ_r — by the following rule, whose validity is evident: Given the elements of the p-th column, compute those of the $p+l$-st thus: if the element e_{ip} is negative or zero, place σ_{i+l} in the $i+l$-st row and $p+1$-st column, or in the first row of the $p+l$-st column if $i = n$. Otherwise put $\sigma_{i+l} + a_i e_{ip}$, in this place. We shall say that C is in a *steady-state* during a series of n intervals $(s, s+1)$, ..., $(s+n-1, s+n)$ if, for every p between s and $s+n$, the p-th and $p+n$-th columns of E are identical. If s is the smallest integer for which this is the case, we shall say that the steady state begins at the interval $(s, s+1)$" [33, pp. 121–122]. Rather than analyzing the steady-state activity of networks, Walter Pitts was more concerned with initial nonequilibrium cases, and how a steady state could be achieved [2, p. 18].

The suggested algorithm describes a parallel neural network: "It will be seen that the construction of the matrix E implies that its infinite diagonals — where we take a diagonal to start again at the top of the succedent column whenever it reaches the last row of E — are wholly independent of one another, so that if we know the starting point of a diagonal of E_s, we can calculate the entries along it uncognizant of any other values in the matrix. Physically, this of course means that the activity in C

can be regarded as composed of wholly independent impulses, commencing originally at a synapse s_j with a value λ_j, and journeying around C in irrelation to the impulses beginning at other synapses. We shall find it convenient to adopt this standpoint, and consider only the case of a single impulse, so that the complete solution must be derived by combining the results of our subsequent procedures for the separate diagonals, and a steady-state for the whole circuit is attained only when one has accrued for each separate diagonal [33, p. 122].

The results provided by Walter Pitts in his articles on the linear theory of neuron networks (the static problem [35] and the dynamic problem [34]), enabled him to draw two essential conclusions: (1) it is possible to find a set of independent networks each of which consists of n simple circuits with one common synapse (*rosettes*), such that network arises by running chains from the centers of the rosettes to various designated points outside: but none back, so that the state of the whole network is determined by the states of the separate rosettes independently — Pitts calls networks of this kind *canonical networks* [34, p. 29]; (2) given any finite network, it is possible to find a set of independent rosettes such that the excitation function of network for every region is a linear combination of those of the rosettes — i. e., we can reduce any network to a canonical network having the same excitation function [34, p. 31]. Thus, in his article of 1943, Walter Pitts solves the inverse network problem, "which is, given a preassigned pattern of activity over time, to construct when possible a neuron-network having this pattern" [34, p. 23] by allowing creating problem-oriented neural networks. Tara H. Abraham indicates that adopting Householder's model of neural excitation, Walter Pitts develops a simpler procedure for the mathematical analysis of excitatory and inhibitory activity in a simple neuron circuit, and aimed to develop a model applicable to the most general neural network possible [2].

"Psychometrika", the official journal of the Psychometric Society (both founded in 1935 by Louis Leon Thurstone, Edward Lee Thorndike and Joy Paul Guilford), is devoted to the development of psychology as a quantitative rational science. It has become another mouthpiece of Nicolas Rashevsky and his students, whose articles examine statistical methods, discuss mathematical techniques, and advance theory for evaluating behavioral data in psychology, education, and the social and behavioral sciences generally. Walter Pitts's article "A general theory of learning and conditioning" has been published in this journal. "The field of conditioning and learning has attained a development on the purely experimental side which renders it an excellent point for the entry of quantitative theory into psychology... The work of this kind done so far has been chiefly from two standpoints: the first ... attempts with some success to explain the phenomena directly upon a neurological basis, while the second ... prefers to elaborate first a macroscopic account of behavior per se, while leaving the neurological foundations until a later stage. These two approaches are of course rather complementary than competitive: the development of theoretical neurology provides very many suggestions for macroscopic work, and the latter simplifies the neurological problem by requiring mechanisms to account for only a few general propositions instead of a multitude of facts in no obvious relation. ... We shall consider the results of our discussion applicable to all aspects of learning and conditioning in which the effect of symbolic or verbal factors is not of great significance; and within this field we shall deal with all eases of learning and conditioning in which independent or related stimuli, with given original tendencies to produce specified types of response, are distributed over time in specified intensities in an arbitrary way, continuous or otherwise; and in which affective stimulation, if this form part of the experimental routine, is distributed in any given manner. In partial confirmation of our hypotheses, we shall point out how most of the principal experimental generalizations can be inferred from the theory, at least as regards comparative order of magnitude; while a rigid quantitative test would require data in a detail not ordinarily given in experimental results. The theory does not seem too difficult to verify in most of its aspects, however, by a fairly extended and precise set of experiments, whose performance would also provide direct information upon a number of matters of considerable import upon which little data are available, and which, even if disconfirming our present system in some of its aspects, would assuredly make suggestions leading to a better one of comparable range and generality." [31, pp. 1–3]

Part I [31] deals only with the case where the stimuli and responses are wholly independent, so that transfer and generalization do not occur, and proposes a law of variation for the reaction-tendency, which takes into account all of classical conditioning and the various sorts of inhibition affecting it. Part II [32] extends a mathematical theory of non-symbolic learning and conditioning, still under the hypothesis of complete independence, to cases where reward and punishment are involved as motivating factors. The preceding results are generalized to the case where stimuli and responses are related psychophysically, thus constituting a theory of transfer, generalization, and discrimination.

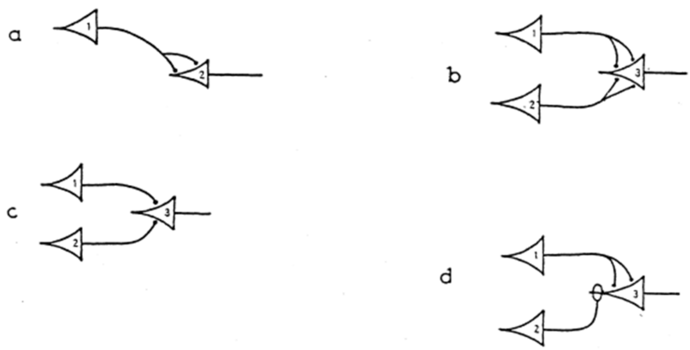
Another article of 1943, "A logical calculus of the ideas immanent in nervous activity" [26], published again in "Bulletin of Mathematical

Biophysics", has resulted from cooperation of Warren Sturgis McCulloch and Walter Pitts and is considered one of the most famous papers on artificial neural networks. They stated five physical assumptions for nets without circles [26, p. 118]:

1. The activity of the neuron is an "all-or-none" process [any nerve has a finite threshold and the intensity of excitation must exceed this for production of excitation — once produced, the excitation proceeds independently of the intensity of the stimulus].
2. A certain fixed number of synapses must be excited within the period of latent addition [time during which the neuron is able to detect the values present on its inputs, the synapses — typically less than 0.25 msec] in order to excite a neuron at any time, and this number is independent of previous activity and position on the neuron.
3. The only significant delay within the nervous system is synaptic delay [time delay between sensing inputs and acting on them by transmitting an outgoing pulse, — typically less than 0.5 msec].
4. The activity of any inhibitory synapse absolutely prevents excitation of the neuron at that time.
5. The structure of the net does not change with time.

The neuron described by these five assumptions is known as the McCulloch-Pitts neuron [7, p. 17]. In the same way as propositions in propositional logic can be "true" or "false," neurons can be "on" or "off" — they either fire or they do not: this formal equivalence allowed them to argue that the relations among propositions can correspond to the relations among neurons, and that neuronal activity can be represented as a proposition [2, p. 19]. "In this way all nets may be regarded as built out of the fundamental elements of Figures a, b, c, d, precisely as the temporal propositional expressions are generated out of the operations of precession, disjunction, conjunction, and conjoined negation. In particular, corresponding to any description of state, or distribution of the values *true* and *false* for the actions of all the neurons of a net save that which makes them all false, a single neuron is constructible whose firing is a necessary and sufficient condition for the validity of that description. Moreover, there is always an indefinite number of topologically different nets realizing any temporal propositional expression" [26, p. 121].

Fig. 5 reveals fundamental elements of McCulloch-Pitts neural networks. The triangle depicts the neuron body, figures in the triangles are neuron numbers, lines are axons, dots adjacent to neurons are excitatory synaptic connections, open circles adjacent to the neuron are inhibitory synaptic connections. In author's expressions for the figures, the dots on either side of the "≡" symbol act as separators, ≡ act as biconditional logical connectives (logical equivalence), single dots act as conjunction (logical AND), ∨ act as disjunction (logical OR), and ∼ act as negation (logical NOT).



EXPRESSION FOR THE FIGURES

a $N_2(t) \;.\!\equiv\!.\; N_1(t-1)$
b $N_3(t) \;.\!\equiv\!.\; N_1(t-1) \vee N_2(t-1)$
c $N_3(t) \;.\!\equiv\!.\; N_1(t-1) . N_2(t-1)$
d $N_3(t) \;.\!\equiv\!.\; N_1(t-1) . \sim N_2(t-1)$

Fig. 5. Fundamental elements of McCulloch-Pitts neural networks

In Fig. 5(a), neuron 2 will fire if and only if neuron 1 fires. Logically, this corresponds to the expression $N_2(t) \Leftrightarrow N_1(t-1)$, which can be read as "neuron 2 will fire at time (t) if and only if neuron 1 fires at time $(t-1)$". Fig. 5(b) shows a network that is isomorphic with the Boolean function "OR" in propositional logic. Its expression, $N_3(t) \Leftrightarrow N_1(t-1) \vee N_2(t-1)$ means that neuron 3 will fire at time (t) if and only if neuron 1 fires or neuron 2 fires at time $(t-1)$. Fig. 5(c) demonstrates the Boolean "AND" function. The expression $N_3(t) \Leftrightarrow N_1(t-1) \wedge N_2(t-1)$ means that neuron 3 will fire at time (t) if and only if neuron 1 fires at time $(t-1)$ and neuron 2 fires at time $(t-1)$. Warren Sturgis McCulloch and Walter Pitts don't provided an example of the 'clean' Boolean "NOT" function — instead it they use a conjoined negation with the instance of an inhibitory neuron. The logical expression $N_3(t) \Leftrightarrow N_1(t-1) \wedge \neg N_2(t-1)$ corresponding to Fig. 5(d), means that neuron 3 will fire at time (t) only if neuron 1 fires at time $(t-1)$ and neuron 2 does not fire at time $(t-1)$.

In [26], there is a set of theorems that "does in fact provide a very convenient and workable procedure for constructing nervous nets to order, for those cases where there is no reference to events indefinitely far in the past in the specification of the conditions" [26, pp. 121–122]. Warren Sturgis McCulloch and Walter Pitts appear to be the first authors since William James to describe a massively parallel neural model. The theories they developed were important for a number of reasons, including the fact that any finite logical expression can be realized by networks of their neurons.

Combining simple "logical" neurons in chains and cycles, the authors show that the brain is able to perform any logical operation and arbitrary logical calculations. The paper is essential for developing computing machines as it allows creating a universal computer operating with logical expressions (in the hands of John von Neumann, the McCulloch-Pitts model becomes the basis for the logical design of digital computers [6, p. 180]): "It is easily shown: first, that every net, if furnished with a tape, scanners connected to afferents, and suitable efferents to perform the necessary motor-operations, can compute only such numbers as can a Turing machine; second, that each of the latter numbers can be computed by such a net; and that nets with circles can be computed by such a net; and that nets with circles can compute, without scanners and a tape, some of the numbers the machine can, but no others, and not all of them. This is of interest as affording a psychological justification of the Turing definition of computability and its equivalents, Church's λ-definability and Kleene's primitive recursiveness: If any number can be computed by an organism, it is computable by these definitions, and conversely." [26, pp. 121–122]

In the same issue of "Bulletin of Mathematical Biophysics", in which [26] was published, Herbert Daniel Landahl (the first doctoral student in Nicolas Rashevsky's mathematical biology program at the University of Chicago, who became the second President of the Society for Mathematical Biology in 1981), Warren Sturgis McCulloch and Walter Pitts published a short (about 3 pages), yet essential addition [23], suggesting a method for converting logical relations among the actions of neurons in a net into statistical relations among the frequencies of their impulses. In the presented theorem, they detailed transition from Boolean calculations (in "true" and "false") to probabilistic ones (numbers within $[0;1]$): the conjunction sign $\vee$ is replaced by $+$, the disjunction sign (single dot) is replaced by $\times$, negation

$\sim$ is replaced by «1−», etc. The correspondence expressed by this theorem connects the logical calculus of the [26] with previous treatments of the activity of nervous nets in mathematical biophysics and with quantitatively measurable psychological phenomena.

The monograph by Alston Scott Householder and Herbert Daniel Landahl "Mathematical Biophysics of the Central Nervous System" has become a kind of conclusion of the discussed period [12]. In Paul Cull's opinion, there is no unambiguous answer to the question which model is better, the Rashevsky continuous model or the McCulloch-Pitts discrete model: "For some purposes, one model is better, but for other purposes, the other model is better. Rashevsky and Landahl were quick to notice, that in physics, one often averaged over a large set of discrete events to obtain a continuous model which represented the large scale behavior of a system, and so they posited that the continuous neuron model might be suitable for modeling whole masses of neurons even if each individual neuron obeyed a discrete model. In the hands of Householder and Landahl, this observation led to the idea of modeling psychological phenomena by neural nets with a small number of continuous model neurons. In particular, they found that the cross-couple connection (Fig. 6) was extremely useful. For such problems as reaction time, enhancement effects, flicker phenomena, apparent motion, discrimination and recognition, they were able to fit these models to experimental data and to use their models to predict phenomena that could be measured and verified" [6, p. 180].

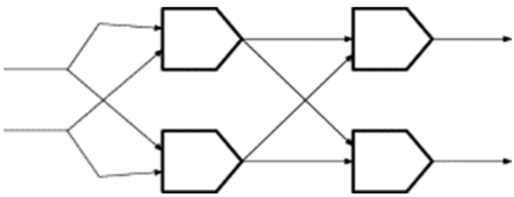


Fig. 6. This cross-couple connection of four neurons is capable of modeling a large number of phenomena (according to [6])

In 1945, Nicolas Rashevsky wrote about [26] and [23]: "authors show that by applying logical calculus, it is possible to construct any complicated network having given properties. One could attempt to construct by the method of McCulloch and Pitts a network that would represent all modes of logical reasoning, and then apply the usual methods of mathematical biophysics to derive some quantitative relations between different manifestations of the processes of logical thinking" [42, p. 146]. "It seems somewhat awkward to have to construct by means of Boolean algebra first a "microscopic circuit" and then obtain a simpler one by a transition to the "macroscopic" picture. We should expect that a generalization of the application of Boolean algebra should be possible so as to permit its use for the construction of networks in which time relations are of a continuous rather than of a quantized, nature" [44, p. 211].

Nicolas Rashevsky intensively develops the apparatus created by McCulloch and Pitts in his further papers. In [45] a theory of such neural circuits is developed which provide for formal logical thinking. As a by-product of this study, a neural mechanism is indicated which provides for the conception of ordinal numbers. A quantitative theory of the probability of erroneous reasoning and of the speed of reasoning in its relations to other psychological phenomena is suggested. Predicate apparatus application enables Nicolas Rashevsky synthesizing huge neural networks from single-type fundamental elements of McCulloch-Pitts (Fig. 7).

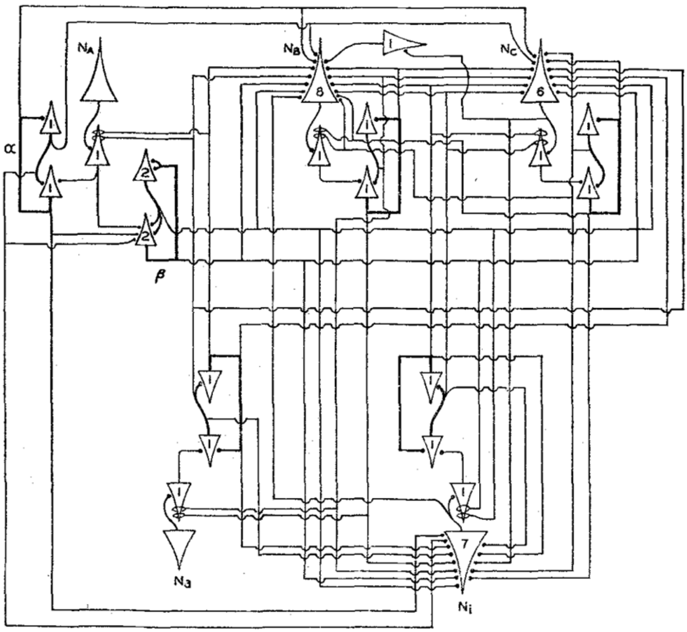


Fig. 7. Nicolas Rashevsky's complex neural network example (from [45, p. 32])

In their paper of 1946, Herbert Daniel Landahl and Richard Runge [24] make the next move towards spreadsheet interpretation of neural networks: the activity of a neural net is represented in terms of a matrix vector equation with a normalizing operator in which the matrix represents only the complete structure of the net, and the normalized vector-matrix product represents the activity of all the non-afferent neurons.

Let a net of n neurons be divided into afferents, efferents, and internal neurons. We shall only mean by an afferent a neuron not acted upon by any neuron in the net under consideration. Similarly, an efferent is a neuron which does not act on any other neuron in the net. We may, however, refer to the afferents as receptors and the efferents as effectors. Let the ρ receptor neurons be $N_1, N_2, ..., N_r, ..., N_\rho$, the τ internals be $N_{\rho+1}, ..., N_i, ..., N_{\rho+\tau}$ and the ε effector neuron be $N_{n-\varepsilon+1}, ..., N_e, ..., N_n$. Define a structure matrix F as a square matrix having the row and column indices $1, 2, ..., n$ corresponding to the n neurons such that

$$F = |f_{jk}| = \begin{array}{c} \\ 1 \\ \\ \\ \\ n \end{array} \begin{pmatrix} 1...r...\rho & \rho{+}1...i...\tau & (n{-}\varepsilon{+}1)...e...n \\ 0 & F_R & F_X \\ \cdots & \cdots & \cdots \\ 0 & F_I & F_E \\ \cdots & \cdots & \cdots \\ 0 & 0 & 0 \end{pmatrix} \qquad (2)$$

Each element in row j determines which neurons are acted upon by neuron N_j and in what manner. Similarly each element in column k determines which neurons act upon N_k and in what manner. The matrices F_R, F_X, F_I, and F_E, appearing in equation (2), determine respectively the relationships receptor-internal, receptor-effector, internal-internal, and internal-effector. Define the matrix R as the $n \times n$ matrix, obtained from F by substituting zeros for all elements except those of F_R. Define in a similar way the matrices X, I, and E. We shall assume that no neuron acts upon itself so that $f_{kk} = 0$ for all k, and F and F_I have all diagonal elements equal to zero.

If any row α in F contains only positive or zero elements, then N_α is a purely excitatory neuron. If any row β in F contains only negative or zero elements, then N_β is a purely inhibitory neuron. If both positive and negative elements occur in a given row, the corresponding neuron may be referred to as a mixed neuron.

Define the $(1 \times n)$ row matrix or vector $\boldsymbol{a}$, by

$$\boldsymbol{a}(t) = (a_1, ..., a_r, ..., a_\rho, a_{\rho+1}, ..., a_i, ..., a_\tau, a_{n-\varepsilon+1}, ..., a_e, ..., a_n), \qquad (3)$$

where any element a_j is 1 or 0 depending on whether N_j does or does not act at the time t. The vector $\boldsymbol{a}(t)$ may be referred to as the activity vector at the time t. This vector may be written as the sum of three $(1 \times n)$ vector components, $\boldsymbol{r}$, $\boldsymbol{i}$, $\boldsymbol{e}$, the receptor, internal, and effector components having the respective set of elements a_r, a_i, and a_e only, and zeros elsewhere. The scalar quantity $v_k(t)$ given by the sum

$$v_k(t) = \sum_{j \in \beta} f_{jk} = \sum_{j=1}^{N} a_j(t-1) f_{jk}, \tag{4}$$

taken over a class β of neurons which is defined as the class of all neurons synapsing on N_k which are active at $t - l$, gives a measure of the net excitation affecting the neuron N_k. A vector $\boldsymbol{v}(t)$, whose components for $k > \rho$ are the values of $v_k(t)$ and for $k \leq \rho$ — the values of $a_k(t)$, can be expressed as

$$\boldsymbol{v}(t) = \boldsymbol{r}(t) + \boldsymbol{a}(t-1)F. \tag{5}$$

In order to normalize $\boldsymbol{v}(t)$, let $\mathcal{G}$ be a post-operator on a row vector, such that, if $[\boldsymbol{v}\mathcal{G}]_k$ is the kth component of the vector $[\boldsymbol{v}\mathcal{G}](t)$,

$$[\boldsymbol{v}\mathcal{G}]_k = \begin{cases} 1 & \text{if } v_k \geq 1; \\ 0 & \text{if } v_k < 1. \end{cases} \tag{6}$$

Since $\mathcal{G}$ operates only on a vector appearing just to the left of it, and not on a matrix, the expression $(\boldsymbol{v}F)\mathcal{G}$ may be written $\boldsymbol{v}F\mathcal{G}$ (the parenthesis could not be eliminated if a pre-operator were used). Equation (5) may be written

$$\boldsymbol{a}(t) = \boldsymbol{v}(t)\mathcal{G} = [\boldsymbol{r}(t) + \boldsymbol{a}(t-1)F]\mathcal{G}. \tag{7}$$

According to the given theorem [60, p. 78], the activity of any net represented by a structure matrix F is determined from the afferent stimulation and its activity at the beginning of the prior interval of time according to the equation

$$\boldsymbol{a}(t) = \boldsymbol{r}(t) + \boldsymbol{a}(t-1)F\mathcal{G}. \tag{8}$$

Equation (8) leads to the recursion formula

$$\boldsymbol{a}(t) = \boldsymbol{r}(t) + \{\boldsymbol{r}(t-1) + [\boldsymbol{r}(t-2) + \cdots + \\ + [\boldsymbol{r}(2) + [\boldsymbol{r}(1) + \boldsymbol{a}(0)F\mathcal{G}]F\mathcal{G}] \ldots \\ \ldots F\mathcal{G}]F\mathcal{G}\}F\mathcal{G}. \quad (9)$$

The vector quantity between the first and last brackets in expression (9) is simply the vector $\boldsymbol{a}(t-1)$.

Thus if the structure of a net is known together with a sequence of $\boldsymbol{r}$'s, $\boldsymbol{r}(0)$, $\boldsymbol{r}(1)$, ..., $\boldsymbol{r}(\tau-1)$, and the initial activity of the internal neurons $\boldsymbol{i}(0)$, it is possible from equation (9) to determine the activities of the net for any time t from 0 to τ, $\boldsymbol{a}(1)$, $\boldsymbol{a}(2)$, ..., $\boldsymbol{a}(\tau)$.

Because of the character of the structure matrix F, equation (8) may be written as a pair of equations

$$\boldsymbol{i}(t) = [\boldsymbol{r}(t-1)R + \boldsymbol{i}(t-1)I]\mathcal{G}, \quad (10)$$

$$\boldsymbol{e}(t) = [\boldsymbol{r}(t-1)X + \boldsymbol{i}(t-1)E]\mathcal{G}, \quad (11)$$

from which one may determine successively $\boldsymbol{i}(t)$ and $\boldsymbol{e}(t)$ for every t. For both $\boldsymbol{i}(t)$ and $\boldsymbol{e}(t)$ formulas similar to expression (9) can be written.

From equation (10), it is evident that the sequence of $\boldsymbol{i}$'s can be determined from a knowledge of the afferent-internal structure and internal-internal structures, together with the sequence of afferent activities and an initial internal activity pattern. On the other hand, to determine the sequence of $\boldsymbol{e}$'s, that is, the pattern of the efferent activity, one must also know the rest of the structure of the net.

Every row and column of F, excluding the first ρ columns and last ε rows, contains at least one non-zero entry; otherwise, it represents an afferent or efferent. If only one non-zero entry occurs in any column, it may be replaced by unity, for if it is less than one, the neuron of the corresponding column can never act, and thus this neuron should be deleted. Furthermore, there is no restriction to set an element equal to one, if this element is greater than one.

$$F = \begin{array}{c} \\ 1 \\ 2 \\ a \\ b \\ 3 \\ 4 \end{array}\begin{array}{c} \begin{array}{cccccc} 1 & 2 & a & b & 3 & 4 \end{array} \\ \begin{pmatrix} 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & -1 & 0 & 1/2 \\ 0 & 0 & 0 & 1 & 0 & 1/2 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix} \end{array}$$

Authors give an example of the application of the presented in [24] method — the matrix F for the circuit illustrated in Fig. 8.

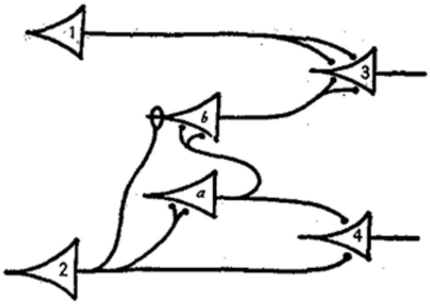


Fig. 8. Figure 1e of the paper "A logical calculus of the ideas immanent in nervous activity" [26]

If the net is initially at rest, then, according to [26], the expression for neuron 3 is $N_3(t) \Leftrightarrow N_1(t-1) \vee N_2(t-3) \wedge \neg N_2(t-2)$ and the condition for the activity of neuron 3 at $t = 0$, is either that neuron 2 acts at $t = -3$ but not at $t = -2$; or that neuron 1 acts at $t = -1$. That is, the sequence of $\boldsymbol{r}$'s, writing only the a_r, components, $\boldsymbol{r}(-3) = (0, 1)$, $\boldsymbol{r}(-2) = (0, 0)$, $\boldsymbol{r}(-1) = (0, 0)$ as well as the sequence $\boldsymbol{r}(-1) = (1, 0)$ is adequate to produce activity in neuron 3. Assume that $\boldsymbol{r}(t) = 0$ for all $t \geq 0$. If $\boldsymbol{r}(-3) = (0, 1)$ then from equation (8) $\boldsymbol{a}(-2) = (0, 0; 1, -1; 0, {}^1\!/_2)\mathcal{G} = (0, 0; 1, 0; 0, 0)$, $\boldsymbol{a}(-1) = (0, 0; 0, 1; 0, 0)$, and $\boldsymbol{a}(0) = (0, 0; 0, 0; 1, 0)$, so that $\boldsymbol{e}(0)$, writing only the a_e components is $\boldsymbol{e}(0) = (1, 0)$, that is, neuron 3 acts but 4 does not. Similarly if $\boldsymbol{r}(-1) = (1, 0)$ then from equation (8) $\boldsymbol{e}(0) = (1, 0)$. For both sequences $\boldsymbol{a}(1) = 0$.

The expression for neuron 4 is $N_4(t) \Leftrightarrow N_2(t-2) \wedge N_2(t-1)$, the condition for neuron 4 to act as $t = 0$ is that neuron 2 acts at $t = -2$ and at $t = -1$. If $\boldsymbol{r}(-2) = (0, 1)$ and $\boldsymbol{r}(-1) = (0, 1)$, then from equation (8) $\boldsymbol{a}(-1) = (0, 1; 1, 0; 0, 0)$ and $\boldsymbol{a}(0) = (0, 0; 1, 0; 0, 1)$, so that neuron 4 acts but 3 does not. For this sequence $\boldsymbol{a}(1) = (0, 0; 0, 1; 0, 0)$ and $\boldsymbol{a}(2) = (0, 0; 0, 0; 1, 0)$ so that neuron 3 always acts as a unit of time after discontianuation of continuous stimulation of neuron 2.

In a paper [24] a method was given by which the efferent activity of an idealized neural net could be calculated from a given afferent pattern. Those results are extended in the next-year paper [25]: (1) conditions are given under which nets may be considered equivalent, (2) rules are given for the reduction or extension of a net to an equivalent net, (3) a procedure is given for constructing a net which has the property of converting each of a given set of afferent activity patterns into its corresponding prescribed efferent activity pattern.

Telson Wei develops another approach to matrix representation of a neural network [62]. The structure of a complete or incomplete neural net is represented here by several matrices: the intensity matrix E, the connection matrix D, the structural matrix T, the diagonal inverse threshold-matrix H, and activity vector $\boldsymbol{a}$ from [24, 25]. The activity equation of the net follows in a general form. A chain or cycle is defined as a neural structure whose connection matrix is unitary. Telson Wei computes the number of simple chains by a recurrent formula.

In their paper of 1948 [50], Alfonso Shimbel and Anatol Rapoport (pioneered in the modeling of parasitism and symbiosis, researching cybernetic theory) develop a probabilistic approach to the theory of neural nets: neural nets are characterized by certain parameters which give the probability distributions of different kinds of synaptic connections throughout the net. In their further papers, they consider steady states in random nets [36, 41] and contribution to the probabilistic theory of neural nets: randomization of refractory periods and of stimulus intervals [37], facilitation and threshold phenomena [38], specific inhibition [39] and various models for inhibition [40].

The last joint article by Walter Pitts and Warren Sturgis McCulloch, "How we know universals the perception of auditory and visual forms", in "Bulletin of Mathematical Biophysics" came out in 1947. "Numerous nets, embodied in special nervous structures, serve to classify information according to useful common characters. In vision they detect the equivalence of apparitions related by similarity and congruence, like those of a single physical thing seen from various places. In audition, they recognize timbre and chord, regardless of pitch. The equivalent apparitions in all cases share a common figure and define a group of transformations that take the equivalents into one another but preserve the figure invariant. So, for example, the group of translations removes a square appearing at one place to other places; but the figure of a square it leaves invariant. ... We seek general methods for designing nervous nets which recognize figures in such a way as to produce the same output for every input belonging to the figure. We endeavor particularly to find those which fit the histology and physiology of the actual structure." [30, pp. 127–128]

Two neural mechanisms are described which exhibit recognition of forms. Both are independent of small perturbations at synapses of excitation, threshold, and synchrony, and are referred to particular appropriate regions of the nervous system, thus suggesting experimental verification. The first mechanism averages an apparition over a group, and in the treatment of this mechanism it is suggested that scansion plays a significant part. The second mechanism reduces an apparition to a standard selected from among its many legitimate presentations. The former mechanism is exemplified by the recognition of chords regardless of pitch and shapes regardless of size. Both are extensions to contemporaneous functions of the knowing of universals heretofore treated by the authors only with respect to sequence in time.

"We have focused our attention on particular hypothetical mechanisms in order to reach explicit notions about them which guide both histological studies and experiment. If mistaken, they still present the possible kinds of hypothetical mechanisms and the general character of circuits which recognize universals, and give practical methods for their design. These procedures are a systematic development of the conception of reverberating neuronal chains, which themselves, in preserving the sequence of events while forgetting their time of happening, are abstracted universals of a kind. Our circuits extend the abstraction to a wide realm of properties. By systematic use of the principle of the exchangeability of time and space, we have enlarged the realm enormously. The adaptability of our methods to unusual forms of input is matched by the equally unusual form of their invariant output, which will rarely resemble the thing it means any closer than a man's name does his face." [30, p. 146]

Thus, the models and methods developed by Walter Pitts and Warren Sturgis McCulloch have created a foundation for designing a new type of computers — neurocomputers based on human brain principles and able to solve tasks of recognizing distorted (noisy) images.

5 Conclusions

1. Extensive application of artificial intelligence in everyday life calls for students' early acquaintance with its models and methods including neural network-based while teaching informatics at secondary schools. It conditions the need for developing training methods of computer simulation of neural networks in the general-purpose simulation environment, i.e. spreadsheets.

2. Basic solutions of the problem of computer simulation training of neural networks in the spreadsheet environment include: 1) joint application of spreadsheets and network simulation tools; 2) application of third-party add-ins to spreadsheet processors; 3) macros development using embedded languages of spreadsheet

processors; 4) application of standard spreadsheet add-ins for non-linear optimization; 5) creation of neural networks in the spreadsheet environment without add-ins and macros.

3. Neural network simulation competences should be formed through mastering models based on the historical and genetic approach. The review of papers on computational neuroscience of its early period allows determining three groups of models, which are helpful for developing corresponding methods: the continuous two-factor model of Rashevsky, the discrete model of McCulloch and Pitts, and the discrete-continuous models of Householder and Landahl.
4. Further research implies considering mathematical models of the Age of Camelot and developing their spreadsheet interpretations of various complexity.

References

1. Abelson, H., Sussman, G. J., Sussman, J.: Structure and Interpretation of Computer Programs. 2nd edn. MIT Press, Cambridge (1996).
2. Abraham, T. H.: (Physio)logical circuits: The intellectual origins of the McCulloch-Pitts neural networks. Journal of the History of the Behavioral Sciences. 38 (1), 3–25 (2002). doi: 10.1002/jhbs.1094
3. Ayed, A. S.: Parametric Cost Estimating of Highway Projects using Neural Networks. Master thesis, Memorial University (1997).
4. Buergermeister, J. J.: Using Computer Spreadsheets for Instruction in Cost Control Curriculum at the Undergraduate Level. In: Dalton, D. W. (ed.) Restructuring Training and Education through Technology, Proceedings of the 32nd Annual Conference of the Association for the Development of Computer-Based Instructional Systems, San Diego, California, October 29 — November 1, 1990, pp. 214–220. ADCIS International, Columbus (1990).
5. Cowan, J. D. Interview with J. A. Anderson and E. Rosenfeld. In: Anderson, J. A., Rosenfeld, E. (eds.) Talking nets: An oral history of neural networks, pp. 97–124. MIT Press, Cambridge (1998).
6. Cull P.: The mathematical biophysics of Nicolas Rashevsky. BioSystems. 88 (3), 178–184 (2007). doi: 10.1016/j.biosystems.2006.11.003
7. Eberhart, R. C., Dobbins, R. W.: CHAPTER 1 — Background and History. In: Eberhart, R. C., Dobbins, R. W. (eds.) Neural Network PC Tools: A Practical Guide, pp. 9–34. Academic Press, San Diego (1990).

8. Freedman, R. S., Frail, R. P., Schneider, F. T., Schnitta, B.: Expert Systems in Spreadsheets: Modeling the Wall Street User Domain. In: Proceedings First International Conference on Artificial Intelligence Applications on Wall Street, Institute of Electrical and Electronics Engineers, New York, 9–11 Oct. 1991.
9. Hegazy, T., Ayed, A.: Neural Network Model for Parametric Cost Estimation of Highway Projects. Journal of Construction Engineering and Management. 124 (3), 210–218 (1998). doi: 10.1061/(ASCE)0733-9364(1998)124:3(210)
10. Hewett, T. T.: Teaching Students to Model Neural Circuits and Neural Networks Using an Electronic Spreadsheet Simulator. Behavior Research Methods, Instruments, & Computers. 17 (2), 339–344 (1985). doi: 10.3758/BF03214406
11. Hewett, T. T.: Using an Electronic Spreadsheet Simulator to Teach Neural Modeling of Visual Phenomena (Report No. MWPS–F–85–1). Drexel University, Philadelphia (1985).
12. Householder, A. S., Landahl, H. D.: Mathematical Biophysics of the Central Nervous System. Principia Press, Bloomington (1945).
13. Householder, A. S.: A neural mechanism for discrimination: II. Discrimination of weights. Bulletin of Mathematical Biophysics. 2 (1), 1–13 (1940). doi: 10.1007/BF02478027
14. Householder, A. S.: A theory of steady-state activity in nerve-fiber networks III: The simple circuit in complete activity. Bulletin of Mathematical Biophysics. 3 (4), 137–140 (1941). doi: 10.1007/BF02477933
15. Householder, A. S.: A theory of steady-state activity in nerve-fiber networks IV. N circuits with a common synapse. Bulletin of Mathematical Biophysics. 4 (1), 7–14 (1942). doi: 10.1007/BF02477933
16. Householder, A. S.: A theory of steady-state activity in nerve-fiber networks I: Definitions and Preliminary Lemmas. Bulletin of Mathematical Biophysics. 3 (2), 63–69 (1941). doi: 10.1007/BF02478220
17. Householder, A. S.: A theory of steady-state activity in nerve-fiber networks II: The simple circuit. Bulletin of Mathematical Biophysics. 3 (3), 105–112 (1941). doi: 10.1007/BF02478168
18. Hryshchenko, N. V., Chernov, Ye. V., Semerikov, S. O.: Fizychni modeli v kursi “Osnovy kompiuternoho modeliuvannia” (Physical models in the course “Fundamentals of computer simulation”). In: Methodological

and organizational aspects of the use of the INTERNET network in the institutions of science and education (INTERNET — EDUCATION — SCIENCE — 98), 1st international scientific and practical conference, Vinnytsia, 1998, vol. 2, pp. 341–348. UNIVERSUM-Vinnytsia, Vinnytsia (1998).

19. James W.: Psychology. Henry Holt and Company, New York (1892).
20. James W.: The Principles of Psychology. Henry Holt and Company, New York (1890).
21. Johnston S. J.: Promised Land Comes Through With Braincel for Excel 3.0. InfoWorld. 13 (7), 14 (1991).
22. Kendrick, D. A., Mercado P. R., Amman H. M.: Computational Economics. Princeton University Press, Princeton (2006).
23. Landahl, H. D., McCulloch, W. S., Pitts W.: A statistical consequence of the logical calculus of nervous nets. Bulletin of Mathematical Biophysics. 5 (4), 135–137 (1943). doi: 10.1007/BF02478260
24. Landahl, H. D., Runge, R.: Outline of a matrix calculus for neural nets. Bulletin of Mathematical Biophysics. 8 (2), 75–81 (1946). doi: 10.1007/BF02478464
25. Landahl, H. D.: A matrix calculus for neural nets: II. Bulletin of Mathematical Biophysics. 9 (2), 99–108 (1947). doi: 10.1007/BF02478296
26. McCulloch, W. C., Pitts, W.: A logical calculus of the ideas immanent in nervous activity. Bulletin of Mathematical Biophysics. 5 (4), 115–133 (1943). doi: 10.1007/BF02478259
27. Mintii, I. S., Tarasov, I. V., Semerikov S. O.: Meta navchannia ta zmist kursu “Vstup do prohramuvannia” dlia maibutnikh uchyteliv informatyky (The purpose of the teaching and the contents of the course “Introduction in programming” for future computer science teacher). Visnyk Cherkaskoho universytetu. Seriia pedahohichni nauky. 279, 57–63 (2013).
28. Mintii, I. S., Tarasov, I. V., Semerikov S. O.: Metodyka formuvannia u maibutnikh uchyteliv informatyky kompetentnostei z prohramuvannia na prykladi temy “Ekspertna systema” (Methods of forming of future informatics teachers competencies in programming by example the theme “Expert system”). Naukovyi chasopys NPU im. M. P. Drahomanova. Seriia №2. Kompiuterno-oriientovani systemy navchannia. 14 (21), 91–96 (2014).

29. Permiakova, O. S., Semerikov, S. O.: Zastosuvannia neironnykh merezh u zadachakh prohnozuvannia (The use of neural networks in forecasting problems). In: Materials of the International Scientific and Practical Conference "Young scientist of the XXI century", KTU, Kryviy Rih, 17–18 November 2008.
30. Pitts, W., McCulloch, W. S.: How we know universals the perception of auditory and visual forms. Bulletin of Mathematical Biophysics. 9 (3), 127–147 (1947). doi: 10.1007/BF02478291
31. Pitts, W.: A general theory of learning and conditioning: Part I. Psychometrika. 8 (1), 1–18 (1943). doi: 10.1007/BF02288680
32. Pitts, W.: A general theory of learning and conditioning: Part II. Psychometrika. 8 (2), 131–140 (1943). doi: 10.1007/BF02288697
33. Pitts, W.: Some observations on the simple neuron circuit. Bulletin of Mathematical Biophysics. 4 (3), 121–129 (1942). doi: 10.1007/BF02477942
34. Pitts, W.: The linear theory of neuron networks: The dynamic problem. Bulletin of Mathematical Biophysics. 5 (1), 23–31 (1943). doi: 10.1007/BF02478116
35. Pitts, W.: The linear theory of neuron networks: The static problem. Bulletin of Mathematical Biophysics. 4 (4), 169–175 (1942). doi: 10.1007/BF02478112
36. Rapoport, A., Shimbel, A.: Steady states in random nets: I. Bulletin of Mathematical Biophysics. 10 (4), 211–220 (1948). doi: 10.1007/BF02477503
37. Rapoport, A.: Contribution to the probabilistic theory of neural nets: I. Randomization of refractory periods and of stimulus intervals. Bulletin of Mathematical Biophysics. 12 (2), 109–121 (1950). doi: 10.1007/BF02478248
38. Rapoport, A.: Contribution to the probabilistic theory of neural nets: II. Facilitation and threshold phenomena. Bulletin of Mathematical Biophysics. 12 (3), 187–197 (1950). doi: 10.1007/BF02478318
39. Rapoport, A.: Contribution to the probabilistic theory of neural nets: III. Specific inhibition. Bulletin of Mathematical Biophysics. 12 (4), 317–325 (1950). doi: 10.1007/BF02477902
40. Rapoport, A.: Contribution to the probabilistic theory of neural nets: IV. Various models for inhibition. Bulletin of Mathematical Biophysics. 12 (4), 327–337 (1950). doi: 10.1007/BF02477903

41. Rapoport, A.: Steady states in random nets: II. Bulletin of Mathematical Biophysics. 10 (4), 221–226 (1948). doi: 10.1007/BF02477504

42. Rashevsky, N.: Mathematical biophysics of abstraction and logical thinking. Bulletin of Mathematical Biophysics. 7 (3), 133–148 (1945). doi: 10.1007/BF02478314

43. Rashevsky, N.: Outline of a physico-mathematical theory of excitation and inhibition. Protoplasma. 20 (1), 42–56 (1933). doi: 10.1007/BF02674811

44. Rashevsky, N.: Some remarks on the boolean algebra of nervous nets in mathematical biophysics. Bulletin of Mathematical Biophysics. 7 (4), 203–211 (1945). doi: 10.1007/BF02478425

45. Rashevsky, N.: The neural mechanism of logical thinking. Bulletin of Mathematical Biophysics. 8 (1), 29–40 (1946). doi: 10.1007/BF02478425

46. Rienzo, T. F., Athappilly, K. K.: Introducing Artificial Neural Networks through a Spreadsheet Model. Decision Sciences Journal of Innovative Education. 10 (4), 515–520 (2012). doi: 10.1111/j.1540-4609.2012.00363.x

47. Ruggiero M. A.: Cybernetic Trading Strategies: Developing a Profitable Trading System with State-of-the-Art Technologies. John Wiley & Sons, New York (1997).

48. Ruggiero, M.: Embedding neural networks into spreadsheet applications. US Patent 5,241,620, 31 Aug 1993.

49. Semerikov, S. O., Teplytskyi I. O.: Shtuchnyi intelekt v kursi informatyky pedahohichnoho VNZ (Artificial intelligence in teaching informatics at pedagogical university). In: Materials of the 4th All-Ukrainian Conference of Young Scientists on the Information Technologies in Education, Science and Technology ITONT–2004, Cherkasy, 28–30 April 2004.

50. Shimbel, A., Rapoport, A.: A statistical approach to the theory of the central nervous system. Bulletin of Mathematical Biophysics. 10 (2), 41–55 (1948). doi: 10.1007/BF02478329

51. Soloviov, V. M., Semerikov, S. O., Teplytskyi, I. O.: Instrumentalne zabezpechennia kursu kompiuternoho modeliuvannia (Instrumental computer simulation courseware). Kompiuter u shkoli ta simi. 4, 28–31 (2000).

52. Soloviov, V. M., Semerikov, S. O., Teplytskyi, I. O.: Osnovy kompiuternoho modeliuvannia v serednii shkoli ta pedahohichnomu vuzi (Fundamentals of computer simulation in secondary school and higher pedagogical institutions). In: Collection of scientific and practical materials of the All-Ukrainian conference on the Pre-professional training of pupils in the context of the implementation of the target comprehensive program "Teacher", vol. 2, pp. 53–56. Dnipropetrovsk (1997).
53. Sussman, G. J., Wisdom, J.: Structure and interpretation of classical mechanics. 2nd edn. MIT Press, Cambridge (2015).
54. Teplytskyi, I., Semerikov, S.: Kompiuterne modeliuvannia mekhanichnykh rukhiv u seredovyshchi elektronnykh tablyts (Computer modeling of mechanical movements in an spreadsheets environment). Fizyka ta astronomiia v shkoli. 5, 41–46 (2002).
55. Teplytskyi, I. O., Semerikov, S. O.: Kompiuterna navchalna fizychna hra "Miaka posadka" (Computer training physical game "Soft landing"). Naukovi zapysky: zbirnyk naukovykh statei Natsionalnoho pedahohichnoho universytetu imeni M. P. Drahomanova. 53, 347–355 (2003).
56. Teplytskyi, I. O., Semerikov, S. O.: Kompiuterne modeliuvannia absoliutnykh ta vidnosnykh rukhiv planet Soniachnoi systemy (Computer simulation of absolute and relative motions of the planets the Solar system). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu. Seriia pedahohichna. 13, 211–214 (2007).
57. Teplytskyi, I. O., Semerikov, S. O.: Modeliuvannia za dopomohoiu vypadkovykh chysel (Simulation using random numbers). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu. Seriia pedahohichna. 17, 248–252 (2011).
58. Teplytskyi, I. O., Semerikov, S. O.: Na perekhresti ekolohii, matematyky, informatyky y fizyky (At the intersection of ecology, mathematics, computer science and physics). Zbirnyk naukovykh prats Kamianets-Podilskoho natsionalnoho universytetu. Seriia pedahohichna. 18, 34–37 (2012).
59. Teplytskyi, I. O.: Elementy kompiuternoho modeliuvannia (Elements of computer simulation). 2nd edn. KSPU, Kryvyi Rih (2010).
60. Teplytskyi, I. O.: Kompiuterne modeliuvannia v shkilnomu kursi informatyky (Computer simulation in the school informatics course). Nyva znan. Informatsiini tekhnolohii v osviti. 1, 63–74 (1994).

61. Teplytskyi, I. O.: Vykorystannia elektronnykh tablyts u kompiuternomu modeliuvanni (Using spreadsheets in computer simulation). Kompiuter u shkoli ta simi. 2, 27–32 (1999).

62. Wei, T.: On matrices of neural nets. Bulletin of Mathematical Biophysics. 10 (2), 63–67 (1948). doi: 10.1007/BF02477433

63. Weinberg, A. M.: Gale J. Young. Physics Today. 45 (1), 84 (1992). doi: 10.1063/1.2809507

64. Werbos, P. J.: Maximizing long-term gas industry profits in two minutes in Lotus using neural network methods. Transactions on Systems Man and Cybernetics. 19 (2), 315–333 (1989). doi: 10.1109/21.31036

65. Yechkalo, Yu .V., Teplytskyi, I. O.: Kompiuterne modeliuvannia doslidu Rezerforda v seredovyshchi elektronnykh tablyts (Computer simulation of Rutherford's experiment in a spreadsheet environment). In: Collection of scientific papers on the Modern technologies in science and education, vol. 2, pp. 56–59. KSPU Publishing department, Kryvyi Rih (2003).

66. Yechkalo, Yu. V.: Kompiuterne modeliuvannia brounivskoho rukhu (Computer simulation of the Brownian motion). Pedahohichnyi poshuk. 5, 97–100 (2010).

67. Yechkalo, Yu. V.: Kompiuterne modeliuvannia rukhu zariadzhenoi chastynky v mahnitnomu poli v seredovyshchi elektronnykh tablyts (Computer simulation of motion of a charged particle in a magnetic field in the environment of spreadsheets). Problemy suchasnoho pidruchnyka. 5 (2), 66–72 (2004).

68. Yechkalo, Yu. V.: Kompiuterne modeliuvannia yak zasib realizatsii mizhpredmetnykh zviazkiv kursu fizyky (Computer modeling as a means of realizing interdisciplinary connections in the physics course). Theory and methods of learning mathematics, physics, informatics. 5 (2), 125–128 (2005).

69. Yechkalo, Yu. V.: Tekhnolohiia navchannia kompiuternoho modeliuvannia fizychnykh protsesiv i yavyshch u starshii shkoli (Tech of learning of computer simulation of physical processes and phenomena in school). In: Abstracts of the 6th All-Ukrainian scientific and methodical workshop on the Computer modeling in education, Kryvyi Rih, 12 April 2013.

70. Yechkalo, Yu. V.: Vybir seredovyshcha modeliuvannia fizychnykh protsesiv (Selection of environment for simulation of physical processes).

Theory and methods of learning mathematics, physics, informatics. 7 (2), 11–14 (2008).

71. Yechkalo, Yu. V.: Vykorystannia Dokumentiv Google dlia orhanizatsii spilnoi roboty zi stvorennia kompiuternoi modeli (The use of Google Docs to collaborate on the creation of computer model). In: Abstracts of the 5th All-Ukrainian scientific and methodical workshop on the Computer modeling in education, Kryvyi Rih, 6 April 2012.
72. Young, G.: On reinforcement and interference between stimuli. Bulletin of Mathematical Biophysics. 3 (1), 5–12 (1941). doi: 10.1007/BF02478102
73. Zaremba T.: CHAPTER 12 — Case Study III: Technology in Search of a Buck. In: Eberhart, R. C., Dobbins, R. W. (eds.) Neural Network PC Tools: A Practical Guide, pp. 251–283. Academic Press, San Diego (1990).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 192–223

УДК 378.147:004.9

Modernization of Professional Training of Electromechanics Bachelors: ICT-based Competence Approach

Yevhenii O. Modlo[1][0000−0003−2037−1557],
Serhiy O. Semerikov[2][0000−0003−0789−0272]
and Ekaterina O. Shmeltzer[1]

[1] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine,
5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine
eugenemodlo@gmail.com

[2] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
semerikov@gmail.com

Abstract. Analysis of the standards for the preparation of electromechanics in Ukraine showed that the electromechanic engineer is able to solve complex specialized problems and practical problems in a certain area of professional activity or in the process of study. These problems are characterized by complexity and uncertainty of conditions. The main competencies include social-personal, general-scientific, instrumental, general-professional and specialized-professional. A review of scientific publications devoted to the training of electromechanics has shown that four branches of engineering are involved in the training of electromechanical engineers: mechanical and electrical engineering (with a common core of electromechanics), electronic engineering and automation. The common use of the theory, methods and means of these industries leads to the emergence of a combined field of engineering — mechatronics. Summarizing the experience of electrical engineers professional training in Ukraine and abroad makes it possible to determine the main directions of their professional training modernization.

Keywords: electromechanics, competencies, bachelors training program.

1 Introduction

The professional training of electromechanics bachelors in higher educational institutions of Ukraine is carried out in 38 universities of Ukraine within the knowledge sector 0507 — electrical engineering and electromechanics (from 1 Sept. 2015 — within knowledge sector 14 — electrical engineering). Now the licensed volume of admission to the bachelor's degree in electromechanics is 6065 students, the state order is 1108, the number of applicants enrolled in the first year is 1217. The direction of “Electromechanics” training is one of the few, according to which in 2012 the excess of the number entrants enrolled on the first year the volume of the state order (more than 10% more than the state orders volume). The related direction “Electrical engineering and electrotechnology” is also state and socially significant (Fig. 1). According to the Resolution of the Cabinet of Ministers of Ukraine No. 266 dated April 29, 2015, these directions are united in specialty 141 “Electricity, electrical engineering and electromechanics”.

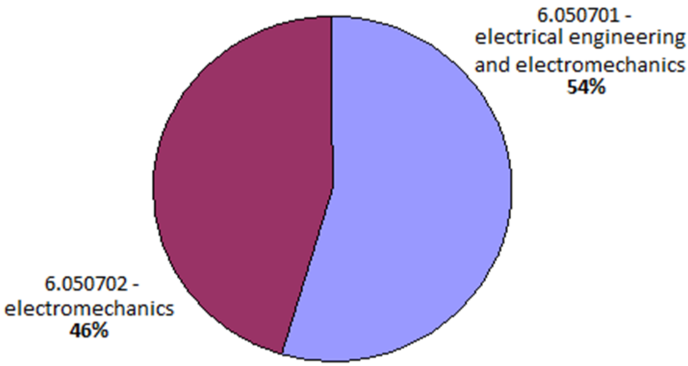


Fig. 1. The value of the state order in the areas of knowledge preparation 0507 — electrical engineering and electromechanics (according to [2])

2 General and professional competence of electrical engineers in Ukraine

The components of the sectoral standard of higher education in Ukraine (educational-professional program [19] and educational qualification characteristic [20] and ways of diagnosing the quality of higher education) are approved by the Order of the Ministry of Education and Science of Ukraine dated November 12, 2014, No. 1308. According to Educational qualification characteristics of the bachelor of electromechanics, graduates of the bachelor’s degree have the qualification 2149.2 — junior electrical engineer with a generalized object of activity — “electric machines and apparatuses, electric drives, electric transport, electromechanics and systems, complexes, devices and equipment” [19, p. 6]. According to [4], electromechanical engineers have to be prepared for the development, maintenance and installation of automated, servomechanical and other electromechanical systems, in particular testing of prototype equipment, production and operational tests, system analysis, maintenance procedures, reports preparation.

Native bachelor of electromechanics should be prepared for these types of work in the processing industry field:

1. electric equipment production: electric motors, generators, transformers, distribution and control equipment, electric household appliances and other electric equipment;
2. production of machinery and general purpose equipment: engines and turbines, hydraulic and pneumatic equipment, bearings, gearing, mechanical gears and drives, lifting and handling equipment, manual electromechanical and pneumatic tools, industrial refrigeration and ventilation equipment;
3. metal-working machinery and machine tools production, machinery and metallurgical equipment, mining and construction, food and beverage manufacturing, tobacco processing, textile, sewing, fur and leather goods, paper and cardboard, plastics and rubber;
4. motor vehicles manufacturing, trailers and semitrailers: units, parts and accessories for motor vehicles, electric and electronic equipment, etc.;
5. other vehicles manufacturing: vessels and floating structures construction, pleasure and sports boats, railway locomotives and rolling stock, military vehicles, other vehicles and equipment;
6. repair and installation of machinery and equipment: repair and maintenance of finished metal products, machinery and equipment of industrial purpose, electrical equipment, ships and boats, other vehicles, other machinery and equipment, installation and installation of machinery and equipment.

According to Level 6 of the National Qualification Framework, a junior electromechanic is able to solve complex specialized problems and practical problems in a particular field of professional activity or in the process of learning that involves the application of certain theories and methods of the corresponding science and it's characterized by complexity and uncertainty of the conditions.

The description of the qualification level of the bachelor of electromechanics includes:

1. *knowledge*:
    - conceptual knowledge gained in the process of learning and professional activity, including certain knowledge of contemporary achievements;
    - critical understanding of the basic theories, principles, methods and concepts in teaching and professional activities;
2. *abilities*:
    - solving unpredictable tasks and problems in specialized areas of professional activity or training, which involves the collection and interpretation of information (data), the choice of methods and tools, the application of innovative approaches;
3. *communication skills*:
    - reporting to specialists and non-specialists of information, ideas, problems, decisions and own experience in the field of professional activity;
    - the ability to effectively formulate a communication strategy;
4. *ability of autonomy and responsibility*:
    - complex actions or projects manegement, responsibility and decision-making in unpredictable conditions;
    - responsibility for the professional development of individuals and / or groups of people;
    - ability to further study with a high level of autonomy.

For this purpose the bachelor of electromechanics should acquire the following production functions [20, p. 14–15]:

- *research* — aimed at the collection, processing, analysis and systematization of scientific and technical information on the direction of work and its use for creative decision-making of research tasks on the basis of scientific and heuristic methods);
- *design (design and development)* — the function is aimed at carrying out a purposeful sequence of actions for the synthesis of systems or their individual components, the development of documentation necessary for the implementation and use of objects and processes;

- *organizational* — is aimed at streamlining the structure and interaction of the constituent elements of the system in order to reduce uncertainty, as well as increase the efficiency of the use of resources and time;
- *managerial* — aimed at achieving the goal, ensuring the sustainable functioning and development of systems through information exchange;
- *technological* — aimed at realizing the goal of known algorithms;
- *control* — is aimed at exercising control within the scope of its professional activities in the scope of official duties;
- *prognostic* — a function that provides the opportunity, on the basis of analysis and synthesis, to carry out predictions in professional activity;
- *technical* — aimed at performing technical work in professional activities.

The junior electrician is also able to perform the following professional work:

- professionals in electric engineering field: Major Electromechanical Captain, Major Electromechanic-Commander, Power-Engineer;
- professionals in other engineering fields: electrician, junior electrician, mining engineer, engineer, engineer for the introduction of new equipment and technology, engineer for system management and maintenance, engineer-designer, repair engineer, engineer for metrology, engineer in the organization of operation and repair, engineer of production preparation;
- Electrical technicians: electromechanician, ship electromechanician, electromechanician of the vessel electrical equipment, electromechanician of the underwater vehicle, group transloading machines electromechanician, electromechanician of lifting installations, electromechanics of underground sections, electromechanician-mentors, telecommunication electromechanincian, electromechanician dispatcher, district electrician, shopfloor electrician, electricsman;
- technical specialists in the field of extractive industry and metallurgy, technician-electromechanicians mining;
- ships specialists: electromechanician of the group fleet, electromechanics of the linear fleet, mechanic (electromechanician)

(ship) — skipper, authorized to accept ships from shipbuilding factories.

The basic competencies determined by the educational qualification characteristics of electromechanics bachelor include the following: social-personal, general-scientific, instrumental, general-professional and specialized-professional.

National Center for Educational Statistics of the US Department of Education branch of knowledge 0507 — Electrical engineering and electromechanics are divided into separate branches of knowledge: 15.03 — Electrical Engineering Technologies and 15.04 — Electromechanical Instrumentation and Maintenance Technologies [4]. The following areas of training are included in the field of knowledge 15.04: biomedical technologies, electromechanical technologies and electromechanical engineering, measuring instruments, robotics technologies, automation technologies, electromechanical measuring instruments and their servicing.

Thus, in the training of electromechanical engineers, four branches of engineering are involved: mechanical and electrical engineering (with a common core of electromechanics), electronic engineering and automation. The common use of the theory, methods and means of these industries leads to the emergence of a combined field of engineering — mechatronics (Fig. 2).

Uday Shanker Dixit defines mechatronics as "a synergetic integration of mechanical engineering with electrotechnics and / or electronics, and possibly with other disciplines, for the purpose of designing, manufacturing, operating and maintaining a product" [5, p. 75].

Despite the lack of a holistic study of the process of training engineers-electromechanics in domestic and foreign works, some components of this process were considered in a number of theses devoted to the training of electricians.

Giuzel S. Sagdeeva distinguishes the general intellectual qualities of the engineer's personality on the operation of electrical devices: ability to concentrate attention, ability to allocate essential features, ability to make a deliberate decision in a difficult technical situation, ability to manage and organize the work of personnel, ability to work with schemes and drawings, content in the memory of devices, models and devices, the ability to self-improvement [29, p. 9].

These qualities of an engineer's personality are the result of the formation of intellectual competence, the acquisition of which provides the basis for: the development of students of all components of the

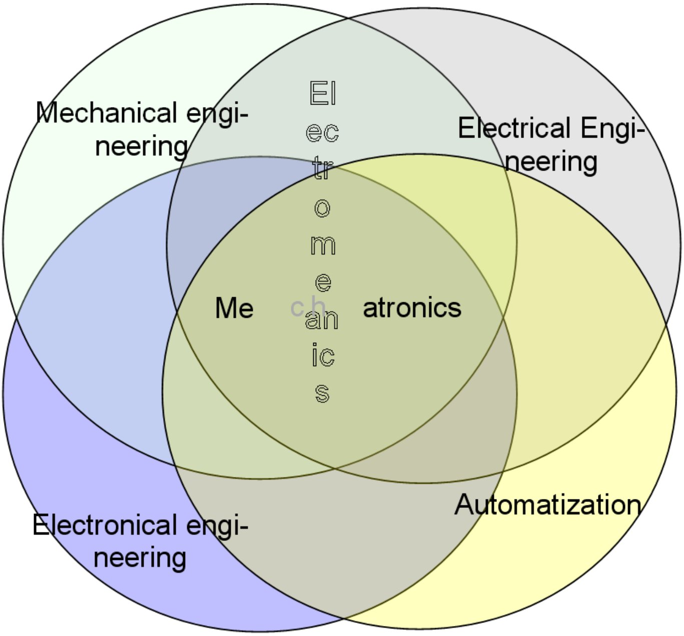


Fig. 2. Mechatronics as a combined branch of engineering

content of education; solving various life and professional problems; overcoming stereotypes and patterns of thinking; development of abilities to flexible variational perception and assessment of events occurring; reflection and consolidation of the experience of effective activity and success in a competitive environment. Sagdeeva's intellectual competence is defined as "metastability, which, by defining the degree of development by the subject of a certain domain, is characterized by a special type of organization of subject-specific knowledge and effective decision-making strategies in this subject area", distinguishing in its structure the following components: motivational, cognitive and metacognitive. The components of the motivational component are: readiness of students for self-education and development; the presence of motives that lead to cognitive activity; personality orientation. The cognitive component includes the ability to work with information: the ability to search, structure, transform, transfer information from one method of encoding to another; ability to make generalizations, conclusions, to highlight the main thing; the ability to compile cognitive schemes of mental activity, algorithms for solving problems. The metacognitive component is represented by the skills and abilities of intellectual self-management and self-organization: it is the ability to set goals, to plan, evaluate, control the cognitive activity, the ability to self-assess and reflexive analysis.

The conditions of intellectual competence of future electricians' development are:

1. simulation of intellectual and developmental situations in accordance with the psychological patterns and mechanisms of development of intellectual competence, taking into account the features of the future profession;
2. inclusion of students in various types of research activities aimed at the development and enrichment of invariant intellectual structures of the individual; improvement of student research methods based on the disclosure and formation of individual styles of intellectual activity;
3. development of psychological and pedagogical support of the process of training future electricians, which implements stimulating, diagnostic and corrective functions [29, p. 12–16].

The development of intellectual competence contributes to the formation of professional electrical thinking directed, according to Larisa N. Vishniakova, to the knowledge, understanding and transformation of electrotechnical objects, phenomena, processes and relations: "the essence of professional electrical engineering is manifested in its laws, namely, in natural conformance (based on the experience of human interaction with the biosphere, technosphere, society), cultural correspondence (associated with the mastery of general-professional and special knowledge and skills that are presented to the profession of social order of society) and the optimum combination of (relatively stable asymmetric harmony or complementarity) natural intuition of foresight and intellectual discipline in the performance of cognitive training and professional action" [34].

In its development, the professional electrical engineering of the student passes the following levels: elementary-empirical (zero), student, methodical, search. The transition of professional electrical thinking from one level to another is associated with transitions in intellectual development: electrical engineering — electrotechnical education — professional competence — electrical engineering and technological culture.

Elena V. Shishchenko [30] and Aleksandr V. Gamov [10] considered the formation and development of professional competencies of students on the basis of interdisciplinary integration. According to Shishchenko, "the interdisciplinary integration of knowledge contributes to competent education, person-oriented technologies of learning, technology of developmental learning, project method, block-module training, contextual training, wide-profile training of specialists, adult learning technology , oriented to the perception and assimilation of knowledge, representing a coherent system; on the formation of skills to perform certain operations, tasks (including research, creative), associated with their professional activities" [30, p. 5]. Integration of electrical engineering disciplines (theoretical electrical engineering, electrical measurements, electronic equipment, electric machines, electric drive and converters) contributes to solving the contradiction between the fast-changing elemental base of electrical installations and aggregates, which are constantly complicated by their algorithmic structure and circuitry, on the one hand, and some conservatism of typical programs and tutorials that contain information on individual, often outdated, electrical installations, on the other hand [30, p. 7].

Dixit takes notice that modern training engineers and electricians must be based on a top-down approach in which first provided a general idea of the final product, though not in great detail the form and then studied in detail subsystem system. This is due to the fact that such training involves many disciplines from different fields of engineering, so students should get an idea of how they will be integrated, "the integration of different disciplines is an essential part mechatronics" [5, p. 86].

Gamov adds that "the integrative approach reveals the possibilities of developing professional competences on the basis of integration: general-professional, special disciplines and information technologies; technologies of problem and modular learning; methods of classical calculation and modeling of electrodynamic systems" [10, p. 11].

Thus, the level of the formation of professional competence of masters of electrical engineering direction Galina Iu. Dmukh [6] determines the degree of development of the following competencies: research (the collection, analysis, processing and systematization of scientific and technical information, the ability to participate in all phases of research, the ability to use the achievements of science and technology, advanced national and foreign experience); operational (ability to carry out examination of technical documentation, supervision and control over the state of technological processes and operation of equipment, ability to effectively use natural resources, materials and energy); design (the ability to carry out a comprehensive technical and economic analysis, knowledge of methods for conducting technical calculations and determination of the economic efficiency of research and development, knowledge of the principles of work, technical, design features of the developed and used technical means); production-technological (knowledge of technology for the design, production and operation of products and facilities for technological equipment); organizational and managerial (interaction with specialists of the related profile). From the experience of masters of electromechanics at the Royal Institute of Technology (Sweden), Mats Hanson came to the conclusion that the most useful project in the teaching of mechatronics is the design-oriented approach [11].

The separation of the competences of the future specialist in the electromechanical profile in the process of simulation of professional training, according to Natalia P. Motorina [21], should be carried out on the basis of a specialist's model, the components of which are:

- identification of a range of main tasks solved by a modern electromechanician (model of activity);
- definition of the complex necessary for a specialist knowledge, skills and professional skills based on the model of activity (model of training);
- clarification of the necessary professional qualities of the specialist (model of personal qualities);
- preparation for the acquisition of perspective directions of development for this specialty, based on the forecast of its development for the next 15–20 years (model of the prospects of the specialty).

According to the results of modeling, the design and implementation of the profile education system (Sergei N. Kashkin [14] vocational training and retraining of specialists on the basis of the theory of continuous multi-level vocational education is carried out. Sergei A. Pchela [24] established the following pedagogical regularities of continuity, characteristic for the continuous training of specialists: structural, procedural and content continuity determine the content of educational programs, the content and quality of teaching and methodological provision of training, the level and quality of material and technical provision of training, the order and sequence of theoretical and practical training, the choice of forms and methods of teaching, types of educational activities and methods for diagnosing the level of professional training of specialists, the level of per training, training of teachers for the implementation of quality education programs. Elena A. Dragunova [7] notes that in this approach, the quality of training can be improved, in particular, through the use of modern software for distance learning and the possibilities of Internet technologies.

The purpose of continuous multi-level vocational education is the training of skilled professionals capable of navigating in ever-changing reality, mastering new modern technologies, implementing them in practice and successfully mastering fundamentally new areas and activities. Successfully self-realizing and feeling comfortable in a modern society, as well as ensuring its sustainable development will be able professionals who can mobilize themselves to improve themselves and transform their professional reality in accordance with the requirements of time and modern society. Tatiana B. Kotmakova [15] defines one of the main professional characteristics of the future specialist, which increases his competitiveness in the labor market — personal mobility — as an integrative quality of the future specialist, which manifests itself in the formed motivation to study, the ability to work in an effective way communication and allows you to stay in the process of active creative self-development.

Increasing competitiveness requires mastering by the future specialist a set of knowledge, skills necessary to active creative professional development, continuous self-improvement and training during the work activity. Therefore, an important task for the professional training of future engineers-electromechanics is not so much the acquisition of ready-made knowledge, as mastering the methods of independent cognitive activity. Maiia H. Hordiienko [12] emphasizes that under accelerated accumulation and obsolescence professionally significant information mastering abilities and skills of independent work enables future professionals to be constantly informed of the latest technologies in his professional field, equips achievements of world science and practice: “At the same time, professionally competent electromechanicians must solve the urgent national problem of energy conservation through the use of various technologies driven which provide the necessary modes of operation of electromechanical complexes. These technologies are implemented by a variety of converters, soft starters, microprocessor management, etc., a significant number of which are produced by foreign companies. To explore and use the best international experience on the latest developments, future electromechanical engineer must be able to independently find the information you need to read it in a foreign language is to possess abilities and skills of independent work with foreign professional literature” [12, p. 3].

Under these conditions, the problem of forming skills and abilities of independent work for future engineers becomes of particular importance in order to ensure their adaptation, self-realization and self-education in the modern conditions of the information society and integration into the world community. The purposeful formation of skills and abilities of independent work of bachelors of electromechanics should begin with fundamental training, which is based on mathematics, physics and informatics.

Tetiana V. Krylova indicates that mathematics as a basis for the study of fundamental, general technical and special disciplines provides wide opportunities for the development of logical thinking, algorithmic culture, the formation of skills to establish causal relationships, to substantiate statements, to model, etc.: "if the methodical system of education Mathematics of bachelors of electromechanics will take into account: the professional orientation of teaching mathematics; learning the beginnings of mathematical modeling in studying the general course of higher mathematics and special mathematical courses; solving problems of special content at the final stage of studying the disciplines of the mathematical cycle; methods, methods and means of activating the independent educational and cognitive activity of students in the study of mathematics; application of means of new information technology training in solving applied problems in the process of studying the general course of mathematics and special mathematical courses; level differentiation and individualization of teaching mathematics students of technical specialties; organization of independent work of students and control over its implementation, this will ensure the implementation of modern requirements for the mathematical preparation of students, promote their mental development, preparation for self-education in conditions of continuing education" [16].

Aleksandra N. Lavrenyna [17] proposes to fill a physics course by taking into account the profile of the training of future specialists, in particular, by analyzing the connections of the electrodynamics of the course in physics with the general technical discipline "Theoretical Foundations of Electrical Engineering" and the special discipline "Electric Machines" with the purpose of determining the role and places of physical knowledge in the system of vocational education of students of electrotechnical specialties.

Svetlana N. Potemkina [26] defined the general requirements for the professional training of an electrical engineer profile in the field of physics:

- to know and to be able to use the basic concepts, laws and models of mechanics, electricity and magnetism, oscillations and waves, quantum physics, statistical physics and thermodynamics;
- to know and to be able to competently solve complex tasks, which include tasks by type of activity;

- to know and to be able to use the methods of theoretical and experimental research in physics;
- to be able to evaluate the numerical order of quantities characteristic of different sections of science;
- to know and to be able to apply standard rules for constructing and reading drawings and diagrams;
- to know the principles of symmetry and conservation laws;
- to know about physical modeling.

Interdisciplinary and modeling skills are used in all components of the fundamental and professional training of the bachelor of electromechanics. A striking example of the use of interdisciplinary modeling is the methodology for the formation of environmental knowledge of future engineers-electromechanics in the process of teaching special disciplines, the author of which developed Iryna O. Soloshych, points out that "the involvement of students in the solution of problem-oriented nature of simulated production situations using interactive and informational methods promotes the effective development of their professional interests, motivation to master the future specialty" [32, p. 12].

Roman M. Sobko [31] offers the following principles for the integrative use of ICT facilities in the training of students of electrical and electromechanical specialties, the main of which are the principles:

- the purposeful use of ICT tools in the professional training of specialists, which provides methodological, psychological, pedagogical and methodological substantiation of the content of ICT education;
- professional orientation of ICT training;
- continuity of use of ICT at all stages of vocational training;
- the degree and systematic formation of the ITC competence of a future specialist
- awareness of the use of ICTs in solving professional problems;
- modeling of phenomena and processes of professional activity using ICT tools [24, p. 9–10].

The implementation of the latter two principles is possible provided that the future specialists prepare for the engineering experiment, which Raisa E. Mazhirina [18] defines as the property of the individual to manage the active cognitive process associated with the analysis of qualitative and quantitative characteristics of industrial objects. The training of future engineers for independent studies, including the development of techniques and techniques of experiment, is an essential part of the professional training of an engineer, whose production activity is associated with constant analysis and directed change of technical and natural systems. Considering that training in electromechanicians takes up a significant place in the field of quick-change engineering — electronic, — the use of ICT for modeling phenomena and processes of professional activity is necessary both in the process of professional training and in the process of professional activity, which necessitates the use of mobile modeling tools.

In the teaching of electrical engineering disciplines using ICT, Natalia P. Fiks [8] suggests using automated teaching and learning complexes, which include computer-based learning tools: textbooks, training generators, virtual laboratories, diagnostic tools and automated systems modeling. An example of such a complex is developed by Natalia G. Pankova [23] a complex of software and information support for the process of teaching electrical engineering disciplines, consisting of training manuals on the simulation and calculation of electrical circuits, methodological instructions for a laboratory workshop using ICT, programs, guidelines and control tasks for calculation and graphic works, test control system of success, system of training classes on the basis of ICT. The highest level of automation of the teaching-methodical complex is realized by Maksim A. Polskii [25] a combined didactic interactive program system that provides the organization of reproductive (recognition and reproduction) and productive heuristic educational and cognitive activity of students in the conditions of gradualness and completeness of studying with a closed directional automatic control. Among the conditions for the effectiveness of the organization of the educational process using such complexes, the researcher calls the high level of ICT competencies of teachers and students — in particular, the ability to work with universal software systems for modeling.

Considering the educational perspectives of applied mechatronics in the context of the integration of traditional topics of mechanical, electrical and computer engineering, C. J. Fraser et al. [9] offer the following sections of the curriculum: system engineering; microprocessor technology; digital electronics; digital and analog interfaces; digital communications; software development; Subordinate management of electric, pneumatic and hydraulic systems; the theory of automatic control.

Joshua Vaughan, Joel Fortgang, William Singhose, Jeffrey Donnell, and Thomas Kurfess [33] offer an integrative course “Creative Solutions and Design” aimed at the formation and development of students of mechatronic and communicative competences. The authors, emphasizing the importance of working in the team, note that team work can not equally develop students' competencies in all relevant fields, so they share work in accordance with their own comfort and abilities. In order to avoid this at the beginning of the course, it is expedient for each student to give an individual project, and in the second half of the course students are involved in team projects.

Yu Wang, Ying Yu, Chun Xie, Huiying Wang, and Xiao Feng [35] described 4 units of practical training at the CDHAW Center at Tongji University (China):

1. pre-training block includes study of the basics of mechanical, electrical and electronic engineering;
2. the block of fundamental training involves laboratory work, in which students check the laws of mechanics, physics, materials science, electrical engineering, etc.;
3. a block of specialized training involves laboratory work using controls, sensors, drives, controllers, microprocessors, etc.;
4. the unit of advanced training involves the student's independent work on projects.

The basic requirements for the professional training of specialists in electromechanics, formulated by the survey of employers, leads Maurice W. Roney [27, p. 26]:

1. Preparation should be fundamental: the emphasis should be more on the general principles of the work of electromechanical systems than on the application of these principles.
2. Communicative skills are extremely important in the work of electronics technicians, so they should be given special attention in the training program.
3. Study of the interconnection of electrical and mechanical elements of systems and devices should occupy a central place in specialized technical courses. Wherever possible, electrical and mechanical principles should be studied together, not alone.
4. Principles of electrical and mechanical physics are the main tools in the work of electronics technicians and any technical training should develop the skills of analytical thinking for which these tools are fundamental. In addition, there is an increasing need for techniques for working with new branches of application of other physical sciences

such as: optical equipment, thermal power plants, hydraulic and pneumatic controls, as well as a wide range of measuring instruments.

To implement these requirements is proposed [27, p. 10]:

1. The main subjects that should be given the greatest attention are:
   - physics — of the applied type (should not be classical physics);
   - mathematics — through applied calculus;
   - communications — drafting, sketching, composition, report writing;
   - industrial electronics — regardless of the area in which the technician might be working, a good working knowledge of electronic devices, circuits, instruments and system is required.
2. The training program should also include material from the sections:
   - light and optics;
   - high vacuum techniques;
   - engineering materials and stress analysis;
   - chemistry, particularly from the viewpoint of corrosion;
   - economics — as applied to industrial situations in design and application;
   - mechanism and basics of mechanical design;
   - transducers for various types of instrumentation;
   - controllers and industrial control;
   - fundamentals of computers.
3. It is very important to have an exact observation: by carefully observing, the technician must be able to analyze and synthesize. Although these two abilities may not develop intentionally in a particular course, they should be developed in all laboratory and classroom activities. Competence in these areas can be more important than just technical abilities.
4. The skills of manual labor with basic tools are also important.
5. If practicable, the training program should be no more than two years old.

In the training of electronics technicians, Roney proposes to follow a model that has a four-component structure (Fig. 3). In the center of the model — a student, on the development of the personality which must be sent all the efforts of pedagogues. To the teaching staff, Roney proposes a requirement for competence in more than one discipline in order to provide interdisciplinary connections and integration of academic disciplines [28, p. 20].

The development of the communicative competence of a future specialist should be supported by all pedagogues: the pedagogue "should not reduce his teaching function to writing mechanics. Instead, he must be able to distinguish the specific needs of students at each stage of the program. He must understand that without special communicative skills, the technician will be poorly trained to perform production functions" [28, p. 22].

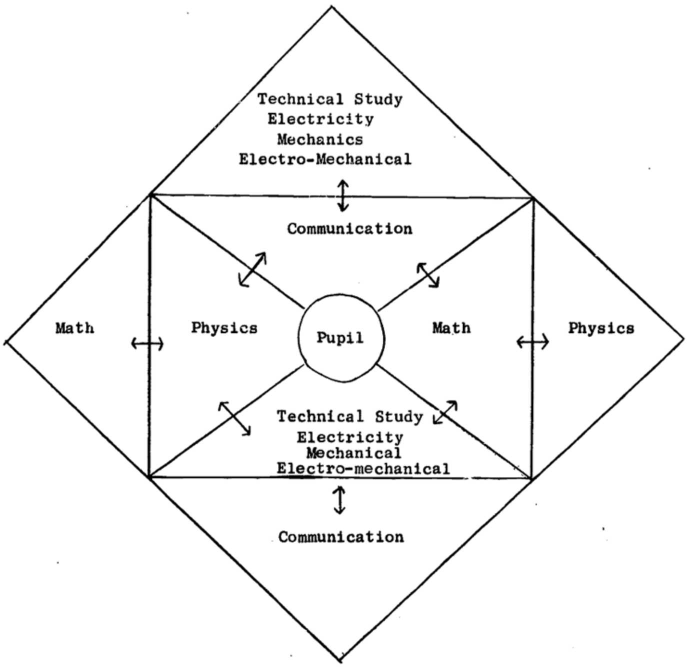


Fig. 3. Technicians-electromechanics training model (by [28, p. 21])

But the most important requirement for pedagogues preparing future specialists in electromechanics, Roney considers "his production experience, which should be significant and as modern as possible. One of the main problems of teaching is the lagging content of training from the current state of development of production" [28, p. 22]. The prestige of the educational institution, according to the author, largely depends on the extent to which the qualifications of the pedagogues correspond to the current state of development of production.

3 General and professional competence of electrical engineers in United States and Canada

The professional training of electromechanical engineers in the United States (The Bachelor of Science in Electro-Mechanical Engineering Technology — BSEMET), according to the ABET (Accreditation Board for Engineering and Technology), has been providing since the early 1990s. according to the related branch of science (Electromechanical Engineering Technology, Engineering Technology: Electro-Mechanical Concentration, Electromechanical Engineering Technology Concentration in Engineering Technology) in accordance with the developed ABET accreditation criteria for training programs for engineers, which identified the necessary requirements for the program of electromechanical training (Electromechanical Engineering Technology).

The requirements of ABET [3, p. 15] clearly distinguish professional activities of electronics and electromechanics. The production functions of the technique-electromechanics include the construction, installation, use and operation and / or maintenance of electromechanical equipment and software. The bachelor of electromechanics will, design, development and management of electromechanical systems.

Technician-electromechanics should have the following competencies:

1. use computer-aided drafting or design tools to prepare graphical representations of electromechanical systems;
2. use circuit analysis, analog and digital electronics, basic instrumentation, and computers to aid in the characterization, analysis, and troubleshooting of electromechanical systems;
3. use statics, dynamics (or applied mechanics), strength of materials, engineering materials, engineering standards, and manufacturing processes to aid in the characterization, analysis, and troubleshooting of electromechanical systems;

Graduates of baccalaureate degree programs must also demonstrate competency to:

4. use appropriate computer programming languages for operating electromechanical systems;
5. use electrical / electronic devices such as amplifiers, motors, relays, power systems, and computer and instrumentation systems for applied design, operation, or troubleshooting electromechanical systems;

6. use advanced topics in engineering mechanics, engineering materials, and fluid mechanics for applied design, operation, or troubleshooting of electromechanical systems;

7. use basic knowledge of control systems for the applied design, operation. or troubleshooting of electromechanical system;

8. use differential and integral calculus, as a minimum, to characterize the static and dynamic performance of electromechanical systems;

9. use appropriate management techniques in the investigation, analysis, and design of electromechanical systems.

There are eight ABET Accreditation Criteria common to all Engineering Training Areas [3, p. 1–5].

The first criterion defines the requirements for the process and the results of the professional training of students; Separately, it is indicated the need to monitor the training of each student in order to facilitate the achievement of educational goals.

The second criterion defines the requirements for the educational objectives of the training program.

The third criterion defines two groups of competencies that students must acquire in order to achieve the objectives of the training program. The first group defines broad-sighted activities related to: the use of different resources; Innovative use of new processes, materials or technologies; execution of standard operating procedures. The second group defines, in the narrow sense, activities that involve limited resources, new ways of using traditional processes and materials, and the implementation of basic operating procedures.

For bachelors of engineering, there are such competencies:

1. an ability to select and apply the knowledge, techniques, skills, and modern tools of the discipline to broadly-defined engineering technology activities;

2. an ability to select and apply a knowledge of mathematics, science, engineering, and technology to engineering technology problems that require the application of principles and applied procedures or methodologies;

3. an ability to conduct standard tests and measurements; to conduct, analyze, and interpret experiments; and to apply experimental results to improve processes;

4. an ability to design systems, components, or processes for broadly-defined engineering technology problems appropriate to program educational objectives;
5. an ability to function effectively as a member or leader on a technical team;
6. an ability to identify, analyze, and solve broadly-defined engineering technology problems;
7. an ability to apply written, oral, and graphical communication in both technical and nontechnical environments; and an ability to identify and use appropriate technical literature;
8. an understanding of the need for and an ability to engage in self-directed continuing professional development;
9. an understanding of and a commitment to address professional and ethical responsibilities including a respect for diversity;
10. a knowledge of the impact of engineering technology solutions in a societal and global context;
11. a commitment to quality, timeliness, and continuous improvement.

The requirement of continuous improvement of the training program is the basis of the fourth criterion. It is proposed to apply appropriate methods for assessing and analyzing student achievements. The obtained results should be used systematically as inputs to continuously improve the training program.

The fifth criterion defines the general requirements for the curriculum:

- The mathematics program must develop the ability of students to apply mathematics to the solution of technical problems. Programs will include the application of integral and differential calculus or other mathematics appropriate to the student outcomes and program educational objectives.
- The technical content of the program must focus on the applied aspects of science and engineering and must represent at least 1/3 of the total credit hours for the program but no more than 2/3 of the total credit hours for the program. Include a technical core that prepares students for the increasingly complex technical specialties they will experience later in the curriculum. Develop student competency in the use of equipment and tools common to the discipline.

- The basic physical and natural science content of the program must include physical or natural science with laboratory experiences as appropriate to the discipline.
- Baccalaureate degree programs must provide a capstone or integrating experience that develops student competencies in applying both technical and non-technical skills in solving problems.
- When used to satisfy prescribed elements of these criteria, credits based upon cooperative / internships or similar experiences must include an appropriate academic component evaluated by the program faculty.
- An advisory committee with representation from organizations being served by the program graduates must be utilized to periodically review the program's curriculum and advise the program on the establishment, review, and revision of its program educational objectives. The advisory committee must provide advisement on current and future aspects of the technical fields for which the graduates are being prepare.

The sixth criterion defines the requirements for teachers, the main is the availability of experience and level of education, corresponding to the expected input of the teacher in the training program. Teacher competence is assessed by education, professional qualification and certification, professional experience, current professional development, discipline, teaching efficiency and communication skills. Together, all teachers should cover all components of the training program.

The staff involved in the training program should be in sufficient quantity to maintain continuity, stability, control, student interaction and counseling. The staff should have sufficient responsibility and authority to improve the curriculum by identifying and reviewing educational goals and learning achievements, as well as for implementing a training program that will help improve student achievement.

The seventh criterion defines the requirements for the means of support (facilitation) of the learning process:

- classrooms, offices, laboratories, and associated equipment must be adequate to support attainment of the student outcomes and to provide an atmosphere conducive to learning;
- modern tools, equipment, computing resources, and laboratories appropriate to the program must be available, accessible, and systematically maintained and upgraded to enable students to attain the student outcomes and to support program needs;

- students must be provided appropriate guidance regarding the use of the tools, equipment, computing resources, and laboratories available to the program;
- the library services and the computing and information infrastructure must be adequate to support the scholarly and professional activities of the students and faculty.

The eighth criterion defines the level of support for a training program from a parent institution and management that is sufficient to ensure the quality and integrity of the training program:

- resources including institutional services, financial support, and staff (both administrative and technical) provided to the program must be adequate to meet program needs;
- the resources available to the program must be sufficient to attract, retain, and provide for the continued professional development of a qualified faculty;
- the resources available to the program must be sufficient to acquire, maintain, and operate infrastructures, facilities and equipment appropriate for the program, and to provide an environment in which student outcomes can be attained.

Standards for the training of electromechanical engineers, proposed by the Department of Education, Ontario Colleges and Universities (Canada) [22], contain three components: Vocational standard — analogue of special professional competencies of the domestic standard, Generic employability skills standard — an analogue of general-professional, instrumental (partly) and general-knowledge (partly) competencies of the domestic standard, and General education standard — an analogue of socio-personal, instrumental (partly) and general (partly) competencies of the domestic standard.

As a result of mastering the Vocational Standard, the following competencies should be formed for graduates:

- fabricate mechanical components and assemblies, and assemble electrical components and electronic assemblies by applying workshop skills and knowledge of basic shop practices in accordance with applicable codes and safety practices;
- analyse, interpret, and produce electrical, electronic, and mechanical drawings and other related documents and graphics necessary for electromechanical design;

- select and use a variety of troubleshooting techniques and test equipment to assess electromechanical circuits, equipment, processes, systems, and subsystems;
- modify, maintain, and repair electrical, electronic, and mechanical components, equipment, and systems to ensure that they function according to specifications;
- apply the principles of engineering, mathematics, and science to analyse and solve design and other complex technical problems and to complete work related to electromechanical engineering;
- design and analyse mechanical components, processes, and systems through the application of engineering principles and practices;
- apply principles of mechanics and fluid mechanics to the design and analysis of electromechanical systems;
- design, analyse, build, and troubleshoot logic and digital circuits, passive AC and DC circuits, and active circuits;
- design, select, apply, integrate, and troubleshoot a variety of industrial motor controls and data acquisition devices and systems;
- design, analyse, and troubleshoot microprocessor-based systems;
- install and troubleshoot computer hardware and high-level programming to support the electromechanical engineering environment;
- analyse, program, install, integrate, and troubleshoot automated systems including robotic systems;
- establish and maintain inventory, records, and documentation systems;
- assist in project management by applying business principles to the electromechanical engineering environment;
- select for purchase electromechanical equipment, components, and systems that fulfill the job requirements and functional specifications;
- specify, coordinate, and conduct quality-control and quality-assurance programs and procedures;
- perform all work in accordance with relevant law, policies, codes, regulations, safety procedures, and standard shop practices;
- develop personal and professional strategies and plans to improve job performance and work relationships with clients, coworkers, and supervisors [22, p. 6–7].

Generic employability skills standard defines the following competencies:

- communicate clearly, concisely, and correctly in the written, spoken, and visual form that fulfills the purpose and meets the needs of the audiences;
- reframe information, ideas, and concepts using the narrative, visual, numerical, and symbolic representations which demonstrate understanding;
- apply a wide variety of mathematical techniques with the degree of accuracy required to solve problems and make decisions;
- use a variety of computer hardware and software and other technological tools appropriate and necessary to the performance of tasks;
- interact with others in groups or teams in ways that contribute to effective working relationships and the achievement of goals;
- evaluate her or his own thinking throughout the steps and processes used in problem solving and decision making;
- collect, analyze, and organize relevant and necessary information from a variety of sources;
- evaluate the validity of arguments based on qualitative and quantitative information in order to accept or challenge the findings of others;
- create innovative strategies and / or products that meet identified needs;
- manage the use of time and other resources to attain personal and / or project related goals;
- take responsibility for her or his own actions and decisions;
- adapt to new situations and demands by applying and / or updating her or his knowledge and skills;
- represent her or his skills, knowledge, and experience realistically for personal and employment purposes [22, p. 27].

Goals and Broad Objectives of *General Education*:

- Aesthetic Appreciation: understand beauty, form, taste, and the role of the arts in society;
- Civic Life: understand the meaning of freedoms, rights, and participation in community and public life;

- Cultural Understanding: understand the cultural, social, ethnic, and linguistic diversity of Canada and the world;
- Personal Development: gain greater self-awareness, intellectual growth, well-being, and understanding of others;
- Social Understanding: understand relationships among individuals and society;
- Understanding Science: appreciate the contribution of science to the development of civilization, human understanding, and potential;
- Understanding Technology: understand the interrelationship between the development and use of technology and society and the ecosystem;
- Work and the Economy: understand the meaning, history, and organization of work; and of working life challenges to the individual and society [22, p. 46–48].

Specialists of Human Resource Systems Group [13] determine two groups of competencies that can be formed at one of five levels (1 — basic, 5 — expert):

1. *General Competencies* includes:
    - writing skills (at level 4 — writes on complex and highly specialized issues);
    - analytical thinking (at level 4 — applies broad analysis);
    - interactive communication (at level 4 — communicates complex messages);
    - problem solving (at level 4 — solves complex problems);
    - planning and organizing (at level 4 — plans and organizes multiple, complex activities);
    - team leadership (at level 3 — builds strong teams);
    - critical judgment (at level 4 — formulates broad strategies on multi-dimensional strategic issues);
    - visioning and alignment (at level 3 — aligns program / operational support);
2. *Technical Competencies* includes:
    - calibration / mathematics (at level 4 — calculates using multiple steps and operations);
    - working with tools and technology (at level 4 — welds, repairs, and fabricates equipment or machinery);

- building & construction design (at level 4 — demonstrates advanced knowledge and ability, and can apply the competency in new or complex situations; guides other professionals);
- electrical systems maintenance and repair (at level 4 — demonstrates advanced knowledge and ability, and can apply the competency in new or complex situations; guides other professionals);
- electrical / electronics engineering (at level 5 — demonstrates expert knowledge and ability, and can apply the competency in the most complex situations; develops new approaches, methods or policies in the area; is recognized as an expert, internally and / or externally);
- electrical equipment operation (at level 5 — expert).

Competence matrix for the sector electronics / electrical engineering [1, p. 14–15], developed within the framework of the European project VQTS II (Vocational Qualification Transfer System), covers 8 groups of competencies, each of which is defined at 3 or 4 levels:

1. planning, mounting and installing electrical and electronic systems;
2. inspecting and configuring electrical and electronical systems and machines in industrial appliances;
3. installing and adjusting electrical components and electronic systems;
4. designing, constructing and modifying electrical / electronic wirings / circuit boards, control circuitries and machines including their interfaces;
5. developing custom designed electrical / electronic systems;
6. supervising and supporting work and business processes;
7. installing, configuring modifying and testing of application software for the programming of electrical / electronic installations;
8. diagnosing and repairing of electrical / electronic systems and equipment.

4 Conclusions

Summarizing the experience of electrical engineers professional training in Ukraine and abroad makes it possible to determine the main directions of their professional training modernization:

1. transition to competence-oriented training standards;

2. development of integrated training programs for “technician-electromechanic engineer-electromechanic” on the basis of the National Qualifications Framework;
3. development of professional standards of training specialists in the field of mechatronics for the metallurgical and mining industry;
4. ensuring continuous training and retraining of electrical engineers based on the use of modern ICT tools.

References

1. Becker, M.: Competence matrix for the sector electronics / electrical engineering. VQTS II — Vocational Qualification Transfer System Leonardo da Vinci — LLP-LdV-TOI-2007-AT-0017, Flensburg. http://www.biat.uni-flensburg.de/biat/Projekte/VQTS-II/WP2-VQTS-Competence-Matrix-Electrician-II_EN.pdf (2009). Accessed 31 Jan 2018.
2. Cabinet of Ministers of Ukraine: Pro derzhavne zamovlennia na pidhotovku fakhivtsiv, naukovo-pedahohichnykh ta robitnychykh kadriv, na pidvyshchennia kvalifikatsii ta perepidhotovku kadriv (pisliadyplomna osvita) dlia derzhavnykh potreb u 2012 rotsi. Kyiv (2012).
3. Criteria for Accrediting Engineering Technology Programs: Effective for Reviews During the 2014–2015 Accreditation Cycle. Incorporates all changes approved by the ABET Board of Directors as of October 26, 2013. ABET, Baltimore (2013).
4. Detail for CIP Code 15.0403. Institute of Education Sciences, National Center for Education Statistics, U. S. Department of Education, Washington. http://nces.ed.gov/ipeds/cipcode/cipdetail.aspx?y=55&cip=15.0403 (2010). Accessed 1 Feb 2018.
5. Dixit, U. S.: Mechatronics Education. In: Davim, J. P. (ed.): Mechanical Engineering Education, pp. 61–106. ISTE, London (2012).
6. Dmuh, G. Ju.: Pedagogicheskie uslovija formirovanija professional’noj kompetentnosti magistrov jelektrotehnicheskogo napravlenija (Pedagogical conditions for the formation of professional competence of masters of electrotechnical direction). Dissertation, Far Eastern Federal University (2010).

7. Dragunova, E. A.: Proektirovanie i realizacija teoreticheskogo obespechenija mnogourovnevoj jelektrotehnicheskoj podgotovki specialistov v vuze (Design and implementation of theoretical support of multi-level electrical engineering training of specialists in the university). Dissertation, Togliatti State University (2000).
8. Fiks, N. P.: Teoreticheskoe obosnovanie sozdanija i opyt primenenija avtomatizirovannogo uchebno-metodicheskogo kompleksa: na primere kursa teoreticheskih osnov jelektrotehniki (Theoretical substantiation of the creation and experience of the application of the automated educational and methodical complex: on the example of the course of theoretical foundations of electrical engineering). Dissertation, Tomsk State University of Control Systems and Radioelectronics (2001).
9. Fraser, C. J., Milne, J. S., Logan, G. M.: An educational perspective on applied mechatronics. Mechatronics. 3 (1), 49–57. (1993). doi: 10.1016/0957-4158(93)90037-3
10. Gamov, A. V.: Razvitie professional'nyh kompetencij studentov na osnove integracii jelektrotehnicheskih disciplin (Development of professional competencies of students on the basis of integration of electrical disciplines). Dissertation, Russian State Vocational Pedagogical University (2008).
11. Hanson, M.: Teaching mechatronics at tertiary level. Mechatronics. 4 (2), 217–225 (1994). doi: 10.1016/0957-4158(94)90045-0
12. Hordiienko, M. H.: Formuvannia umin i navychok samostiinoi roboty z inozemnoiu fakhovoiu literaturoiu u maibutnikh inzheneriv (Formation of skills and abilities of independent work with foreign professional literature from future engineers). Dissertation, Institute of Pedagogical Education and Adult Education of the Academy of Pedagogical Sciences of Ukraine (2008).
13. Human Resource Systems Group Ltd.: Electrical Engineer Job Description. Job Group: Engineering. http://ccjournals.eu /materials/ee.pdf (2013). Accessed 2 Feb 2018.
14. Kashkin, S. N.: Razrabotka modeli professional'no orientirovannogo nepre-ryvnogo tehnologicheskogo obrazovanija budushhego specialista (na primere jelektrotehnicheskogo profilja) (Development of the model of professionally oriented continuous technological formation of the future specialist (on an example of electrotechnical profile)). Dissertation, Voronezh regional institute of advanced studies and retraining of educators (2006).

15. Kotmakova, T. B. Formirovanie lichnostnoj mobil'nosti kak professional'nogo kachestva budushhih specialistov v processe obuchenija v vuze (na primere special'nosti "Jelektricheskij transport zheleznyh dorog") (The formation of personal mobility as a professional quality of future specialists in the process of training in the university (on the example of the specialty "Electric transport of railways")). Dissertation, Far Eastern State Transport University (2011).
16. Krylova, T. V.: Naukovi osnovy navchannia matematyky studentiv nematematychnykh spetsialnostei (na bazi metalurhiinykh, enerhetychnykh i elektromekhanichnykh spetsialnostei vyshchoho zakladu tekhnichnoi osvity) (Scientific fundamentals of teaching mathematics students of non-mathematical specialties (on the basis of metallurgical, energetic and electromechanical specialties of the higher institution of technical education)). Dissertation, National Pedagogical Dragomanov University (1999).
17. Lavrenina, A. N.: Sistema professional'no napravlennogo obuchenija fizike studentov jelektrotehnicheskih special'nostej vuza (The system of professionally directed training of physics students of electrical engineering specialties of the university). Dissertation, Togliatti State University (1999).
18. Mazhirina, R. E.: Formirovanie gotovnosti studentov jelektrotehnicheskih special'nostej k provedeniju inzhenernogo jeksperimenta (Formation of readiness of students of electrotechnical specialties for engineering experiment). Dissertation, Orenburg State University (2002).
19. Ministry of Education and Science of Ukraine: Haluzevyi standart vyshchoi osvity Ukrainy HSVOU 6.050702–2014. Osvitno-profesiina prohrama bakalavra. Haluz znan 0507 Elektrotekhnika ta elektromekhanika. Napriam pidhotovky 6.050702 Elektromekhanika. Kvalifikatsiia 2149.2 Molodshyi inzhener-elektromekhanik (The branch standard of higher education of Ukraine BSHEU 6.050702–2014. Educational and professional bachelor's program. Branch of knowledge 0507 Electrical engineering and electromechanics. Direction of preparation 6.050702 Electromechanics. Qualification 2149.2 Junior engineer-electromechanic). Kyiv (2014).
20. Ministry of Education and Science of Ukraine: Haluzevyi standart vyshchoi osvity Ukrainy HSVOU 6.050702–2014. Osvitno-kvalifikatsiina kharakterystyka bakalavra. Haluz znan 0507 Elek-trotekhnika ta

elektromekhanika. Napriam pidhotovky 6.050702 Elektromekhanika. Kvalifikatsiia 2149.2 Molodshyi inzhener-elektromekhanik (The branch standard of higher education of Ukraine BSHEU 6.050702–2014. Educational and professional bachelor's characteristic. Branch of knowledge 0507 Electrical engineering and electromechanics. Direction of preparation 6.050702 Electromechanics. Qualification 2149.2 Junior engineer-electromechanic). Kyiv (2014).

21. Motorina, N. P.: Metodika organizacii professional'noj jelektrotehnicheskoj podgotovki sovremennogo inzhenera (Technique of organization of professional electrotechnical training for a modern engineer). Dissertation, Tambov State Technical University (2002).

22. Ontario Ministry of Training, Colleges and Universities: Electromechanical Engineering Technology Program Standard: The approved program standard for all Electromechanical Engineering Technology programs of instruction leading to an Ontario College Advanced Diploma delivered by Ontario Colleges of Applied Arts and Technology (MTCU funding code 61021). Toronto (2003).

23. Pankova, N. G.: Metodika obuchenija jelektrotehnicheskim disciplinam v tehnicheskom universitete s primeneniem informacionnyh tehnologij (Methods of teaching electrical engineering disciplines in a technical university using information technology). Dissertation, Nizhny Novgorod State Technical University n.a. R. E. Alekseev (2004).

24. Pchela, S. A.: Obespechenie preemstvennosti podgotovki specialistov jelektro-tehnicheskogo profilja v bazovoj professional'noj shkole (Ensuring the continuity of the training of electrical specialists in the basic vocational school). Dissertation, Mari State University (2007).

25. Polskii, M. A.: Metodicheskie osnovy sozdanija i primenenija kombinirovannyh didakticheskih interaktivnyh programmnyh sistem po jelektrotehnicheskim disciplinam (Methodical bases for the creation and application of combined didactic interactive software systems in electrotechnical disciplines). Dissertation, Astrakhan state technical university (2006).

26. Potemkina, S. N.: Metodika professional'no napravlennogo obuchenija zadach po fizike studentov jelektrotehnicheskih special'nostej vuzov (Method of professionally directed training of the problems of physics of students of electrotechnical specialties of high schools). Dissertation, Togliatti State University (1999).

27. Roney, M. W.: Electro-mechanical Technology: A Field Study of Electro-mechanical Technician Occupations: Final Report, Part I. U. S. Department of Health, Education and Welfare, Washington (1966).
28. Roney, M. W.: Electromechanical Technology: A Post-High School Technical Curriculum: Final Report, Part II. U. S. Department of Health, Education and Welfare, Washington (1966).
29. Sagdeeva, G. S.: Razvitie intellektual'noj kompetentnosti budushhih specialistov (na primere podgotovki inzhenerov-jelektrikov) (Development of intellectual competence of future specialists (on the example of training of electrician engineers)). Dissertation, Kazan National Research Technological University (2013).
30. Shishchenko, E. V.: Formirovanie professional'nyh kompetencij u studentov tehnicheskih special'nostej na osnove integracii jelektrotehnicheskih disciplin (na primere zheleznodorozhnogo tehnikuma) (Formation of professional competences for students of technical specialties on the basis of integration of electrical engineering disciplines (on the example of a railway technical school)). Dissertation, Samara State Technical University (2005).
31. Sobko, R. M.: Dydaktychni osoblyvosti intehratyvnoho navchannia kompiuternykh tekhnolohii u profesiinii pidhotovtsi elektrykiv (Didactic features of integrative teaching of computer technologies in the professional training of electricians). Dissertation, The Institute of Pedagogy of the National Academy of Pedagogical Sciences of Ukraine (2002).
32. Soloshych, I. O.: Metodyka formuvannia ekolohichnykh znan u maibutnikh inzheneriv-elektromekhanikiv u protsesi navchannia spetsialnykh dystsyplin (Method of formation of ecological knowledge of future engineers-electromechanics in the process of training of special disciplines). Dissertation, Ukrainian Engineering Pedagogics Academy (2006).
33. Vaughan, J., Fortgang, J., Singhose, W., Donnell, J., Kurfess, T.: Using mechatronics to teach mechanical design and technical communication. Mechatronics. 18 (4), 79–186. (2008). doi: 10.1016/j.mechatronics.2008.01.003
34. Vishniakova, L. N.: Poniatiino-modulnaia metodika formirovaniia u studentov professionalnogo elektrotekhnicheskogo myshleniia (Conceptual-modular methodology of students' formation of

professional electrotechnical thinking). Dissertation, Magnitogorsk State University (2004).

35. Wang, Y., Yu, Y., Xie, Ch., Wang, H., Feng, X.: Mechatronics education at CDHAW of Tongji University: Laboratory guidelines, framework, implementations and improvements. Mechatronics. 19 (8), 1346–1352 (2009).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 224–234

УДК 37.018.43:004.9]–057.34

Usage of E-learning Tools in Self-education of Government Officers Involved in Global Trade Activities

Olga O. Triakina[1[0000−0001−5872−3891]],
Olena O. Pavlenko[1[0000−0002−3868−3252]],
Nataliia P. Volkova[2[0000−0003−1258−7251]] **and Darja A. Kassim**[3]
[1] University of Customs and Finance,
2/4, Volodymyra Vernadskoho St., Dnipro, 49000, Ukraine
[2] Alfred Nobel University, 18, Naberezhna Sicheslavska St.,
Dnipro, 49000, Ukraine
[3] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine,
5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine
o.triakina@ukr.net, amsu.pavlenko@gmail.com,
npvolkova@yahoo.com

Abstract. The article concerns the issue of e-learning tools implementation, including the Customs Learning and Knowledge Community electronic platform designed by the World Customs Organization and the Trade Facilitation Implementation Guide case studies collected by the United Nations Economic Commission for Europe, into the self-education process of current government employees (within in-service training) and future public officers (within master's programs) connected with international trade transactions. The authors give a description of the content and characteristical features of existing e-learning instruments related to training of professionals in Customs and trade fields as well as of certain tasks developed by the authors. The efficiency of the abovementioned e-learning tools has been experimentally proved in the paper, which has shown that these tools promote the growth of the professional competence of government officers and give a great opportunity for them to be involved in life-long learning to acquire various professional knowledge and skills.

Keywords: e-learning tools, self-study, government officers, Customs Learning and Knowledge Community e-learning platform, case studies, interactive courses, self-education.

1 Introduction

Since out-of-date educational methods proved to be inefficient while informatization became a reality and systematically expands its influence, especially considering the global tendency of life-long learning [1, 8], among the leading methods of organizing self-education activities of future professionals (individual search for professional information, use of modern information technologies, reflexive analysis of educational activities, self-compilation of results and forecasting) [13] the use of electronic training is considered to be an innovative method involving introduction of modern information technologies. So it has become a mainstream to devise various on-line techniques for electronic learning. Our study has revealed that the term "e-learning" in the works of scientists [5, 7] is considered to be equal to the concepts of "distance learning', "online learning", "open education". Its main advantages are accessibility 24 hours a day, simplicity of usage as well as availability of various modern technologies.

Therefore, international organizations including the World Trade Organization (WTO), the European Union (EU), the World Customs Organization (WCO), the United Nations being concerned about government officers' level of professionalism, have developed specific electronic instruments for e-learning [3]. We are convinced that efficient electronic training of specialists worldwide and particularly in Ukraine is possible by means of these instruments adaptation to the national systems of professional training, in-service training and self-education.

2 Description of the Existing E-learning Instruments Designed by the International Organizations for Self-education of International Trade-Related Government Employees

In particular, the WCO electronic platform Customs Learning and Knowledge Community (CLiKC) [14] is designed for e-learning of Customs officers. This innovative electronic platform is fully consistent with the objectives of training a highly qualified customs officer, namely: facilitates the development of professional knowledge of Customs officers, provides modern structures and methods of effective professional training in the field of Customs, promotes the improvement of scientific research as well as provides ideas for the adaptation of in-service training models under the demands of national Customs administrations. These goals are clearly reflected in its structure, consisting of the following three elements:

1. educational materials (electronic thematic modules; interactive training courses; regulatory documents including the main Customs and trade standards and procedures of international organizations; demo slides; glossaries; instructions on portfolio drawing);
2. methods of professional knowledge assessment (intermediate tests,

exercises, surveys and tasks for monitoring the level of knowledge at a particular topic);

3. tools of interaction (forums, chats, expert pools, blogs, workshops). These tools facilitate the exchange of experience concerning the implementation of the WCO CLiKC e-learning platform into national Customs training programs as well as provide an opportunity to discuss the problematic issues that arise in the professional activities of Customs officers [6].

The thematic modules (see table 1) [14] were presented in the form of lectures with a defined content, step by step elaborated curriculum and practical tasks for solving certain professional situations. They cover issues of the Revised Kyoto Convention, risk assessment, profiling and selection of passengers and cargoes for inspection, Customs valuation as well as commercial fraud questions.

Interactive training courses, in turn, contain relevant theoretical material, aimed at deepening the knowledge system, creation of professional skills and abilities, including professionally-oriented tasks of various levels of complexity, which encourage students' creative activity, analytical approach to the solution of professional problems. For learners' comfort they are included in four thematic blocks (see table 2) [14] and are available in five languages: English, French, Arabic, Spanish, Portuguese and Russian. In our opinion, such structure of the electronic platform for Customs training contributes to the successful performance of learners' self-study, since it involves a high level of motivation, clear statement of cognitive tasks, understanding of the algorithm and methods of performing self-study assignments, types and forms of control and evaluation criteria [4].

Our study has found out that the mentioned interactive courses include innovative learning tools that help future Customs officers (within the framework of master's programs) or current employees of Customs administrations (within the framework of in-service training programs) acquire necessary skills to solve professional tasks, act operatively in specific situations and process information flows. In addition, the content of the training materials included ultimately corresponds to demands for the professional training of highly skilled specialists. In particular, situational tasks, business and role games, problem issues, slides and video materials, case studies based on international agreements and conventions effectively reflect the trends of the international Customs environment and promote a consistent and systematic development of both professional, organizational, managerial and communicative competences of Customs and other trade-related government officers within the self-study process [5, pp. 189–193] [9].

Table 1. Example of thematic modules included into CLiKC

Thematic module (hours)	**Topics for practical training**
1. Revised Kyoto Convention (8)	Lesson 1. Reasons for revision of the International Convention on the Simplification and Harmonization of Customs Procedures Lesson 2. The structure of the Revised Kyoto Convention Lesson 3. General Appendix Lesson 4. Special Appendixes
2. Risk assessment, profiling and selection of passengers and cargoes for inspection (42)	Lesson 1. Risk assessment: concepts Lesson 2. Profiling Lesson 3. Risk management cycle Lesson 4. Public and private flights Lesson 5. Commercial airplanes Lesson 6. Profiling of passengers Lesson 7. Passenger selection for inspection Lesson 8. Smuggling of drugs by intracorporal methods Lesson 9. Checking passports Lesson 10. Checking airline tickets Lesson 11. Profiling and selection of commercial cargoes for inspection Lesson 12. Air cargo risk indicators Lesson 13. Smuggling Lesson 14. Ships selection for search Lesson 15. Risk indicators for marine cargo Lesson 16. Smuggling through land borders Lesson 17. Way of thinking of traffickers Lesson 18. Post-seizure analysis Lesson 19. Operational activities Lesson 20. Memorandum of Understanding

Another example of using e-learning instruments for training both government officers and business sector employees involved in international trade operations is related to Trade Facilitation Implementation Guide

Table 2. Interactive training courses of the WCO electronic platform CLiKC (250 hours)

Block 1 *Law enforcement activities*	Block 2 *Conventions and documents*	Block 3 *Tariffs and trade*	Block 4 *Capacity building of Customs administrations*
•Customs control •Protection of intellectual property rights •Post-audit •Multilateral agreements on the protection of the environment •Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) •Substances that destroy the ozone layer •Risk assessment •Commercial fraud	•TIR Convention •Framework Standards for Security and Simplification of International Trade Procedures •Convention on Temporary Importation •WCO Data Model •Revised Kyoto Convention	•Harmonized commodity description and coding system •Customs valuation •Transfer prices •Rules of origin	•Integrity of Customs officers

(TFIG) designed by the United Nations Economic Commission for Europe [12] and the EU Customs Competency Framework [2]. TFIG covers different case studies and best practices including such issues as Single Window, Authorized Economic Operator, advance rulings, post-clearance audit etc. that can be used as topics for on-line discussions, debates, presentations, comparative analysis, brainstorming and other forms of interactive learning, while the Customs Competency Framework describes key requirements for Customs profession and practical techniques to achieve necessary Customs knowledge and skills.

3 Implementation of the E-learning Tools into the Professional Training of Government Officers Related to International Trade Activities

Implementation of the WCO CliKC electronic platform and e-learning instruments of other international organizations was made, primarily, in the educational process of masters in the field of Customs. The following steps were taken: registration of students in the system using passwords received from the national coordinator; students' work with materials covering thematic modules and interactive courses as well as TFIG case studies, tasks, exercises, scenarios; studying into authentic English texts, compiling vocabularies, searching for additional materials in a foreign language, expanding the understanding of the main professional categories, discussing situations in professional English with the use of different grammatical and lexical constructions, scenario modeling through role-playing and business games (among others, within classes of "Business English" and "Foreign language for professional purposes"); fulfillment of tasks being developed by authors on the base of the mentioned e-learning instruments for on-line discussions and forums (see table 3 containing several examples of such tasks) [11, pp. 176–185]. All of these contributed to the development of both professional knowledge and skills as well as the improvement of professionally-directed foreign language communicative competence of future government officers.

The tasks developed by the authors were also tested and then introduced into the system of training personnel of the Customs authorities of Ukraine. In particular, Khmelnytsky Customs Human Resources department was offered to use the theoretical points and practical recommendations for implementation of the e-learning platform CLiKC in the process of self-education of Customs officers as well as the methodical provision, namely the textbook developed by the author [10] for professional competence improvement.

Thus, after organizing and conducting the experimental training, which took place under the influence of specially developed pedagogical technology, we conducted a diagnosis of the level of Customs officers' professional competence development in the control (CG) and two experimental groups (EG1 and EG20). Data obtained during this process were mathematically and statistically processed using Pearson's χ^2 and Fischer criteria [14]. The obtained results are summarized in table 4 and the following diagram (see Fig. 1), the analysis of which enables to trace the growth of the phenomenon being researched [11, pp. 190–193].

Table 3. Tasks for on-line discussions

Thematic module / Interactive course	**Questions for discussion**	**Situations for discussion**
1. Risk assessment	1. How can term "risk" be understood from a Customs viewpoint? 2. Which businesses does risk assessment cover and in which way? Give certain examples 3. Which risk areas does import or export of commercial consignments include?	At Frankfurt airport, German Customs seized 10 kgs of cocaine from a shipment of automobile parts from Brazil. On examining their date base, Customs officers found that this was the seventh case in two years involving automobile parts shipped from Brazil.
2. Security of supply chain	1. What is a bill of lading? In which situations is it used? 2. What is a bill of exchange? Which main steps need to be taken to make a bill of exchange payment? 3. What is a letter of credit? What does it guarantee? 4. Which other terms of delivery are used in the international trade transactions? Give some examples. 5. What are potential risks of fraud in the flow of goods in international trade? 6. What steps should be taken to secure international flow of goods?	On the arrival of a flight from Bogota (Colombia), the Customs Targeting Unit at Paris international airport picked out an air waybill for a shipment of handicrafts bound for France. The company shown as consignor was unknown, and the company shown as consignee was not listed under the address given. The telephone number was a real one, but it was a number of a bookshop whereas it should have been an arts and crafts shop. An external inspection showed that there were no markings on the packages. When the packages were opened, they were found to contain handicrafts made from cocaine paste. There were 20 kgs of cocaine.

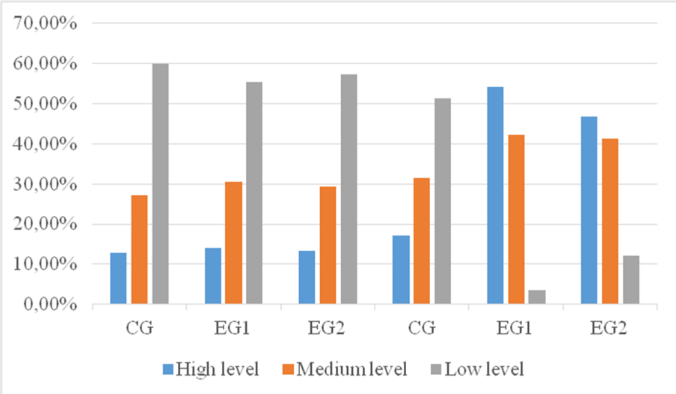


Fig. 1. Comparative diagram of evaluation of the professional competence improvement at the diagnostic and control stages of the experiment

Table 4. General assessment of the levels of professional competence development

Level	Diagnostic phase						Control phase					
	CG		EG1		EG2		CG		EG1		EG2	
	N	%	N	%	N	%	N	%	N	%	N	%
High	9	12,86	12	14,12	10	13,33	12	17,14	46	54,12	35	46,67
Medium	19	27,14	26	30,59	22	29,33	22	31,43	36	42,35	31	41,33
Low	42	60,00	47	55,29	43	57,34	36	51,43	3	3,53	9	12,00

Consequently, the figures obtained show significant changes in the two experimental groups in comparison with the results acquired during the diagnostic phase. As it can be seen, 54.12% respondents of the first experimental and 46.67% respondents of the second experimental group reached a high level of knowledge, mastery of necessary skills and development of professionally significant personal qualities. In the control group, which was trained according to a standardized scheme, the high level of professional competence increased only by 4.28%, while the indicator of the same level in the first experimental group rose by 40%, in the second experimental group — by 33.34%.

In our opinion, such results were achieved due to the updating of the content of the specialized training by means of implementing the CLiKC e-learning platform, other e-learning instruments as well as specific tasks developed by the authors into the framework of self-study process of current and future staff of the Ukrainian Customs and other trade-related government authorities.

4 Conclusions

To sum it up, we should highlight that the abovementioned e-learning instruments are the most progressive methods of training current and future government employees connected with global trade operations, since they have many opportunities and benefits, namely:

- stipulate tutoring, facilitate access to Customs and trade experience (TFIG case studies), current legal and regulatory framework;
- include a variety of relevant theoretical and practical teaching materials, the content of which promotes learners' cognitive activity, since it reflects current conditions of Customs environment worldwide and provides specific tools for solving professional problems;
- the content of interactive courses of the CliKC e-learning platform simulates the future professional activity of a specialist;
- tasks, exercises and scenarios have video and audio support that stimulate interest and motivation of students;
- the diversity of authentic texts and professional vocabulary in foreign languages accompanied by audio and video files leads to the improvement of professionally-oriented foreign language communicative competence;
- electronic training modules facilitate consistent and systematic acquisition of professional knowledge and skills in accordance with the international professional standards of Customs and other government officers;
- include automatic assessment systems for evaluation of achievements within each interactive course that stimulates self-esteem and self-reflection;
- offer government agencies and business structures an opportunity to share documents and experiences concerning managerial, strategic and technical issues;

- they are an effective tool for developing the competences of future specialists in the field of foreign economic activity;
- provide life-long professional improvement.

References

1. European Comission: Explaining the European Qualifications Framework for Lifelong Learning. Office for Official Publications of the European Communities, Luxembourg (2008).
2. European Commission: EU Customs Competency Framework. https://ec.europa.eu/taxation_customs/eu-training/eu-customs-competency-framework_en (2016). Accessed 25 Dec 2017.
3. Graaf, M.: Communication, integral to the achievements of the European Union Customs Union. WCO News. 73, 24–25 (2014).
4. Pavlenko, O. O., Triakina, O. O., Timchenko-Mikhailidi, N. S., Pugach, V. B.: Evaluation of the communicative competence level of masters in the field of foreign economic activity and methods of its development. Bulletin of Alfred Nobel University, Series "Pedagogy and Psychology". 2 (14), 197–203 (2017).
5. Pavlenko, O. O.: Formuvannia komunikatyvnoi kompetentsii fakhivtsiv mytnoi sluzhby v systemi neperervnoi profesiinoi osvity (Forming Communicative Competency of Customs Officers under the System of Lifelong Professional Education). Dissertation, Taras Shevchenko National University of Kyiv (2010).
6. Poro, A.: European Customs training community benefits from new knowledge sharing tool. WCO News. 64, 32–33 (2011).
7. Semerikov, S. O., Striuk, M. I., Moiseienko, N. V.: Mobilne navchannia: istoryko-tekhnolohichnyi vymir (Mobile learning: historical and technological dimension). In: Konoval, O. A. (ed.) Teoriia i praktyka orhanizatsii samostiinoi roboty studentiv vyshchykh navchalnykh zakladiv (Theory and practice of organization of independent work of students of higher educational institutions), pp. 188–242. Knyzhkove vydavnytstvo Kyreievskoho, Kryvyi Rih (2012).
8. Striuk, M. I., Semerikov, S. O., Striuk, A. M.: Mobilnist: systemnyi pidkhid (Mobility: a systems approach). Information Technologies and Learning Tools. 49 (5), 37–70 (2015).

9. Triakina, O. A.: Implementation of the on-line modules of the World Customs Organization into professional training of Ukrainian Customs personnel. Europaische Fachhochschule, 6, 31–33 (2014).
10. Triakina, O. O., Movchan, D. O.: Foreign language for professional purposes (English): manual for students' self-study. AMSU, Dnipropetrovsk (2014).
11. Triakina, O. O.: Pidhotovka mahistriv u haluzi mytnoyi spravy na zasadakh mizhnarodnykh profesiynykh standartiv mytnykiv (Training of masters in the field of Customs affairs in accordance with the international Professional Standards of Customs officers). Dissertation, Classical private university (2015).
12. UNECE: Trade Facilitation Implementation Guide. http://tfig.unece.org (2012). Accessed 25 Dec 2017.
13. Volkova, N. P., Tarnopolskyi, O. B.: Modeliuvannia profesiinoi diialnosti u vykladanni navchalnykh dystsyplin u vyshakh (Modeling of professional activity in teaching of academic disciplines in higher education). Alfred Nobel University, Dnipropetrovs'k (2013).
14. World Customs Organization. http://www.wcoomd.org (2018). Accessed 27 Jan 2018.

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 235–246

УДК 378.016:91]:004.94

Google Classroom as a Tool of Support of Blended Learning for Geography Students

Olha V. Bondarenko[1[0000−0003−2356−2674]], **Svitlana V. Mantulenko**[1[0000−0001−5673−0174]] and **Andrey V. Pikilnyak**[2[0000−0003−0898−4756]]

[1] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
bondarenko.olga@kdpu.edu.ua, mantulenkokdpu@ukr.net

[2] State Institution of Higher Education "Kryvyi Rih National University" 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
pikilnyak@gmail.com

Abstract. The article reveals the experience of organizing blended learning for geography students using Google Classroom, and discloses its potential uses in the study of geography. For the last three years, the authors have tested such in-class and distance courses as "Cartography and Basics of Topography", "Population Geography", "Information Systems and Technologies in Tourism Industry", "Regional Economic and Social World Geography (Europe and the CIS)", "Regional Economic and Social World Geography (Africa, Latin America, Asia, Anglo-America, Australia and Oceania)", "Socio-Economic Cartography".

The advantages of using the specified interactive tool during the study of geographical disciplines are highlighted out in the article. As it has been established, the organization of the learning process using Google Classroom ensures the unity of in-class and out-of-class learning; it is designed to realize effective interaction of the subjects learning in real time; to monitor the quality of training and control the students' learning achievements in class as well as out of it, etc.

The article outlines the disadvantages that should be taken into account when organizing blended learning using Google Classroom, including the occasional predominance of students' external motivation in education and their low level of readiness for work in the classroom; insufficient level of material and technical support in some classrooms; need for out-of-class pedagogical support; lack of guidance on the content aspect of Google Classroom pages, etc.

Through the test series conducted during 2016–2017, an increase in the number of geography students with a sufficient level of academic achievements and a decrease of those with a low level of it was revealed.

Keywords: Google Classroom, blended learning, in-class and distance learning.

1 Introduction

1.1 The Problem Statement

The topicality of the problem using the Google Classroom is determined by a wide range of problems that can be presented in the form of contradictions between the social requirements for geography students' professional training, its specific characteristics (the need for organizing systematic educational activities outside the specially equipped laboratories of higher educational institutions (HEI): field practices, integrated practices, etc.) and the prevalence of higher educational institutions providing traditional didactic forms, methods and tools; between the constant growth of the volume of students' independent and individual work and the need for the facilitation of all types of educational activities of geography students at any time and in any place of its course using the available and corresponding tools of information and communication technologies (ICT), including the mobile ones; between the potential use of modern ICTs and inadequate level of readiness for their implementation by university lecturers and students.

One of the ways to overcome these contradictions is the implementation of *combined geography training*, which, according to the research carried out by Andrii M. Striuk [21], is understood as a Geography training technique, integrating the in-class and out-of-class educational activities, provided that a pedagogically balanced combination of traditional as well as innovative techniques for the in-class, distance and mobile training is carried out for the effective educational goals achievement.

1.2 Theoretical background

Some aspects of the problem under study are highlighted in the scientific articles devoted to theoretical and methodological principles and the methodology of distance education (Aleksandr A. Andreev [1], Myroslav I. Zhaldak [24], Volodymyr M. Kukharenko [3], Yukhym I. Mashbyts [8], Svitlana V. Shokaliuk [17]); blended training organization (Volodymyr M. Kukharenko [6], Natalia V. Rashevska [12], Serhii O. Semerikov [16], Andrii M. Striuk [20], Yurii V. Tryus [23], Bohdan I. Shunevych [18]); development of information-and-education environment (Aleksandr A. Andreev [1], Kateryna I. Slovak [20], Mariia A. Kyslova [7], Liubov F. Panchenko [11], Maiia V. Popel [18], Mariia P. Shyshkina [19]); the use of innovative ICT in the educational process (Valerii Yu. Bykov [3], Illia O. Teplytskyi [14, 15]).

The interest in solving the chosen problem is caused by research on geography methods of teaching, which reveals tendencies of educational space renewal by means of informatization of higher education (Oleh M. Topuzov [22]); geographic information systems and technologies (Viktor M. Samoilenko [13]); possibilities of providing geography distance learning (Yurii A. Fedorenko [4]). The blended learning of geography is represented on a larger scale in the writings of foreign scholars: the implementation of combined learning in the study of geography in the first year (Phillipa Mitchell and Pip Forer [9]), the influence of combined geography teaching on critical thinking of students (Özgen Korkmaz and Ufuk Karakuş [5]) and others.

The analysis of scientific developments and information resources of domestic higher educational institutions suggests that Moodle is a traditional tool of supporting blended learning in higher education [10], although nowadays there are other alternative options for open learning management systems, Google Classroom in particular.

At the same time, Google Classroom as a tool of supporting the blended training for geography students, has not yet found a comprehensive study and full coverage in the scientific writings of domestic researchers.

1.3 The objective of the article

The objective of the article is to highlight the experience of supporting the blended training for geography students by using Google Classroom.

2 Presenting the Main Material

Google Classroom is an educational interactive tool that allows creating an informatively rich educational environment integrating the Google Docs text editor, Google Drive cloud storage, Gmail and other applications (YouTube, Google Sheets, Google Slides, Google Forms, etc.) [7].

In terms of the interactive on-line interaction the Google Classroom is to: ensure the integrity of classroom and out-of-class work (group, independent, individual, etc.); realize effective interaction of learning subjects in real time through: creating tasks for each particular course and group with hyperlink onto multimedia content; editing and commenting on the state of a student's tasks; compiling individual tasks into thematic modules; publishing announcements, questions, information digests, etc.; controlling the students' individual tasks in both classroom and out-of-class time; setting deadlines for each task; commenting on the revised multimedia content offered for the tasks; assessing students' academic achievements on a national or international scale; copying the academic achievements to the Google Sheets to generate statistical reports, visual monitoring of the quality of training [2].

Within the Google Classroom, the interaction of all learning subjects ("student — student", "student — student group", "teacher — student", "teacher — student group") takes place not only for distance education (training communication outside the HEI), but also for the traditional in-class learning (training communication within the HEI) using e-mail, electronic conferences and other Internet communication tools. The most common forms of learning tools provided by the Google Classroom include: e-mail (Google Mail), e-conferencing (Hangouts), Google Forms, communication via chats, and others.

The revealing of the content of geographic disciplines, as well as the monitoring and control of geography students' academic achievements, is possible through the implementation of computer-based learning tools, in particular content delivery tools (Docs, Drive, Presentations, YouTube), visualization tools (Presentations, Maps, YouTube, Earth), control tools (Sheets, Forms), etc. (Fig. 1).

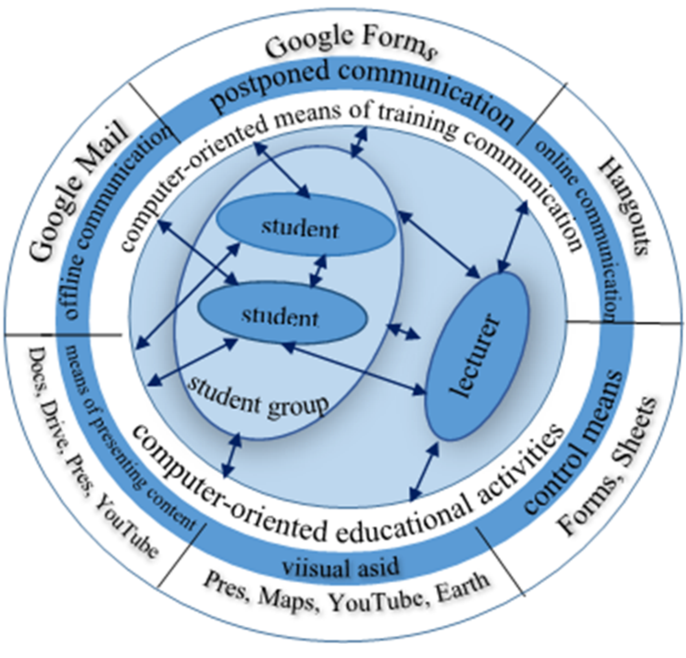


Fig. 1. The model of the information and education environment of blended learning for geography students in HEI based on Google Classroom

According to the developed model there have been developed in-class and distance learning courses in the following geographic disciplines: "Cartography and Basics of Topography", "Population Geography", "Information Systems and Technologies in Tourism Industry", "Regional Economic and Social World Geography (countries of Europe and the CIS)", "Regional Economic and Social World Geography (Africa, Latin America, Asia, Anglo-America, Australia and Oceania)", "Socio-Economic Cartography" which have been tested for three years of study.

Let's have a closer look at the specific features of implementing the blended teaching of geographic disciplines in Google Classroom.

Each of the offered courses has a clearly defined structure. In the e-class, there are three pages "Stream", "Students", "Information", which have a certain content. So, the following basic elements are traditionally presented in "Stream": "practical / laboratory classes", "independent work", "nomenclature", "individual tasks" etc.

For every practical or laboratory lesson contained on the "Stream" page, you can not only add guidance to the tasks, but also attach any necessary file, vocation, and video, i.e., all the elements revealing the content of the subject being studied.

The "Students" page usually shows the class code and the contingent of the course attendees with access to their e-mail. The "Information" page, as a rule, provides such elements as "the course tasks and objectives, the classroom, the calendar / schedule of classes", "curriculum program", "list of recommended literature (basic, additional)", "contour maps", "maps and atlases", "reference sources", "methodical materials", "multimedia gallery", "Internet resources for creating maps". The contents of the page "Information" may vary depending on the specifics of the discipline content. The "Information" page contains electronic resources necessary for the tasks provided in "Stream" and provides a wide access to multimedia content, electronic libraries, textbooks, articles, maps, atlases, sites of international organizations, research institutes, databases, etc.

The extra benefits of using the specified resource for geographic courses is determined by the fact that most classes require work with contour maps, charts, diagrams, etc. In the Google Classroom, students can create maps by themselves using various editors and resources (DataGraf, Google Earth), tasks (learningapps.org); work with interactive maps (MigrationsMap, kartograph.org), statistical sources (USS\Ukrainian State Statistics Service, countrymeters.info); analytical data of international organizations (UNO, WHO, etc.); demonstrate knowledge of geographic nomenclature (online.seterra.net); conduct thematic control of knowledge (Google Forms) and others.

A compulsory element in geography students' professional training is the knowledge of the geographical nomenclature. As a rule, students pass the nomenclature by oral questioning using wall maps. The disadvantages of such a method of training are considered to be: a large time amount spent on the survey of one student and a group as a whole; the obsolete content of the wall social and economic maps; subjective assessment of knowledge of the nomenclature, etc.

Google Classroom allows replacing the traditional methodic of compiling the nomenclature for the interactive one. For example, second-year students are offered the Seterra online resource (https://online.seterra.com) and the Click-that-hood (http://click-that-hood.com) has been adjusted for the third-year students. The content of the task is that a student is to demonstrate the knowledge of the nomenclature within the time limit, save the version and send it to the teacher for marking.

The advantages of such a check of the nomenclature are: the individual pace of the task; objectivity of assessment; mapping skills; rational in-class time management.

When studying the above-mentioned disciplines, Google Classroom is used with a different didactic purpose. Thus, students of the first year use it with a propaedeutic purpose, as a multimedia library (without downloading works and sending it for correcting analysis to the teacher). This is explained by the fact that in practical classes of the "Cartography and Basics of Topography" course geography students are, first of all, to be able to work with geographic maps and carry out topographical surveys of the area. Therefore, the Google Classroom use will in no way replace work with a map or field surveys. However, freshmen performing such tasks as the definition of the scale of distances and areas, orientation angles, absolute heights on a topographic map face various difficulties. Unfortunately, the degree of understanding of the new material in the classroom in the presence of pedagogical support is much higher than during the independent extra-curriculum knowledge acquisition. In addition, at home, the student is not able to work with most geodesic instruments, whereas in the practical class one needs to know not only their structure, but also use them in practice. The multimedia library content allows revising in full extend what has been learned in class, and it provides access to the video, which demonstrates the algorithm of topographic, promotes a better acquisition of means and methods of topographic survey of the area.

While studying the "Population Geography" course the main emphasis is placed on the fact that second-year students, unlike freshmen, should not only review the content of the study material and reproduce it, but also perform constructive tasks, find information in various sources characterizing the population of the world and particular countries, to analyze processes and to identify demographic tendencies, to characterize quantitative and qualitative indices of the country's population based on the aggregation of cartographic and statistical data — all of it is impossible without having access to relevant record-statistics, which are of a dynamic nature. However, independent search for the necessary data carried out by students often causes difficulties. The teacher can help: by restricting the search field by offering linking to the sites of reputable statistical organizations ("Information — Reference Sources" page).

While studying the "Regional Economic and Social Geography" and "Socio-economic Cartography" courses in Year III–IV for Bachelor Degree and Year I for Master Degree, geography students work with Google Classroom in a complex way: they perform the proposed tasks in the required editors (Docs, Sheets, Slides, etc.), send them to the teacher for checking up, comment on the multimedia content of the class, monitoring their academic achievements, offer discussion and data analysis of the information found during the self-search to the colleagues, etc. [2].

Google Classroom acquires a particular importance during the study of "Information Systems and Technologies in Tourism Industry" course, as it can be perceived from the course name, ICT is its inalienable part. Thus, within the Google Classroom it is convenient to consider the hardware and software of the automation work of tourist enterprises; to demonstrate the organizational and communicational provision of the work of the tourist office, etc. In studying this discipline, students learn to use office applications (Google Docs, Microsoft Office 365), specific products (Quick Sales 2.0, SELF-Agent, etc.), get acquainted with automated reservation systems in tourism (Amadeus, Galileo) and others.

At the final stage of the study of the mentioned above geographical disciplines during 2016 and 2017 the students' academic achievements have been monitored and summed up. As the proof of the developed distance learning courses effectiveness, the results of studying the course "Regional Economic and Social World Geography" are presented in Fig. 2. (traditional training method was used in Group I, and blended learning with Google Classroom — in Group II).

Analysis of Fig. 2 illustrates the positive dynamics in the levels of students' academic achievements in Group II. So, it is noticeable to observe an increase in the number of students with a sufficient level and a decrease in those who have shown a low level. In Group II, the number of high-level students increased from 7.1% to 10.7%; with sufficient — from 32.2% to 42.9%; with an average decreased from 46.4% to 42.9%; with a low — from 14.3% to 3.5%. There were no significant changes in Group I.

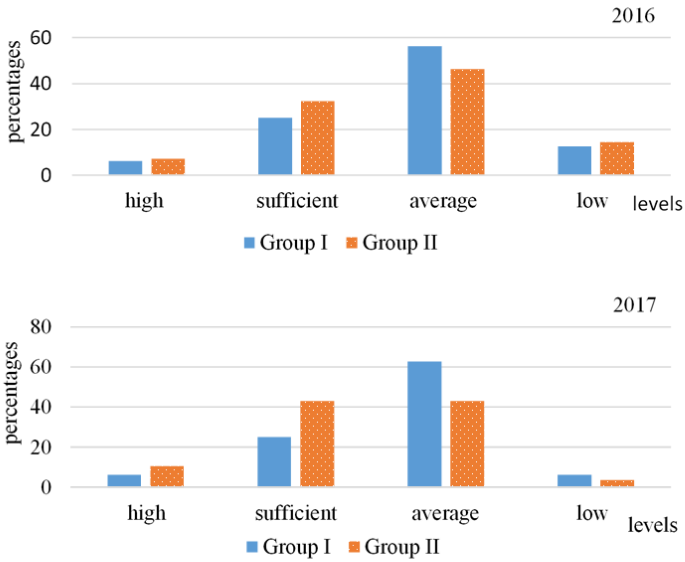


Fig. 2. Levels of students' academic achievements in the course "Regional Economic and Social World Geography"

3 Conclusion

1. Summarizing the above stated, we may claim the benefits of using the Google Classroom for blended learning organization are as follows: real-time interaction of real-time learning subjects, which is particularly valuable if the volume of independent work is increased; the presence of constant pedagogical support and ensuring the integrity of both in-class and out-of-class work; increasing the visual aids in learning; development of critical thinking; formation of professional geographic competencies; attracting students to the familiar electronic environment with the use of ICT; operational control of educational achievements.
2. The disadvantages to take into account when organizing distance learning through the Google Classroom are to be considered: the

predominance of external learning motivation and the low level of readiness of individual students for working in the new environment; lack of proper material and technical support for particular academic classrooms in HEI; the need for extra-curriculum pedagogical support, which requires additional time consuming from the teacher; inadequate attention of individual teachers to the problem of in-class and distance learning implementation.

3. Further study of the problem on organizing the blended learning for geography students is planned in the direction of developing a model and methodic of using Google Classroom as a tool of blended training future teachers of geography.

References

1. Andreev, A. A.: Didakticheskie osnovy distantcionnogo obucheniia v vysshikh uchebnykh zavedeniiakh (Didactic bases of distance learning in higher educational institutions). Dissertation, University of Moscow (1999).
2. Bondarenko, O. V.: Vykorystannia Google Classroom pid chas vyvchennia rehionalnoi ekonomichnoi i sotsialnoi heohrafii svitu (Using Google Classroom towards a study of the regional economic and social geography of the world). In: Implementation of ICT in the educational process of educational institutions, pp. 3–5. Poltava V. G. Korolenko National Pedagogical University, Poltava (2016).
3. Bykov, V. Yu., Kukharenko, V. M., Syrotenko, N. H., Rybalko, O. V., Bohachkov, Yu. M.: Tekhnolohiia stvorennia dystantsiinoho kursu (Technology of creation of a distance course). Milenium, Kyiv (2008).
4. Fedorenko, Yu. A.: Mozhlyvosti dystantsiinoho navchannia heohrafii y orhanizatsiia dystantsiinoi formy virtualnoho uroku (Possibilities of distance learning of geography and organization of remote form of virtual lesson). Kompiuter u shkoli ta simi. 1, 40–42 (2011).
5. Korkmaz, Ö., Karakuş, U.: The Impact of Blended Learning Model on Student Attitudes towards Geography Course and Their Critical Thinking Dispositions and Levels. The Turkish Online Journal of Educational Technology. 8 (4), 51–63 (2002).
6. Kukharenko, V. M., Berezenska, S. M., Buhaichuk, K. L., Oliinyk, N. Yu., Oliinyk, T. O., Rybalko, O. V., Syrotenko, N. H., Stoliarevska,

A. L.: Teoriia ta praktyka zmishanoho navchannia (Theory and practice of blended learning). Miskdruk, NTU "KhPI", Kharkiv (2016).

7. Kyslova, M. A., Semerikov, S. O., Slovak, K. I.: Rozvytok mobilnoho navchalnoho seredovyshcha yak problema teorii i metodyky vykorystannia informatsiino-komunikatsiinykh tekhnolohii v osviti (Development of mobile learning environment as a problem of the theory and methods of use of information and communication technologies in education). Information Technologies and Learning Tools. 42 (4), 1–19 (2014).
8. Mashbyts, Yu. I.: Teoretyko-metodolohichni zasady proektuvannia dystantsiinykh navchalnykh seredovyshch (Theoretical and methodological foundations of designing distance learning environments). In: Smulson, M. L. (ed.) Dystantsiine navchannia: psykholohichni zasady (Distance learning: psychological foundations), pp. 8–41. Imeks-LTD, Kirovohrad (2012).
9. Mitchell, P., Forer P.: Blended Learning: The Perceptions of First-year Geography Students. Journal of Geography in Higher Education. 34 (1), 77–89 (2010). doi: 10.1080/03098260902982484
10. Nechypurenko, P. P., Semerikov, S. O.: VlabEmbed — the New Plugin Moodle for the Chemistry Education. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR-WS.org), vol. 1844, pp. 319–326 (2017).
11. Panchenko, L. F.: Teoretyko-metodolohichni zasady rozvytku informatsiino-osvitnoho seredovyshcha universytetu (Theoretical and methodological basis of the development informational educational environment of university). Dissertation, Luhansk Taras Shevchenko National Universit (2011).
12. Rashevska, N. V., Semerikov, S. O., Slovak, K. I, Striuk, A. M.: Model kombinovanoho navchannia u vyshchii shkoli Ukrainy (The model of blended learning in the high school of Ukraine). In: Sbornik nauchnykh trudov (Collection of scientific papers), pp. 54–59. Miskdruk, Kharkiv (2011).

13. Samoilenko, V. M.: Heohrafichni informatsiini systemy ta tekhnolohii (Geographic Information Systems and Technologies). Nika-Center, Kyiv (2010).
14. Semerikov, S., Teplytskyi, I., Shokaliuk, S.: Mobilne navchannia: istoriia, teoriia, metodyka (Mobile learning: history, theory, methodic). Informatyka ta informatsiini tekhnolohii v navchalnykh zakladakh. 6, 72–82 (2008).
15. Semerikov, S., Teplytskyi, I., Shokaliuk, S.: Mobilne navchannia: istoriia, teoriia, metodyka (Mobile learning: history, theory, methodic). Informatyka ta informatsiini tekhnolohii v navchalnykh zakladakh. 1, 96–104 (2009).
16. Semerikov, S. O., Striuk, A. M.: Kombinovane navchannia: problemy i perspektyvy zastosuvannia v udoskonalenni navchalno-vykhovnoho protsesu y samostiinoi roboty studentiv (Blended learning: problems and prospects of improvement in the educational process and students' independent work). In: Konoval, O. A. (ed.) Teoriia i praktyka orhanizatsii samostiinoi roboty studentiv vyshchykh navchalnykh zakladiv (Theory and practice of organization of independent work of students of higher educational institutions), pp. 135–163. Knyzhkove vydavnytstvo Kyrieievskoho, Kryvyi Rih (2012).
17. Semerikov, S. O., Teplytskyi, I. O., Shokaliuk, S. V.: Novi zasoby dystantsiinoho navchannia informatsiinykh tekhnolohii matematychnoho pryznachennia (New distance learning tools of information technologies for mathematical purposes). Visnyk. Testuvannia i monitorynh v osviti. 2, 42–50 (2008).
18. Shunevych, B., Musiyovska, O.: Foreign Language Blended Learning at Higher Schools in Ukraine. In: Proceedings of the International Conference on Computer Science and Information Technologies (CSIT'2006), Lviv Polytechnic National University, Lviv, September 28th–30th 2006, pp. 197–200 (2006).
19. Shyshkina, M., Kohut, U., Popel, M.: The Systems of Computer Mathematics in the Cloud-Based Learning Environment of Educational Institutions. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and

Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR-WS.org), vol. 1844, pp. 396–405 (2017).

20. Slovak, K. I., Semerikov, S. O., Tryus, Yu. V.: Mobilni matematychni seredovyshcha: suchasnyi stan ta perspektyvy rozvytku (Mobile mathematical environments: current state and development prospects). Naukovyi chasopys Natsionalnoho pedahohichnoho universytetu imeni M. P. Drahomanova. Seriia No 2. Kompiuterno-oriientovani systemy navchannia. 12 (19), 102–109 (2012).
21. Striuk, A. M.: Teoretyko-metodychni zasady kombinovanoho navchannia systemnoho prohramuvannia maibutnikh fakhivtsiv z prohramnoi inzhenerii (Theoretical and methodological foundations of blended learning of system programming of future specialists in software engineering). Vydavnychyi viddil DVNZ "Kryvorizkyi natsionalnyi universytet", Kryvyi Rih (2015).
22. Topuzov, O.: Tendentsii funktsionuvannia protsesiv onovlennia osvitnoho prostoru zasobom informatyzatsii vyshchoi shkoly (Trends of the educational process update area information by the graduate school). In: Stratehiia pidpryiemstva: zmina paradyhmy upravlinnia ta innovatsiini rishennia dlia biznesu (Enterprise strategy: changing management paradigm and innovative solutions for business), International scientific-and-practical Conference, Kyiv National Economic University named after Vadym Hetman, Kyiv, 14–15 November 2013, pp. 409–411. KNEU, Kyiv (2013).
23. Tryus, Yu. V., Herasymenko, I. V.: Kombinovane navchannia yak innovatsiina osvitnia tekhnolohiia u vyshchii shkoli (Blended learning as an innovation educational technology in higher school). Theory and methods of e-learning. 3, 299–307 (2012).
24. Zhaldak, M. I.: Kompiuterni navchalni prohramy u seredovyshchakh dystantsiinoho navchannia (na prykladi dystantsiinoho kursu "Teoriia ymovirnostei i matematychna statystyka") (Computer training in distance learning environments (on the example of the distance course "Theory of Probability and Mathematical Statistics")). In: Smulson, M. L. (ed.) Dystantsiine navchannia: psykholohichni zasady (Distance learning: psychological foundations), pp. 42–50. Imeks-LTD, Kirovohrad (2012).

УДК 378.147:004.9]:62–051

Augmented Reality and the Prospects for Applying Its in the Training of Future Engineers

Natalya V. Rashevska[1[0000−0001−6431−2503]] **and Vladimir N. Soloviev**[2[0000−0002−4945−202X]]

[1] State Institution of Higher Education “Kryvyi Rih National University”, 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
nvr1701@gmail.com

[2] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
vnsoloviev2016@gmail.com

Abstract. The education system of Ukraine is closely linked with the world education trends, therefore it requires constant renewal and expansion. One of the progressive areas of organizing studying process is creating the studying environment which will allow students to reveal their intellectual potential while searching for the necessary knowledge. That’s why the *purpose of the article* is analysis of the concept of augmented reality and prospects of its application in the process of training future engineers. The *object of study* is the system of training future engineers and the subject is using of augmented reality technologies in the process of training future engineers. The *research method* is *analyzing the impact* of the augmented reality technologies on the training future engineers. During the research, we have identified positive aspects of the augmented reality technologies in the process of training future engineers. We have defined the stages of creating some methodical system components of teaching fundamental disciplines in the higher technical school through interdisciplinary integration and technologies of augmented reality.

Keywords: technology of augmented reality; process of training future engineers.

1 Introduction

The key to human success is our education, which takes on a new feature in the 21st Century — learning throughout our life, and the ability to apply this knowledge in practice.

The rapid change of technology, the development of information and communication technologies, the change in the paradigm of educating has led to the fact that the amount of knowledge necessary for a person to succeed is constantly changing and increasing, and therefore there is a need to acquire new knowledge quickly and qualitatively, and be able to apply our knowledge in everyday life and educating.

Formal educating in a higher technical educational institution under the traditional system in the 20th century has been replaced by new forms of educating — distance, electronic and mobile [21]. Each of these forms has its own positive and negative features, but none of them was able to replace the traditional educating process — "live" communication between a teacher and a student. One of the models of educating that was able to combine the traits of traditional educating with innovation was the model of mixed educating (blended learning), which enabled the student to become an active seeker of their own knowledge [18, 19].

For more immersion of the student into the educating process, in order to better visualize the knowledge gained, technologies of the complementary (mixed, augmented, virtual etc.) reality, which make it possible to change the approach to the organization of the process of educating in higher education are more relevant in recent times [16].

2 Related work

The analysis of scientific sources provided an opportunity to argue that the use of technologies of augmented reality in the educating process:

- increases motivation for educating [9] and self-motivation [13];
- increases the quality of education [5, 8, 12];
- creates conditions for obtaining more thorough knowledge [17];
- creates conditions for improving the quality of inclusive education [14];
- provides the opportunity to build an educating process based on the model of mixed educating [4, 23] with the involvement of mobile information and communication technologies [10].

3 The Aim of the Study

Thomas Preston Caudell, the author of the term "augmented reality", in 1990 was the engineer of research laboratory at Boeing [6], and later, with the development of information and communication technologies, the term gained widespread consumption not only as a technology expansion of reality, but and as technologies that can be used in the learning process.

That is why, the purpose of the article is to analyze the concept of augmented reality and the prospects for its application in the process of preparing future engineers.

4 Discussion and Results

Let us analyze the notion of "augmented reality" in the historical context [20]. Four years later, from the first mention of the concept of "augmented reality" by Caudell in 1994, the article "Taxonomy of mixed reality" was published, in which the authors consider such concepts as virtual reality, mixed reality and augmented reality [15]. In opinion Paul Milgram and Fumio Kishino, augmented reality is a technology by which the user's capabilities are expanded by introducing into the user's perception field various virtual objects in real time mode (Fig. 1).

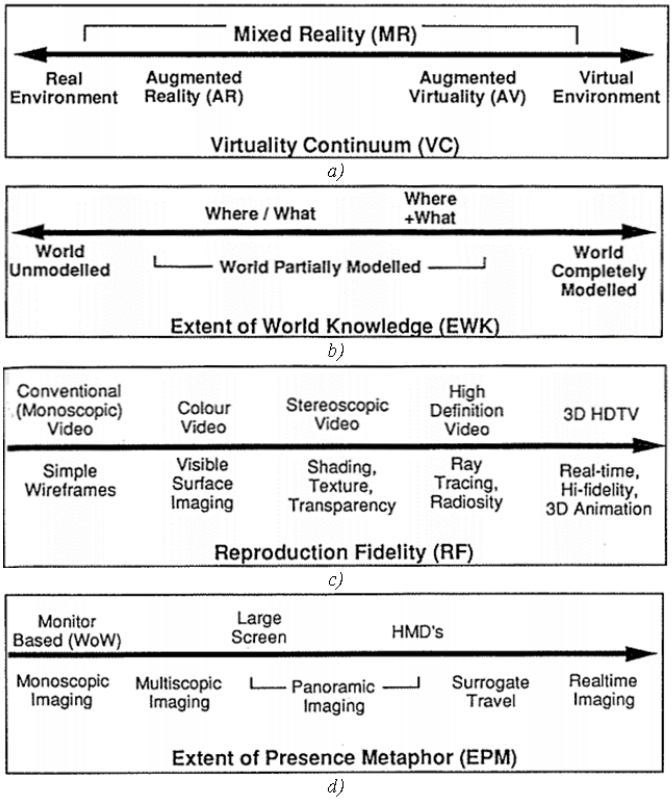


Fig. 1. Milgram-Kishino taxonomy of mixed reality visual displays: a) simplified representation of a "virtuality continuum"; b) extent of World Knowledge dimension; c) Reproduction Fidelity dimension; d) extent of Presence Metaphor dimension

In 1997, Ronald T. Azuma first formulated the basic principles that characterize systems using augmented reality:

1. the combination of real and virtual world;
2. interaction in real time;
3. work with three-dimensional space, and also provides an interpretation of the concept of augmented reality.

In his view, augmented reality is the technology of integrating real and computer-generated virtual objects in the real world [2].

Later, in 2001, scientist added to this list the application of augmented reality applications by incorporating virtual and computer content into it, allowing a wider application of mixed reality through a simulation that takes place in a virtual rather than a real world [1].

A wide application of the term "augmented reality" began to acquire with the development of software and hardware for its creation and support.

According to Evgeniia A. Daineko [7], there are several reasons for the growth in the popularity of technologies of augmented reality: 1) interactivity, 2) accessibility, 3) realism, 4) innovativeness.

So, *augmented reality* is technology that allows you to combine computer-aided 3D graphics, animation, video and textual information with real-time objects [3]; it is a mixed reality that can be perceived by a person, and supplemented with the help of a computer with elements of some reality [22]; it is a technology that combines the physical environment of a person with a layer of virtual reality in real time. It is used to visually supplement printed material with various virtual objects: text, sound, video, etc. [11]; this environment with the addition of the physical world with digital data, are perceived as elements of real life. When creating augmented reality in space in real time, objects are placed using special software and devices for their reproduction [16].

Using the technologies of augmented reality in the process of preparing future engineers will allow:

- to carry out the integration of fundamental disciplines and visualize the educating process;
- make the learning process holistic, vivid, rich and will strengthen the fundamentalization of engineering education;
- to build an open system of education that will provide each student the opportunity to create a personal trajectory of educating;

- to expand the boundaries of educating — acquire knowledge using the teaching materials of the world's leading technical universities;
- to make the educating process individualized and adapted for each student;
- to increase cognitive activity of students in the process of teaching fundamental disciplines and make the student an active competitor of knowledge;
- to support independent work of the student;
- to intensify the educating process;
- to increase the student's creative thinking and expand the vision of the world.

5 Conclusion

Summarizing the above, it can be argued that for the further implementation of certain components of the application of augmented reality technologies in the process of educating future engineers, it is necessary:

- to identify means of augmented reality that can be used in the process of teaching fundamental disciplines;
- to determine the forms and methods of organizing the process of teaching fundamental disciplines, taking into account the augmented reality in the higher technical school;
- to develop educating materials for visualization of the educating process, which combined theoretical and practical information on the subjects of the specialty and implemented intersubject communications;
- to develop a methodology for teaching fundamental disciplines based on the technology of augmented reality and experimentally test or disprove its effectiveness.

References

1. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., MacIntyre, B.: Recent Advances in Augmented Reality. IEEE Computer Graphics and Applications. 21 (6), 34–47 (2001).

2. Azuma, R. T.: A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments. 6 (4), 355–385 (1997). doi: 10.1162/pres.1997.6.4.355
3. Bova, V. V., Lezhebokov, A. A., Nuzhnov, E. V.: Obrazovatelnye informatcionnye sistemy na osnove mobilnykh prilozhenii s dopolnennoi realnostiu (Educational information system based mobile applications with augmented reality). Izvestiya SFedU. Engineering sciences. 6 (167), 200–210 (2015).
4. Chang, Y. H., Liu, J.-ch.: Applying an AR Technique to Enhance Situated Heritage Learning in a Ubiquitous Learning Environment. The Turkish Online Journal of Educational Technology. 1 (3), 21–32 (2013).
5. Civelek, T., Ucar, E., Ustunel, H., Aydin, M. K.: Effects of a Haptic Augmented Simulation on K–12 Students' Achievement and their Attitudes towards Physics. Eurasia Journal of Mathematics, Science & Technology Education. 10 (6), 565–574 (2014). doi: 10.12973/eurasia.2014.1122a
6. Coimbra, T., Cardoso, T., Mateus, A.: Augmented Reality: an Enhancer for Higher Education Students in Math's learning? Procedia Computer Science. 67, 332–339 (2015). doi: 10.1016/j.procs.2015.09.277
7. Daineko, E. A., Ipalakova, M. T., Serikov, S. S., Zhanabai, G. K.: Primenenie tekhnologii dopolnennoi realnosti v obrazovanii (Application of augmented reality technologies in education). In: Proceeding of the 13th International scientific and practical conference on Fundamental and applied research in the modern world, 17 March 2016, vol. 1, pp. 26–28. Strategiia budushchego, St. Petersburg (2016).
8. Estapa, A., Nadolny, L.: The Effect of an Augmented Reality Enhanced Mathematics Lesson on Student Achievement and Motivation. Journal of STEM Education: Innovations and Research. 16 (3), 40–48 (2015).
9. Ferrer-Torregrosa, J., Torralba, J., Jimenez, M. A., García, S., Barcia, J. M.: ARBOOK: Development and Assessment of a Tool Based on Augmented Reality for Anatomy. Journal of Science Education and Technology. 24 (1), 119–124 (2015). doi: 10.1007/s10956-014-9526-4
10. Ismail, I., Idrus, R. M., Gunasegaran, Th.: Motivation, Psychology and Language Effect on Mobile Learning in Universiti Sains Malaysia. International Journal of Interactive Mobile Technologies. 4 (4), 31–36 (2010).

11. Ivanchenko, A. E., Ignatova, T. A.: Tekhnologiia dopolnennoi realnosti v obrazovanii (Technology of additional reality in education). Alleia nauki. 4 (10), 322–324 (2017).
12. Lu, S.-J., Liu, Y.-C.: Integrating augmented reality technology to enhance children's learning in marine education. Environmental Education Research. 21 (4), 525–541 (2015). doi: 10.1080/13504622.2014.911247
13. Martin-Gutierrez, J., Guinters, E., Perez-Lopez, D.: Improving Strategy of Self-Learning in Engineering: Laboratories with Augmented Reality. Procedia — Social and Behavioral Sciences. 51, 832–839 (2012). doi: 10.1016/j.sbspro.2012.08.249
14. McMahon, D., Cihak, D. F., Wright, R.: Augmented Reality as a Navigation Tool to Employment Opportunities for Postsecondary Education Students With Intellectual Disabilities and Autism. Journal of Research on Technology in Education. 47 (3), 157–172 (2015). doi: 10.1080/15391523.2015.1047698
15. Milgram, P., Kishino, F.: A taxonomy of mixed reality visual displays. IEICE Transactions on Information and Systems. E77–D (12), 1321–1329 (1994).
16. Modlo, Ye. O., Yechkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).
17. Pérez-López, D., Contero, M.: Delivering educational multimedia contents through an augmented reality application: A case study on its impact on knowledge acquisition and retention. The Turkish Online Journal of Educational Technology. 12 (4), 19–28 (2013).
18. Rashevska, N. V., Semerikov, S. O., Slovak, K. I., Striuk, A. M.: Model kombinovanoho navchannia u vyshchii shkoli Ukrainy (The blended learning model in Ukrainian higher education). In: Sbornik nauchnykh trudov, pp. 54–59. Miskdruk, Kharkiv (2011).
19. Rashevska, N. V., Semerikov, S. O.: Modeli zmishanoho navchannia (Blended learning models). New computer technology. 11, 103–104 (2013).

20. Semerikov, S. O., Striuk, A. M., Slovak, K. I., Rashevska, N. V., Yechkalo, Yu. V.: Liudyna z kompiuternym oblychchiam (do 80-richchia Aivena Edvarda Sazerlenda) (A man with a computer face (to the 80th anniversary of Ivan Edward Sutherland)). New computer technology. 16, 9–24 (2018).
21. Semerikov, S. O., Striuk, M. I., Moiseienko, N. V.: Mobilne navchannia: istoryko-tekhnolohichnyi vymir (Mobile learning: historical and technological dimension). In: Konoval, O. A. (ed.) Teoriia i praktyka orhanizatsii samostiinoi roboty studentiv vyshchykh navchalnykh zakladiv (Theory and practice of organization of independent work of students of higher educational institutions), pp. 188–242. Knyzhkove vydavnytstvo Kyreievskoho, Kryvyi Rih (2012).
22. Striuk, A., Rassovytska, M., Shokaliuk, S.: 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 (CEUR-WS.org), vol. 2104, pp. 412–419 (2018).
23. Wang, H.-Y., Duh, H. B.-L., Li, N., Lin, Tz.-J., Tsai, Ch.-Ch.: An Investigation of University Students' Collaborative Inquiry Learning Behaviors in an Augmented Reality Simulation and a Traditional Simulation. Journal of Science Education and Technology. 23 (5), 682–691 (2014). doi: 10.1007/s10956-014-9494-8

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 255–262

УДК 378.147:004.9]:622–051

Defining the Structure of Environmental Competence of Future Mining Engineers: ICT Approach

Vladimir S. Morkun[1[0000−0003−1506−9759]],
Serhiy O. Semerikov[2[0000−0003−0789−0272]],
Nataliya V. Morkun[1[0000−0002−1261−1170]],
Svitlana M. Hryshchenko[1[0000−0003−4957−0904]]
and Arnold E. Kiv[3]
[1] State Institution of Higher Education "Kryvyi Rih National University",
11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
{morkunv, nmorkun}@gmail.com, s-grischenko@ukr.net
[2] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave.,
Kryvyi Rih, 50086 Ukraine
semerikov@gmail.com
[3] Ben-Gurion University of the Negev, Beer Sheba, Israel
kiv@bgu.ac.il

Abstract. The *object* is to the reasonable selection of the ICT tools for formation of ecological competence. Pressing *task* is constructive and research approach to preparation of future engineers to performance of professional duties in order to make them capable to develop engineering projects independently and exercise control competently. *Subject of research*: the theoretical justification of competence system of future mining engineers. *Methods*: source analysis on the problem of ecological competence formation. *Results*: defining the structure of environmental competence of future mining engineers. *Conclusion*: the relevance of the material covered in the article, due to the need to ensure the effectiveness of the educational process in the preparation of the future mining engineers.

Keywords: environmental competence, education, future mining engineer, information and communication technologies.

1 Introduction

Nowadays information and communication technologies (ICT) applying is one of the principle education tasks, which provides the education process improvement, its accessibility and effectiveness and preparing the younger generation for living in the information society. Education must serve for the society needs. Processes reflecting current trends in society provide information technologies development and implementing. At present the ICT usage in education can be a catalyst in solving important social problems connected with increasing the educational resources and services availability and quality, real and equal opportunities in getting education for citizens despite their residence, social status and income [6]. Currently, high technologies cover almost all areas of our life. Professionals having common practical and theoretical skills of work with different information types are highly wanted.

One of the most important education tasks is to develop students' active cognitive attitude to knowledge. Cognitive activity in universities is a necessary stage in preparing for further professional life. Teacher's task is to seek and find the best methods and tools of improving the educational process and leading to the cognitive interest development.

2 Materials and methods

The study is carried out in "Kryvyi Rih National University" according to the plan of joint research laboratory using cloud technologies in education process of "Kryvyi Rih National University" and the Institute of Information Technologies within the research project "Adaptive system of individual teaching for mining engineers based on the integrated structure of artificial intelligence "A digital tutor" [8]. The author analyzes sources devoted to investigating the problems of ecological competence formation and usage of geoinformation technology in the teaching future mining engineers [7, 10]. This research also improves the system of competence among future mining engineers, gives its theoretical explanation and represents geoinformation technology means used in education process [11, 12].

3 Results and discussion

Prerequisite for development of methodic of usage of geoinformation technologies as a tool for formation of environmental competence of future mining engineers is the solution of the following specific tasks of research:

1. determination of major factors of modernization of professional education of future mining engineer;
2. theoretical justification of competence system of future mining engineers;
3. defining the structure of environmental competence of future mining engineers;
4. earmarking of geoinformation technologies, application of which promotes safe activity of mining plants.

In result of solution of the first task, the major factors for modernization of professional education of future mining engineers is the public contract for preparation of competent specialists were determined. They are specified in the state industry standards of higher education and in the society sustainable development.

The main regulatory document determining the judicial and basic arrangements for the activity of mining engineers concerning mining works performance, securing emergency protection of mining plants, establishments and organizations is the Law on mining of Ukraine (1999).

Abdallah M. Hasna [5] considers the contribution of the principals stated in the article 7 of the Mining law of Ukraine [6] into social, economical, ecological and technical development as the function of sustainable development — model of resource use, focused on the satisfaction of human's wants when preserving of the environment in such a way, that all these wants could be satisfied not only by current generations but also by future ones. In such a way state policy in mining industry focused on the sustainable development of mining industry, science and education.

In result of solution of the second task, it was stated that development of competency building approach to professional education happens, on the one side, under the influence of public contract on the preparation of competent specialists, on the other side — it influences on the formation of such contract in the direction of changing of state industry standards of higher education.

Application of competency building approach to modernization of state industry standards of higher education leads to the necessity of theoretical justification and development of competence system of future mining engineers, the component of which are environmental competences.

In result of solution of the third task it was stated that formation of environmental competence of future mining engineer happens within professional education.

The main environmental requirements in the field of mining works, prevention of ill effect of mining works and securing of ecological safety during mining works is not only a subject matter of certain articles of the Mining law of Ukraine, but also obligate constituent of preparation of environmentally competent mining engineer [13, 14].

In result of solution of the fourth task it was concluded that development of ICT [15] promotes the changes of production technological mode (including mining production), which provides stable technological development, namely geoinformation technologies. Education modernization in today's society can be hardly imagined without education innovation developing especially such as GIS technologies. GIS is an integrated set of hardware, software and media means, providing input, storing, processing, manipulating, image analyzing and space-coordinated data representation [3]. GIS using in education allows to perform independent analyzing, interrelations search, analogy detecting and developing abilities to explain the differences. The last statement is true to engineering professionals. This implementation in the engineering profession also has allowed to reduce waste of time during the session, to create specific pedagogical conditions for developing future professionals skills, increase cognitive interest, to set subjective position in learning activities, to build cognitive autonomy, students' information and communication competence, motivational readiness for cognitive activity. The results of the analysis show that the main key words that different researchers refer to environmental competence, are as follows:

- in relation to the subject activity: "person", "personality", "personal", "education", "characteristics", "ability", "willingness", "quality", "behavior", "society";
- in relation to the object of activity: "value", "moral nature", "environment", "nature", "natural", "preservation";
- in relation to the content and nature of the activity: "environmental", "professional", "practical", "experience", "ability", "skill", "use", "knowledge", "cognitive", "system", "provide", "significant".

Due to the fact that, by definition of DeSeCo specialists [16], environmental sustainability (ecological sustainability) is the basis of the key competences of the individual associated with success in society, consideration of environmental competency is advantageously carried out at three levels:

- on the general level of ecological culture and environmental awareness (Zenobia Barlow and Michael K. Stone [1]);
- on a social-professional level of environmental literacy (Carmel Bofinger [2], B. E. Harvey [4]);
- on the special professional level of environmental competence (Svitlana M. Hryshchenko, Vladimir S. Morkun and Serhii O. Semerikov [9]).

The carried out analysis gives the possibility to determine environmental competence of future mining engineer as personal formation, which includes the acquired during preparation profession-oriented environmental awareness (cognitive component), adopted ways for securing environmentally safe mining works (praxeological component) in the interest of sustainable development (axiological component) and the qualities of socially responsible ecological behavior (socially-behavioral component) are formed [9].

By definition, formation of environmental competency of future mining engineer happens during professional education of bachelors in mining, that is why for determination of environmental competencies we will refer to the components of developed system of socially-personal, instrumental, general scientific, general professional and specially professional competences of future mining engineer.

In their turn the requirements for stable social, economical and environmental society development induce to definition of ICT focused on their support. Securing of sustainable development of mining industry required definition of ICT, which consider scale and influence of mining production — ICT tools.

4 Conclusion

Summarizing, we would like to mark that environmental competency of future mining engineer is a personal formation, which includes the acquired during preparation profession-oriented environmental awareness (cognitive component), adopted ways for securing environmentally safe mining works (praxeological component) in the interest of sustainable development (axiological component) and the qualities of socially responsible ecological behavior (socially-behavioral component) are formed.

Formation of environmental competency is fulfilled during acquirement of the following:

- Socially-personal competences: understanding and perception of ethical norms of behavior in respect to other people and nature (bioethics principals); ecological literacy;
- General scientific competence: deep knowledge in ecology necessary for usage in professional activity;
- Generally professional competence: the ability to use scientific lows and means during evaluation of environmental condition, participate in environmental works, make ecological analysis of events in the field of activity, develop plans on events concerning reduction of manmade load on the environment;
- Special professional competence: securing of ecologically balanced activity, working knowledge of reasonable and integrated development of geo-recourses potential.

Teaching geoinformation technologies taking into account regional situation, provides personality formation in the natural social and cultural environment. Thus, regional residence differences influence the content of their activities and interests. The education system based on regional characteristics supports interest. That is why teaching should be organized according to actual needs of students. Educational problems should be solved due to initiation and growth of activity, because real environmental situations exist within the students' surrounding.

Thus, solving the problem of ecological competence formation as part of the complex problem in terms of competence approach it requires justifying the choice of using geoinformation technology as a means of ecological competence formation among the future mining engineers.

References

1. Barlow, Z., Stone, M. K.: Living Systems and Leadership: Cultivating Conditions for Institutional Change. Journal of Sustainability Education. 2 (March). http://www.jsedimensions.org/wordpress/wp-content/uploads/2011/03/BarlowStone2011.pdf (2011). Accessed 1 Feb 2018.
2. Bofinger, C.: Comparison of the Australian and South African Mining Engineering Courses to the Competency Requirements for Mine Managers. http://www.qldminingsafety.org.au/_dbase_upl/06_01.pdf (2007). Accessed 1 Feb 2018.
3. Bonham-Carter, G. F.: Geographic Information Systems for Geoscientists: Modelling with GIS. Pergamon, Oxford (1994).
4. Harvey, B. E.: New Competencies in Mining — Rio Tinto's Experience. In: Council of Mining and Metallurgical Congress. Qld, Cairns, 27–28 May 2002.
5. Hasna, A. M.: Dimensions of sustainability. Journal of Engineering for Sustainable Development: Energy, Environment, and Health. 1 (2), 47–57 (2007). doi: 10.3992/2166-2517-1.2.47
6. Hirnychyi zakon Ukrainy (Mining law of Ukraine). Law 1127–XIV, 6 Oct. 1999. http://zakon0.rada.gov.ua/laws/show/1127-14 (1999). Accessed 1 Feb 2018.
7. Hryshchenko, S., Morkun V.: Using gis-technology in role-play as an effective means of ecological competence formation among the future engineers. Metallurgical and Mining Industry. 4, 139–142.

http://www.metaljournal.com.ua/assets/MMI_2014_6/MMI_2015_4/020-Grischenko-Morkun.pdf (2015). Accessed 1 Feb 2018.

8. Hryshchenko, S.: Modern approaches in the study of engineering students. Metallurgical and Mining Industry. 12, 144–146. http://www. metaljournal.com.ua/assets/Journal/english-edition/MMI_2015_12/022 Hryshchenko.pdf (2015). Accessed 1 Feb 2018.
9. Hryshchenko, S. M., Morkun, V. S., Semerikov, S. O.: Vykorystannia heoinformatsiinykh tekhnolohii pry pidhotovtsi hirnychoho inzhenera (The use of GIS in the mining engineer training). Publishing center of SIHE "KNU", Kryvyi Rih (2015).
10. Morkun, V., Semerikov S., Hryshchenko, S.: Environmental competency of future mining engineers. Metallurgical and Mining Industry. 4, 4–7. http://www.metaljournal.com.ua/assets/Journal/1.2014.pdf (2014). Accessed 1 Feb 2018.
11. Morkun, V., Semerikov, S., Hryshchenko, S., Slovak, K.: Environmental Geo-information Technologies as a Tool of Pre-service Mining Engineer's Training for Sustainable Development of Mining Industry. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR-WS.org), vol. 1844, pp. 303–310 (2017).
12. Morkun, V., Semerikov, S., Hryshchenko, S., Zelinska, S., Zelinskyi, S.: Environmental Competence of the Future Mining Engineer in the Process of the Training. The Social Sciences. 12 (11), 2034–2039 (2017). doi: 10.3923/sscience.2017.2034.2039
13. Morkun, V. S., Semerikov, S. O., Hryshchenko, S. M.: Content and teaching technology of course "Ecological Geoinformatics" in training of future mining engineers. Information Technologies and Learning Tools. 57 (1), 115–125. http://journal.iitta.gov.ua/index.php/itlt/article/download/1549/1139 (2017). Accessed 1 Feb 2018.
14. Morkun, V. S., Semerikov, S. O., Hryshchenko, S. M., Slovak, K. I.: System of competencies for mining engineers. Computer science,

information technology, automation. 5, 23–31. http://csita.com.ua/wp-content/uploads/2017/03/Morkun-V.S.-Semer%D1%96kov-S.-O.pdf (2016). Accessed 1 Feb 2018.

15. Morkun, V. S., Semerikov, S. O., Hryshchenko, S. M.: Use of the system Moodle in the formation of ecological competence of future engineers with the use of geoinformation technologies. Computer science, information technology, automation. 4, 30–32. http://csita.com.ua/wp-content/uploads/doc/CSITA%20%E2%84%964.pdf (2016). Accessed 1 Feb 2018.
16. The Definition and Selection of Key Competencies: Executive Summary. http://www.oecd.org/pisa/35070367.pdf (2005). Accessed 1 Feb 2018.

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 263–275

УДК 378.147:004.9]:622–051

Investigation of Opportunities of the Practical Application of the Augmented Reality Technologies in the Information and Educative Environment for Mining Engineers Training in the Higher Education Establishment

Snizhana O. Zelinska[1[0000−0002−3071−5192]],
Albert A. Azaryan[2[0000−0003−0892−8332]]
and Volodymyr A. Azaryan[2]
[1] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
[2] State Institution of Higher Education "Kryvyi Rih National University", 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
zvit-zss@ukr.net

Abstract. The augmented reality technologies allow receiving the necessary data about the environment and improvement of the information perception. Application of the augmented reality technologies in the information and educative environment of the higher education establishment will allow receiving the additional instrumental means for education quality increasing. Application of the corresponding instrumental means, to which the platforms of the augmented reality Vuforia, ARToolKit, Kudan can be referred, will allow presenting the lecturers the necessary tools for making of the augmented reality academic programs.

Keywords: augmented reality, virtual object, applied software application, platform of the augmented reality, information and educative environment.

1 Introduction

The topicality of making this investigation is caused by the following reason. Nowadays the active implementation of the various information and communicative technologies is observed practically in all the spheres of human life activity, and especially in the educative process.

One of the leading and promising technologies is the technology of augmented reality. Its popularity is observed to a marked degree during the recent years. It initiated the rash progress of the wide range of the developments in the field of the augmented reality. At the same time, it is necessary to mention that implementation of any technology deals with the definite advantages and disadvantages. The main disadvantage of the augmented reality technologies is practically the full absence of the documentation support, and their advantage is the obvious availability and receiving the universal tools in teaching any subjects.

The various aspects of application of the augmented reality technologies as the component of the pedagogical process were examined by Vsevolod A. Serbin and Nadezhda N. Zilberman [13]. The subject of the investigation of the group of the authors (Viktoriia A. Bakhareva, Artem V. Feshchenko, Yevhenii O. Modlo, Serhiy O. Semerikov, Vsevolod A. Serbin, Viktoriia V. Tkachuk, Yuliia V. Yechkalo, Uliana S. Zakharova [2, 7]) were the technologies of the virtual and augmented reality in the educative environment of the higher education establishment. The classification and the perspective trends of the augmented reality technologies application are given in the works of Boris S. Iakovlev and Sergei I. Pustov [11, 12]. However, it is necessary to mention that there are a great amount of the separate data in the frame of the examining theme. Each researcher pays his attention to the characteristics in which he is interested. This fact does not allow receiving the entire system of the practical application of the augmented reality technologies in the subject sphere. That is why it is necessary to make additional investigations in the field of the augmented reality technologies in the information and educative environment of the higher education establishment.

2 The Aim and Objectives of the Study

The aim of the article is to study the possibilities of the augmented reality technologies in the information and educative environment of the higher education establishment.

According to the aim, the necessity of raising and determining the following tasks was defined: to give the characteristic for the definition "the augmented reality technology"; to analyze the possibilities of the augmented reality technologies application; to describe the possibilities of the augmented reality platforms — Vuforia, ARToolKit, Kudan; to outline the prospects for using augmented reality technologies in mining and professional training.

3 Discussion and Results

The augmented reality (AR) is a term appeared in the IT field. Originally, it was used for indication of the virtual information imposition technology on the real surrounding world [9]. The development and active implementation of the augmented reality technologies in the fields of medicine, science, industry, manufacture, social communications and in the other fields sped up the necessity of comprehension of the social consequences of their influence. According to John C. Havens, they are displayed in changing the methods of the social interaction. In particular, he thinks that the augmented reality is not just a technology but it is the most efficient method of the direct interaction with the digital data [3].

Nowadays it became obvious that the technological interpretation of the augmented reality is too narrow. The augmented reality is not just a new technology but it is the unprecedented environment of human habitation which needs being investigated in the theoretical comprehension and prognostication of the perspectives of its application [5].

In addition to above-mentioned information, the definition of the augmented reality may be formulated by the following words. The augmented reality is the result of introduction of any sensory data into the field of perception with the goal to add the information about the environment and improvement of information perception; the augmented reality is the apprehended mixed reality created with the computer added elements of the apprehended reality application.

It is essential to mention that nowadays the problematics of the augmented reality application is not practically introduced in the native pedagogical discourse. It also causes the topicality of our appeal to it. It must be noted that two aspects of this problematics can be pointed out. Firstly, it is application of the different augmented reality technologies in the educative process. Secondly, it is comprehension of the heuristic potential of the augmented reality conception.

The foreign experience of the augmented reality technology application in the field of education is described by Nadezhda N. Zilberman and Vsevolod A. Serbin [13]. The various scripts and strategies of the practical application of the augmented reality software programs in the primary and higher education are distinguished. The possibilities of the key services and software program applications for creating the augmented reality segments are described. The classification of the software program applications of the augmented reality is set. The problem of forming of the methodology of the augmented reality technologies practical application in the field of education is raised.

The following types of the educative augmented reality applications are detailed by the author: books with the augmented reality technology which create the peculiar bridge between the digital and physical world; games; educative applications; objects modelling; applications for skills training.

The propositions for classification of the augmented reality technologies were formulated by Boris S. Iakovlev and Sergei I. Pustov. The augmented reality interfaces are divided into autonomous and interactive from the point of view of the interaction with the user [11, 12].

Autonomous augmented reality interfaces do not suppose the direct interaction with user, and to a bigger degree, they serve only for the auxiliary data provision about the definite object. Such software program applications can be used for the objects analysis, they are in a man's sight, and one can output the corresponding information about them. For example, a student views the electromechanical systems and apparatus in the demonstration classroom. He receives the additional data about the composition, principles of constructing, analysis and synthesis methods, structural and functional schemes about electromechanical equipment controlling and etc. with the help of the corresponding software program application [10].

In contrast to the autonomous augmented reality technologies, the interactive ones suppose the direct interaction with user. The interactive augmented reality technologies have all the necessary possibilities for tuning the types of the applied augmented segments of data, and they have the possibilities to receive the corresponding answers for the distinguished objects. As a case in functional point of such kind of software program augmented reality application, one can name the programs introducing the possibilities of changing surface colour by means of overlaying (car's colour changing).

The technological possibilities of the augmented reality can also be divided into some groups: constructing of the virtual objects in the real decorations; augmented reality browser; face identification; distance control of gestures.

The goal of the investigation by Artem V. Feshchenko et al. is to study the possibilities of the devices practical application (for example, Google Glass), technological platform of the virtual reality (vAcademia) and augmented reality services (LayAR, Augment) [2]. It is proved in the work that Google Glass is a sufficient disputed technology for using in the educative practice. Foreign experience of Google Glass using in the field of education cannot be characterized as exclusively positive one. The alternative technology of the augmented reality implemented with the help of the mobile devices and online services is more perspective for using in the higher education establishment. Virtual educative environments application is perceived by the participants as online game. Therefore, the active practical vAcademia application in the educative process of the university is not considered as a reasonable one.

Work of applications with the augmented reality technologies is available now. It is available in the sufficient wide spectrum of devices, one can single out smartphones, tablet computers. Owing to this, practically each person has a technical problem of the direct augmented reality application. It lies in the choice and implementation of the specific unified platform of the augmented reality.

Nowadays there are a great amount of available libraries which intend for creating program augmented reality applications among which one can single out Vuforia, ARToolKit, Kudan.

Vuforia [8] is the platform of the augmented reality and the designer's specialized tools of the software augmented reality (Software Development Kit — SDK) for the mobile devices which were worked out by the company Qualcomm. Vuforia uses the computer vision technologies, and also the simple volumetric real objects technologies and the possibilities of the flat figures tracking at real time.

With the help of the technological augmented reality platform Vuforia, the designer can easily add the computer visualization functional of the virtual 3D-objects into the necessary software application realizing the peculiarities of identification and more exact understanding of the images and objects which are observed in the reality or making 3D-reconstructions of the surrounding and observed environment in the real world.

By means of Vuforia, one can create AR-applications for the wide range of the industrial tasks among which one can single out interactive instructions of the working place, service direction, marketing materials, educative information. The full functional kit is realized for the whole diversity of the possible AR-applications.

ARToolKit [1] is a tracking library with the open source code for creating of the powerful augmented reality applications, which apply the virtual images in the real world. ARToolKit is used for decision of two key problems in the extended reality: real objects tracking and virtual objects interaction.

ARToolKit uses the algorithms of computer vision for solving the problem of snooping the user's point of view. The tracking ARToolKit libraries compute the real position and camera orientation in relation to the physical markers at real time. It allows working out the wide spectrum of the augmented reality applications easily.

Kudan [6] counts on the high productivity, provides the effective calculations, and it allows receiving the exact and reliable results. There are large numbers of the constructional blocks for Kudan system, the main basis of the code can orient on the majority of the processors' architectures. There is no dependency from availability of the used operational system's functionality. Some classes of processors can be used, beginning from the low-powered processor of the general function and ending the high-performance processors. A great amount of the hardware sensors, beginning from the monocular sensors and stereo cameras ending the visual and inertial depth cameras, are supported.

Every aspect of the system has a great amount of quantity of settings, and one can work with it by means of simple API. It allows tuning the target equipment easily, and afterwards using it.

The enumerated augmented reality libraries give the wide possibilities for the designer, beginning from the different operational systems support ending the deployed instrument kit, which identifies and snoops the objects. Proceeding from the produced requirements for the augmented reality technologies, it becomes obvious to prefer library's using. The library will require the minimal resources investment from the financial point of view and from the point of view of design's complication. The augmented reality platform Vuforia corresponds the set requirements among the above-mentioned libraries most of all. Free version availability will allow shortening the financial costs, and Unity support will allow working out software program application, which will support all set of Unity platforms. It simplifies the process of working out and this system supporting (Fig. 1).

Fig. 1. An example of using Vuforia in the professional training of future mining engineers

According to Jónatan Jacobs, R. C. W. Webber-Youngman and Etienne van Wyk, potential augmented reality applications in the mining industry is drilling work, navigational aid and operator assistance, maintenance and repair tasks, and the provision of real-time information [4]:

1. When applying augmented reality to assist with drilling practices, through visual guidance on the usage of the drilling equipment or machine, the accuracy and efficiency of drilling could be enhanced. This application could further be expanded to display the real-time location and orientation of the drill bit below surface or within the rock face, as measured through various tracking technologies. The visualisation of such positioning information of the drill bit and rod would then allow for faster reaction and adjustments by operators to improve drilling accuracy (Fig. 2).

Fig. 2. Augmented drill hole with indicated deflection on the drill head

2. An augmented reality application could be developed for safety purposes that allows mining operators to see hazardous scenarios and objects, such as the road boundaries, approaching vehicles, or the distance to reverse to the dumping site or crusher. The virtual displays over the real world view of the operator could provide various forms of information, as well as a live video feed on "blind-spots" (Fig. 3).
3. General maintenance and repair tasks on equipment, machinery and entire systems (e.g. conveyor belts, entire hoisting systems, pipelines etc.) can be conducted with greater efficiency through the utilisation of augmented reality. Essential information can be recalled at the working site, in real-time, and displayed. This could include information on various parts and devices, as well as where they are stored or instructions on how to remove or replace them. Other equipment or machinery information could also be displayed such as current air or pneumatic pressures, fluid levels or the required torque to fasten or loosen a nut (Fig. 4).

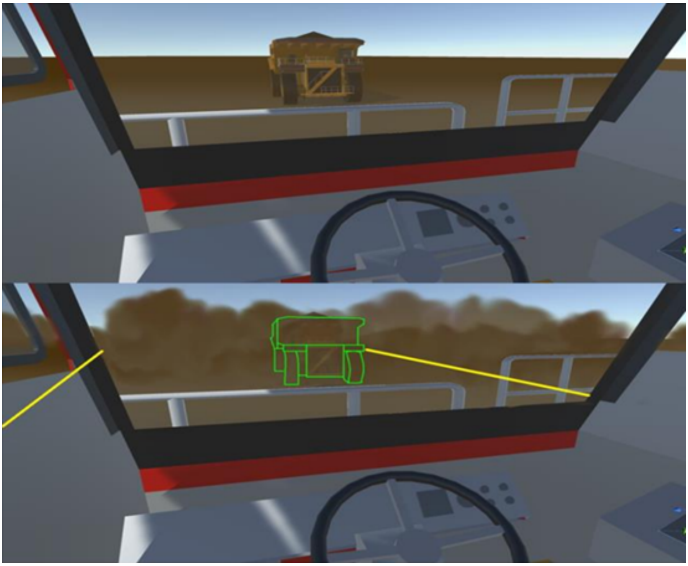


Fig. 3. An augmented outline of an approaching haul truck

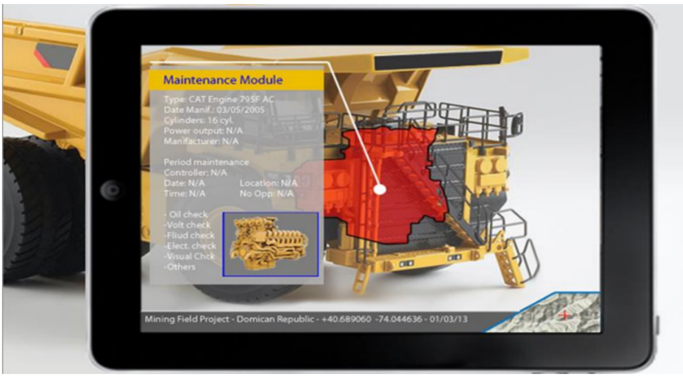


Fig. 4. Example of an augmented reality application for maintenance of a haul truck

4. Augmented reality application could go further to provide real-time guidance and assistance with step-by-step instructions on how to complete a specified task. Along with the ability to recall virtual equipment manuals or any information required to perform the work, such an application could bolster task efficiencies. In the same manner,

assistance can be provided to perform effective inspections in order to reduce the risk of unscheduled maintenance requirements (Fig. 5).

Fig. 5. Augmented maintenance on an engine

5. Augmented reality could provide helpful and potentially lifesaving information. An augmented reality system could be combined with proximity detection technologies to detect dangerous equipment and warn personnel to maintain a safe following distance. Another potential application is to combine augmented reality with other software systems to form a new integrated technological system (Fig. 6).

Fig. 6. Real-time augmented reality information in vehicles

The SWOT-analysis of potential augmented applications for the mining industry allowed the authors [4] to highlight the following

– *Strengths*:
  - Fewer mishaps when completing tasks.
  - Expandable new technology.
  - Consists of several technologies and/or systems.
  - Faster task completion times.
  - Can enhance communication and bridge long distances through collaboration.
  - Can bridge language barriers.
  - Increased awareness.
  - Instant access to information, right at the workplace.
  - Information is in real time.
  - Can work with and connect numerous other systems and technologies.
  - Adds value to the other systems/technologies that it is linked to.
  - Interactive technological applications.
  - Better memory retention.
  - Reduced risk of inaccurate or wrong perceptions.
  - Elimination or reduction of mundane tasks.
  - Increased task efficiency.
  - Reduced operating costs.
  - Reduced labour requirements.
  - Reduced reliance on specialist personnel/contractor skills.

– *Weaknesses*:
  - Colour blindness factor.
  - Job loss/reduction.
  - Dependent on other technological systems, devices, knowledge/information source or patents.
  - Moderately high costs when various technologies need to be acquired and combined.
  - Internet or local server access is required.
  - Additional hardware and software requirements.

- Limited visual space in human field of vision.
- System is only as good as the software coding that runs it.
- Reduces human skill improvement.
- Computer system is unable to improve and grow like a person.
- Retraining or additional training requirements.
- Size/storage limitations on mobile display devices.
- Hardware limitations.
- Dependent on human interaction.

– *Opportunities*:

- Higher task efficiency.
- Higher brain functionality.
- Increase safety to zero harm.

– *Threats*:

- New/foreign concept.
- New ground/unknown territory.
- Augmented reality often means radical change.
- Technological incompetence.
- Too much reliance on technology.
- Poor synergy between components.

4 Conclusion

In the capacity of the advantages of the augmented reality technologies application one can name interactivity, simple application, possibility of inclusion into the large information context, using of the effect of a student's surprise.

Nevertheless, there are some restrictions of this technology application. First of all, they deal with the technical peculiarities of the augmented reality technologies practical realization. The screen of the user's device restricts the augmented reality. Success of the marker's identification depends on many factors. They are lighting, angle of the user's camera, camera's quality. The augmented reality applications can interpret only a two-dimensional image.

Thus, there is no purposeful implementation of the augmented reality technologies into the educational process nowadays, and there is an extremely little quantity of the similar applied software decisions. Nevertheless, many IT specialists have the similar opinion. They think the augmented reality's future in the various fields of the human life activity has rather great prospects, and eventually the augmented reality technologies in the field of education lead out the system of education on the qualitative new level.

As a whole, it may be said that nowadays the augmented reality technologies in the field of education are on the stage of their coming into being. Taking into account the prospects of their development, it is necessary to conduct analytics of the foreign experience and to perform educational experiments with the augmented reality at native schools and higher education establishments.

References

1. ARToolKit. https://github.com/artoolkit (2018). Accessed 26 Jan 2018.
2. Feshchenko, A. V., Bakhareva, V. A., Zakharova, U. S., Serbin, V. A.: Tekhnologii virtualnoi i dopolnennoi realnosti v obrazovatelnoi srede vuza. Open and distance education. 4 (60), 12–20 (2015). doi: 10.17223/16095944/60/2
3. Havens, J. C.: The Impending Social Consequences of Augmented Reality. Mashable. http://mashable.com/2013/02/08/augmented-reality-future (2013). Accessed 25 Dec 2017.
4. Jacobs, J., Webber-Youngman, R. C. W., van Wyk, E.: Potential Augmented Reality Applications in the Mining Industry. ResearchGate (2016). doi: 10.13140/RG.2.2.27751.44961
5. Kislova, O. N.: "Dopolnennaia realnost" skvoz prizmu internet-praktik sovremennogo studenchestva ("Augmented reality" through the prism of the modern students' internet-practice). Metodolohiia, teoriia ta praktyka sotsiolohichnoho analizu suchasnoho suspilstva. 20, 351–356 (2014).
6. Kudan. https://kudan.readme.io (2017). Accessed 29 Jan 2018.
7. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

8. PTC Inc.: Vuforia | Augmented Reality. https://www.vuforia.com (2018). Accessed 17 Jan 2018.
9. Semerikov, S. O., Striuk, A. M., Slovak, K. I., Rashevska, N. V., Yechkalo, Yu. V.: Liudyna z kompiuternym oblychchiam (do 80-richchia Aivena Edvarda Sazerlenda) (A man with a computer face (to the 80th anniversary of Ivan Edward Sutherland)). New computer technology. 16, 9–24 (2018).
10. Striuk, A., Rassovytska, M., Shokaliuk, S.: 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 (CEUR-WS.org), vol. 2104, pp. 412–419 (2018).
11. Yakovlev, B. S., Pustov, S. I.: Istoriia, osobennosti i perspektivy tekhnologii dopolnennoi realnosti (History, features and prospects of the augmented reality). Izvestiia TulGU, Tekhnicheskie nauki. 3, 479–484 (2013).
12. Yakovlev, B. S., Pustov, S. I.: Klassifikatciia i perspektivnye napravleniia ispolzovaniia tekhnologii dopolnennoi realnosti (Classification and promising application augmented reality). Izvestiia TulGU, Tekhnicheskie nauki. 3, 484–492 (2013).
13. Zilberman, N. N., Serbin, V. A.: Vozmozhnosti ispolzovaniia prilozhenii dopolnennoi realnosti v obrazovanii (The possibilities of using augmented reality applications in education). Open and distance education. 4 (56), 28–33 (2014).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 276–289

УДК 004.65:001.891

Automation of the Export Data from Open Journal Systems to the Russian Science Citation Index

Serhiy O. Semerikov[1[0000−0003−0789−0272]], **Vladyslav S. Pototskyi**[1], **Kateryna I. Slovak**[2[0000−0003−4012−8386]], **Svitlana M. Hryshchenko**[2[0000−0003−4957−0904]] **and Arnold E. Kiv**[3]

[1] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
{semerikov, pototskiyvl}@gmail.com

[2] State Institution of Higher Education "Kryvyi Rih National University", 11, Vitali Matusevich St., Kryvyi Rih, 50027, Ukraine
slovak@fsgd.ccjournals.eu, s-grischenko@ukr.net

[3] Ben-Gurion University of the Negev, Beer Sheba, Israel
kiv@bgu.ac.il

Abstract. It is shown that the calculation of scientometric indicators of the scientist and also the scientific journal continues to be an actual problem nowadays. It is revealed that the leading scientometric databases have the capabilities of automated metadata collection from the scientific journal website by the use of specialized electronic document management systems, in particular Open Journal Systems. It is established that Open Journal Systems successfully exports metadata about an article from scientific journals to scientometric databases Scopus, Web of Science and Google Scholar. However, there is no standard method of export from Open Journal Systems to such scientometric databases as the Russian Science Citation Index and Index Copernicus, which determined the need for research. The *aim* of the study is to develop the plug-in to the Open Journal Systems for the export of data from this system to scientometric database Russian Science Citation Index. As a *result* of the study, an infological model for exporting metadata from Open Journal Systems to the Russian Science Citation Index was proposed. The SirenExpo plug-in was developed to export data from Open Journal Systems to the Russian Science Citation Index by the use of the Articulus release preparation system.

Keywords: Scientometric Indicators, Scientometric Databases, Specialized Systems for Electronic Workflow Support, SirenExpo plug-in.

1 Introduction

The formalized accounting of the scientist's productivity according to the published results is an important component of the evaluation of his activity, the activity of scientists and scientific institutions — is carried out with the help of scientometric databases. Internet-accessibility of the scientific publication for today is one of the top-priority requirements for its inclusion in any scientometric databases.

The main source of information about the publication is their annotations and other metadata posted on the website of the scientific journal. The use of standard protocols for metadata exchange promotes a better calculation of scientometric indicators not only of the scientist but also of the scientific journal itself (primarily its impact factor) [3, 5, 6, 8, 16].

Unfortunately, not all leading scientometric databases have the possibility of automated metadata collection from the scientific journal's site, which actualized the conduct of an appropriate study.

2 Literature Review and Problem Statement

The issue of qualitative and quantitative evaluation of published scientific results is due to the cause of the appearance of scientometry. Scientometrics determines the quality of scientific works and the quality of the scientist's work by analyzing scientific works on certain criteria.

One of the founders of scientometry is John Desmond Bernal, who described the laws of the functioning and development of science, the structure and dynamics of scientific activity, the interaction of science with the material and spiritual sphere of society, the role of scientometry in the social process in his work «The Social Function of Science» [1] of 1939.

After World War II, Derek John de Solla Price made a significant contribution to the development of science. Being a mathematician and a physicist, he defended his second thesis on the history of science. D. J. de Solla Price used quantitative methods to study science [13].

The term «scientometrics» was first used by V. V. Nalimov and Z. M. Mulchenko in the monograph «Scientometrics. Study of science as an information process», published in 1969. Authors define scientometrics as one of the branches of science, in which «science is viewed as a system that self-organizing and directs its own information flows» [10, p. 6]. «While studying science as an information process, it turns out to be possible to apply quantitative (statistical) research methods... It seems natural to call this direction of research — scientometrics» [10, p. 9].

A great contribution to scientometrics was made by Eugene Eli Garfield [6], who in 1960 founded Institute for Scientific Information. In 1964, E. Garfield launched the Science Citation Index [5], which became a powerful tool of scientometrics and became the basis of the scientometric database Web of Science. The main scientometrics indicators are: Science Citation Index; h-index; g-index; $i10$-index and impact factor [14, 15].

Science Citation Index (SCI) — is a measure of the author's influence or scientific work on the development of science (see Fig. 1, Fig. 2). SCI reflects the total number of references to a particular scientific work or author in other scientific articles. The negative side of scientometric research using SCI is that this index does not take into account the time of article influence on science. That means the author, who created an article of poor quality about 20 years ago and quoted at least once a year, receives the same citation index as the good work that received 20 citations per 20 years.

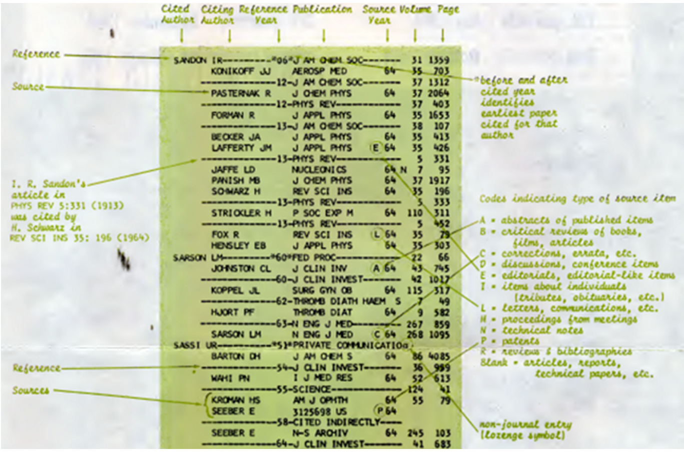


Fig. 1. Indexed articles from SCI (according to [9, p. 3])

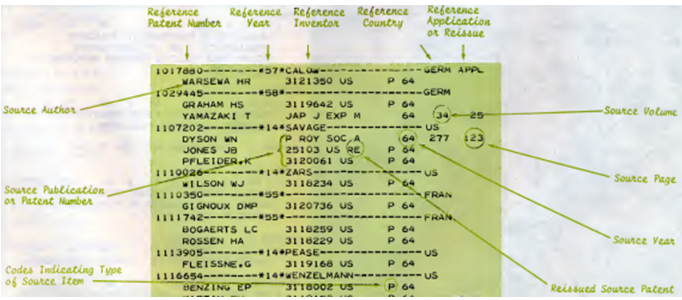


Fig. 2. The list of references to SCI (according to [9, p. 3])

Also, the citation index does not reflect the characterization of the scientific potential of the scientist. That is, a scientist who has written one work that has gained a certain popularity, and without having written more works, can have the same popularity with that scientist who has many scientific works. This and other shortcomings of the citation index prompted scientists to create new methods for assessing scientific papers.

The h-index was developed by Jorge E. Hirsch, a professor of physics at the California University of San Diego, who proposed «Hirsch's index» in 2005 [8], where he described the algorithm of the index, as well as the advantages and disadvantages of alternative methods (Table 1). According to J. Hirsch, the relationship between the h-index and the total number of citations can be described by the formula

$$N_{c,tot} = ah^2. \quad (1)$$

J. Hirsch find empirically that a ranges between 3 and 5.

h-index is a scientific metric that is a quantitative characteristic of the performance of a scientist, group of scientists or a country. According to J. Hirsch, the scientist has an index h, if his N_p articles are quoted at least h times. Scientific works that do not satisfy this condition are not included in the indexation.

The peculiarity of the h-index is that it well reflects the results of scientific work when comparing the productivity of the scientific process in one area of activity. The disadvantage of the h-index is that the scientific index depends on the activity of the scientist. If a scientist ceases to engage in scientific work, his index will be the same as he was before, or at best, the scientist will have an h-index equal to the number of his articles.

The problem of staticity of the h-index was attempted to solve by a Belgian scientist from Universiteit Hasselt Leo Egghe by offering the g-index [4]. For a plurality of papers by a scholar sorted by the number of quotes, g-index is the largest number that g most cited articles received a total of at least g^2 citations (see Fig. 3).

$i10$-index is the number of publications that were quoted not less than 10 times [7]. $i10$-index was developed by Google in 2011. This indicator depends predominantly on the age of the researcher and has a tendency to grow steadily. The five-year $i10$-index allows you to assess the current performance, and the overall — the impact of the work of a scientist on modern science without taking into account his past successes [8].

Impact factor (IF) is the ratio of the number of citations of articles of a certain journal to the total number of articles published in this journal

Table 1. Traditional methods for assessing the performance of a scientist according to [8]

No	Method	Advantage	Disadvantage
(i)	total number of papers (N_p)	measures productivity	does not measure importance or impact of papers
(ii)	total number of citations ($N_{c,tot}$)	measures total impact	– hard to find and may be inflated by a small number of “big hits”, which may not be representative of the individual if he or she is a coauthor with many others on those papers. In such cases, the relation in Eq. 1 will imply a very atypical value of $a > 5$; – gives undue weight to highly cited review articles versus original research contributions.
(iii)	citations per paper ($N_{c,tot}/N_p$)	allows comparison of scientists of different ages	hard to find, rewards low productivity, and penalizes high productivity
(iv)	number of “significant papers”, defined as the number of papers with more then y citations	eliminates the disadvantages of criteria (i), (ii) and (iii) and gives an idea of broad and sustained impact	y is arbitrary and will randomly favor or disfavor individuals, and y needs to be adjusted for different levels of seniority
(v)	number of citations to each of the q most-cited papers	overcomes many of the disadvantages of the criteria above	it is not a single number, making it more difficult to obtain and compare; also, q is arbitrary and will randomly favor and disfavor individuals

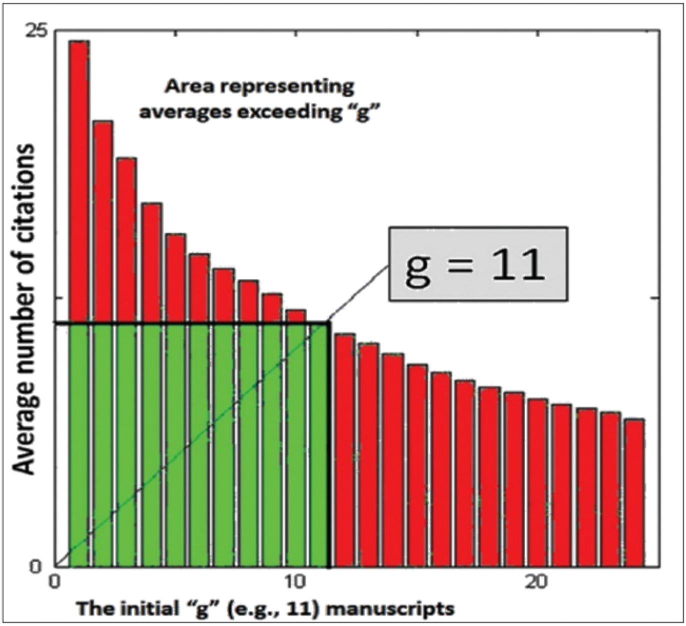


Fig. 3. The graph of the g-index (according to [14])

(Eq. 2). In each particular year, the factor influencing the journal is the number of citations this year of the articles published in the journal over the past two years, divided by the total number of articles in this journal over the past two years [2].

$$IF_y = \frac{Citations_{y-1} + Citations_{y-2}}{Publications_{y-1} + Publications_{y-2}}. \quad (2)$$

The basis for the analysis of the quantity and quality of the above indicators is the scientometric databases. They include bibliographic, abstract or full-text material on scientific publications, as well as tools for further tracking articles cited, internal search, etc. Scientometric databases are divided into commercial and free ones. The most popular commercial scientometric databases are Scopus and Web of Science. Non-profit-oriented ones include Google Scholar, Russian Science Citation Index, DOAJ, WorldCat, Index Copernicus. The analysis of the leading scientometric databases has made it possible to identify their two main categories: 1) databases that index article's metadata automatically (Scopus, Web of Science), and 2) databases that article's metadata need to be entered by user's own hands (Russian Science Citation Index, Google Scholar and Index Copernicus).

Reduce the costs of supporting the work of the editorial board by creating the ability for members of the editorial board to work in the mode of remote access, increase the efficiency of editorial and publishing processes, improve scientific metrics, etc. provide specialized systems for supporting electronic document management.

The study identified four of the most popular systems that have different functionality for the publication of scientific papers — Open Journal Systems, DSpace, Koha and EPrints. The largest support for the editorial staff of the journal provides the Open Journal Systems (OJS) [12], the latest version of which (3.1) is partially documented and in a state of development. OJS is a free software developed by a nonprofit Public Knowledge Project. The system has a wide range of tools for editors of scientific journals. If some functionality is missing, it can be expanded using plug-ins. The OJS functionality and low system requirements have made it the standard to support the work of editorial boards of scientific journals. OJS successfully exports metadata about articles from scientific journals to such well-known scientometric databases as Scopus, Web of Science, Google Scholar, but there is no standard export method from OJS to such scientometric databases as Russian Science Citation Index and Index Copernicus. eLibrary development is used for submitting data to the Russian Science Citation Index that is the Articulus. The manual data input to Articulus is duplicated the work on preparing the description of the articles that has already was done in OJS, and therefore it's important to automate this process in order to reduce the unproductive time costs of members of the editorial board of the journal.

3 The Aim and Objectives of the Study

The aim of the study is to develop the plug-in to the Open Journal Systems for the export of data from this system to sciencemetric database Russian Science Citation Index.

To accomplish the set goal, the following tasks had to be solved:

1. to develop an infological model for the metadata export from Open Journal Systems to the Russian Science Citation Index;
2. to develop and test the plug-in to the Open Journal Systems for the metadata export to the Russian Science Citation Index.

4 Simulation and Development of Software for Export Automation from Open Journal Systems to Russian Science Citation Index

The OJS has a number of additions to export data in popular formats, as well as to the DOAJ open source directory. Unfortunately, with the transition to the new (third) version of OJS, the documentation for the plug-in developer is still not relevant.

In addition to the undocumented structure of the plug-in, there is another problem — the under-contentiousness of the metadata required for the Russian Science Citation Index. In Table 2, an infological model for the export of metadata from OJS to the Russian Science Citation Index was developed by analyzing the results of numerous experiments on the data export to/from the Russian Science Citation Index. As a result, XML structures were installed for import into the Russian Science Citation Index system.

Table 2. Model of Metadata Export from OJS to Russian Science Citation Index

RSCI tag	Description
Titleid	log title identifier
ISSN	an international standard serial number that allows to identify periodicals
EISSN	an international standard serial number that allows to identify an electronic periodical
JournalInfo	the block where you can specify Title
Title (JournalInfo)	the subset of the JournalInfo tag, in which you can specify the name of the journal in different languages using the language attribute (lang="UKR", lang="ENG", etc).
Issue	the main tag, which describes all data of journal issue
Volume	journal volume
Number	issue number
AltNumber	end-to-end issue number
Part	part of issue
DateUni	date in YYYYMM format

OperCard	a tag describing user information in the Articulus system (automatically filled in by the system when creating or importing a journal)
IssTitle	volume name
Pages	number of pages in a volume
Articles	the main block, which contains a description of all the articles
Article	the block of the article, which describes all metadata articles
ArtType	type of article
Authors	the main block of the article's authors
Author	a block that describes single author using the tags: surname, initials, orgName (Organization Name), email, otherInfo (other information)
ArtTitles	article title block description. The block may include different languages that are specified when describing the title of an article
Text	text of the article
Codes	bibliographic description of the article, e. g., UDC, Dublin Core etc.
KeyWords	a block that describes the article keywords using the keyword tag
References	references to other articles
Files	files that belong to the article

The development of the export model allowed us to move on to the next task — designing and developing a plug-in for export.

When developing the plug-in, the PHP programming language was used; the server with the LAMP-stack worked under Ubuntu Server 17.04. The following main assets were used to analyze and write the plug-in: PHPStorm, HeidiSQL, Git.

OJS has a number of shortcomings in the documentation that describes the rules and requirements for writing plug-ins to the system. But it is important to note that the program code is written by OJS authors, is well commented and uses comments in the form of Doxygen [17]. In the process of document search, the automatically generated Doxygen documentation for the OJS components was found.

To generate an XML file, you had to understand the structure of the import file to the Russian Science Citation Index — for this purpose, the Articulus system exported and identified the XML tags needed for export. Based on experiments with Articulus exports to the metadata described in Table 2, mandatory and optional fields were identified and their association with the OJS metadata was established.

The general scheme of the plug-in operation (see Fig. 4), is fairly transparent, which resulted in its rapid prototyping and development.

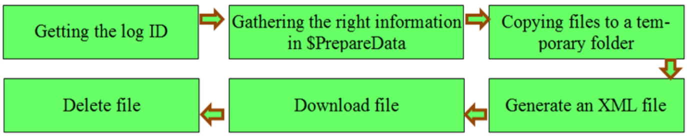


Fig. 4. General scheme of work of the developed plug-in

The created plug-in, called SirenExpo (https://github.com/Ladone/SirenExpo) (see Fig. 5). It was installed in the OJS system by copying the plug-in directory to the appropriate directory.

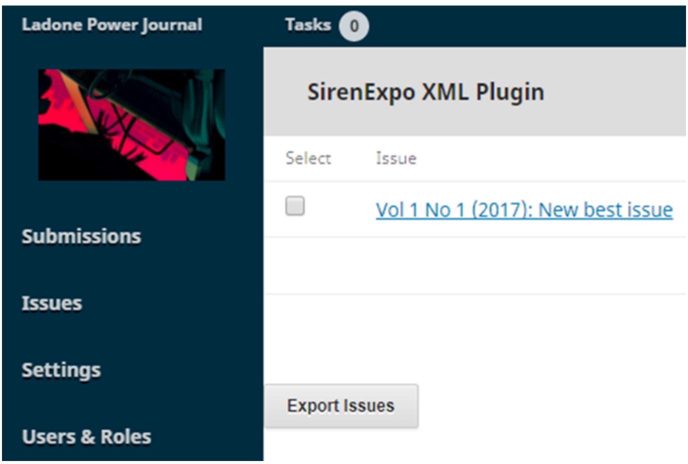


Fig. 5. SirenExpo plug-in interface

When using the plug-in, the user receives a list of journal issues that are available to him for export. To download the issue, select the issue and click on the "Export Issues" button. The program generates an archive and returns to the user. An example of the generated archive contains two pdf-files and one XML-file (see Fig. 6).

Fig. 6. Generated issue files

When authorizing the Articulus system, the user will receive a list of issues that can be transferred for indexing in the Russian Science Citation Index. In the menu, you need to click the "Restore Project" button. The user will go to the project recovery page, where you need to upload the archive generated by the SirenEXPO plug-in.

Fig. 7. Restoring of the project in Articulus

After uploading the file, the user receives a brief description of the journal issue, which was restored using the import function to Russian Science Citation Index (see Fig. 7).

At the Articulus, you need to click the "Restore project" button, and then a dialog box will open, in which you need to select the archive file generated by the SirenEXPO plug-in. After uploading the archive, all metadata required for the Russian Science Citation Index will be successfully imported. It is also possible to go to the restored project using the link "Open Project", in which there will be a window for editing the metadata of the journal. Editing of the restored project is depicted in Fig. 8.

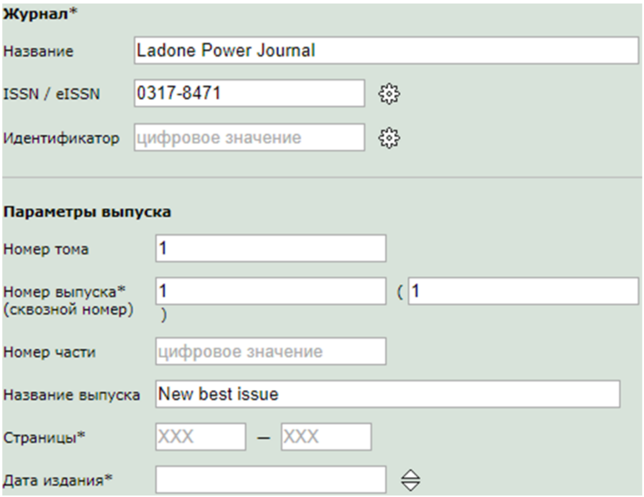


Fig. 8. Editing the restored project

So, with the help of SirenEXPO plug-in, you can export journal issues from the Open Journal Systems to the Russian Science Citation Index. The resulting archive is successfully uploaded into the Articulus — as a result, a new project with metadata imported from Open Journal Systems is created.

5 Conclusions

As a result of the research, a new plug-in for the OJS was created, with the help of which you can export data to the scientometric database Russian Science Citation Index. The work describes the plug-in structure, the source code clearly shows where the information came from and how it was developed. If you need to create a new plug-in to OJS or add another scientometric database that needs to be imported, based on this development and research results, you can create new plug-ins for export to other scientometric databases, such as Index Copernicus.

References

1. Bernal, J. D.: The Social Function of Science. George Routledge & sons Ltd., London (1939).
2. Cawkell, A. E.: Science perceived through the Science Citation Index. Endeavour. New Series. 1 (2), 57–62. doi: 10.1016/0160-9327(77)90107-7
3. Directory of Open Access Journals. DOAJ. https://doaj.org/ (2018). Accessed 1 Feb 2018.
4. Egghe, L.: Theory and practise of the g-index. Scientometrics. 69 (1), 131–152 (2006). doi: 10.1007/s11192-006-0144-7
5. Garfield, E.: "Science Citation Index" — A New Dimension in Indexing Citation Indexes for Science: A New Dimension in Documentation through Association of Ideas. Science. 144 (3619), 649–654 (1964).
6. Garfield, E.: Citation Indexes for Science: A New Dimension in Documentation through Association of Ideas. Science. 122 (3159), 108–111 (1955).
7. Google Scholar Citations. Google Scholar Blog. https://scholar.googleblog.com/2011/07/google-scholar-citations.html (2011). Accessed 1 Feb 2018.
8. Hirsh, J. E.: An index to quantify an individual's scientific research output. Proceedings of the National Academy of Sciences of the United States of America. 102 (46), 16569–16572 (2005). doi: 10.1073/pnas.0507655102
9. Institute for Scientific Information: Science Citation Index 1964 Overview. Institute for Scientific Information, Philadelphia (1964).
10. Nalimov, V. V., Mul'chenko, Z. M.: Naukometriya. Izuchenie Razvitiya Nauki kak Informatsionnogo protsessa (Scientometrics. Study of science as an information process). Nauka, Moscow (1969) (in Russian).
11. Open Archives Initiative. Cornell University Library Information Technology, Ithaca. http://www.openarchives.org (2017). Accessed 1 Feb 2018.

12. Open Journal Systems | Public Knowledge Project. Simon Fraser University Library, Burnaby. https://pkp.sfu.ca/ojs/ (2014). Accessed 1 Feb 2018.
13. Price, D.: Little science, big science ... and beyond. Columbia University Press, New York (1986).
14. Ranjan, A., Kumar, R., Sinha, A., Nanda, S., Dave, K. A., Collette, M. D., Papadimos, T. J., Stawicki, S. P.: Competing for impact and prestige: Deciphering the "alphabet soup" of academic publications and faculty productivity metrics. International Journal of Academic Medicine. 2 (2), 187–202 (2016). doi: 10.4103/2455-5568.196875
15. Samofal, O. I.: Naukometriia. Bibliometriia (Scientometrics. Bibliometry). Scientific Library of Yaroslav Mudryi National Law University, Kharkiv. http://library.nlu.edu.ua/index.php?option=com_k2&view=itemlist&task=category&id=273 (2014). Accessed 1 Feb 2018.
16. Tkachuk, V. V., Yechkalo, Yu. V., Semerikov, S. O.: Reitynh suchasnoho naukovtsia yak skladnyk reitynhu universytetu (The rating of a modern scientist as a component of the University's ranking). In: Proceedings of the International Scientific and Technical Conference on Development of Industry and Society, Kryvyi Rih National University, Kryvyi Rih, 24–26 May 2017.
17. Van Heesch, D.: Doxygen: Generate documentation from source code. http://www.stack.nl/~dimitri/doxygen/ (2016). — Accessed 1 Feb 2018.

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 290–296

УДК 004.9:[33+37+659]

Augmented Reality: Ukrainian Present Business and Future Education

Iryna S. Mintii[0000−0003−3586−4311] **and Vladimir N. Soloviev**[0000−0002−4945−202X]
Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
{iryna.mintii, vnsoloviev2016}@gmail.com

Abstract. *The aim of the study*: analysis of the current state and prospects for the development of augmented reality in Ukraine in business and education. *The objectives of the study*: to analyze the experience of using the augmented reality in advertising, marketing, education of Ukraine; to investigate the problems existing in this direction. *The object of the study*: the process of using augmented reality in advertising, marketing, education. *The subject of the study*: specific projects using the augmented reality in advertising, marketing, education. The used *method of study* was theoretical that included analysis of articles and materials of conferences on the research problem. *The results of the study*: nowadays, the augmented reality is used primarily in the field of advertising and marketing of Ukraine. As an example is the advertisement of Kyivstar (virtual tour around Ukraine, augmented reality quest), some of the Ukrainian companies have certain results in in this direction, for example, Augmented Pixels, Simo AR (in the development of a browser with augmented reality, the Kontramarka ticket service is implemented), Live Animations (such projects as Wonderland AR, My Yeti, Live Coloring, Gapchinska, Live Photo are already implemented). Among the problems that exist with the introduction of these technologies in education, first of all, we should note the shortage of specialists in the preparation of such educational projects and the uncoordinated actions of business and education in this direction. *Main conclusions and recommendations*: in order to disseminate research results it is necessary to hold thematic events of the all-Ukrainian level.

Keywords: augmented reality, AR, business, advertising, marketing, education, Ukrainian projects.

According to the chief of Apple — Tim Cook, the technology of augmented reality is also known as AR and such a “a big idea” capable of changing the world, as before it was done by a smartphone [18]. According to the definition of Ronald T. Azuma, the augmented reality has three characteristic features: combines virtual and real, interacts in real time, works in 3D [3]. Despite the fact that this term is quite new among the masses, scientists refer to the augmented reality by the end of the 1950 when Morton Leonard Heilig developed a simulator called Sensorama [5].

In Ukraine, an ordinary citizen can often deal with augmented reality in the field of advertising or marketing. Therefore, let’s consider these areas in more detail.

In the sphere of advertising, the giant of Ukrainian mobile communication Kyivstar has more achievements in the direction of using the augmented reality. So, one of the first applications is the application Kyivstar Reality [8]. Thanks to this application, you can read the mark from the Kyivstar billboard, and from the static image the advertisement on the smartphone screen turns into a realistic video. The next step of this mobile operator was the holding of a three-week quest (starting from October 4, 2017) with elements of augmented reality using the application V. QUEST [7]. Participants had to find virtual tips. The quest took place in Kiev, Kharkov, Lviv, Dnipro, Odessa and other cities of Ukraine. Further Kyivstar within the framework of the advertising campaign "Qualitative 3G" arranged a virtual tour of Ukraine in 360 format [9]. Once in front of the billboard, all users of the Kyivstar Reality application can travel to Ukraine. It's enough just to activate the application and put the smartphone on a billboard with a special marker. Travel in 360 mode will begin with the depicted city. In the future, the user can select the navigation using the markers on the map. For a full immersion in the trip, you can visit the branded shops and use the Virbox with helmets VR cardboard (helmet for simulating virtual reality, assembled according to a special scheme of cardboard, optical lenses, magnet and velcro fastening). A smartphone with preinstalled software is embedded in the helmet in the smartphone, the magnetometer can react to changing the magnetic field. According to the data from the smartphone camera, magnetometer and accelerometer, the program simulates the effect of virtual reality [20].

Among the Ukrainian companies working in the direction of augmented reality, we can note the startup Simo AR [4], in the plans of which is the creation of a search browser with augmented reality, will provide the opportunity to purchase goods in one click with the help of a smartphone camera. Between the implemented projects of this startup can be called ticket service Kontramarka [17], recognizes posters and offers users to immediately purchase a ticket.

Another Ukrainian company that creates projects for augmented reality is Brainberry Global. On October 30, 2015, Augmented Reality MeetUp 2.0 was held in Kiev for representatives of business, digital agencies and technologists who are interested in trends and key aspects of the application of Augmented Reality technologies in various fields of business and science [19]. The organizer of the event is IT company Brainberry Global presented to the public the world's first video message service Minute of Life [12] with augmented reality, which users can create themselves and place on different physical objects. So, for starters it is suggested to download or record a video or photo, then add audio files, view the received video message and create a marker. Also, the company announced its start-up "ABC, Talk with me" — a mobile application that recognizes letters on cubes. Thus, the child can check the correctness of the word made up of cubes.

Live Animations is an international IT company of Ukrainian "origin", specializing in the development of innovative products with augmented reality for children [10]. The slogan of the company is "We make the world better by adding charms to it". Among her projects can be called:

- Wonderland AR: the book "Alice in Wonderland" with illustrations by Eugenia Gapchinskaya that come alive with the use of augmented reality;
- My Yeti: a wrapper for ice cream, when you move the smartphone camera to the image of the Yeti, a cartoon series about the adventures of the Yeti is loaded [14];
- Live Coloring: "reviving" coloring: you can download the coloring, paint it and revive in the colors in which they are painted;
- Gapchinska: "animated" images of angels on a box of chocolates, postcards or other, where there is an image logo. They can be photographed, also the application allows you to create a romantic postcard for a loved one and the angels will also be there alive;
- Live Photo: "animated" notebooks: if the wrapper of special notebooks, books, notebooks, puzzles, etc. has a "Live Photo" logo, then using a special application you can "revive" the characters of the wrapper.

At the end of 2017, the Venture Reality Fund [18] published the results of the AR/VR market research, according to which Augmented Pixels is named among the leaders in the machine vision category, an international startup with Ukrainian "roots" in the augmented reality area (the first name is AR23D, founded in 2010 in Odessa). Augmented Pixels entered the list of the largest suppliers of components for Computer Vision (a system of so-called computer vision, allowing machines to identify, track and classify objects).

It should be noted that in the countries of the near abroad, targeted activities are carried out in the direction of "Augmented Reality". Among them one can single out:

- the conference and the hackathon "AVRA MINSK DAYS" that was on April 14–16, 2017. The format of the event provided an opportunity not only to learn about successful projects, new technological achievements, get acquainted with industry representatives, but also to unite professionals to create their breakthrough product in the AR/VR area and present it to investors. The program of the event: VR Talks (reports of experts on the spectrum of application of AR / VR technologies, with facts and figures, case studies and demonstration of products), VR Show Stage (demonstration of new AR / VR projects — spheres from games and entertainment, to business, education, industry, art), Test Drive (the opportunity to test the latest AR/VR devices, attractions, incredible games, movies and animation, etc.), AVRA Job (job fair for AR/VR professionals, communication with potential employers) [1];

- business forum "AVRA DAYS SKOLKOVO" was on October 24, 2017 about effective AR/VR technology. The purpose of the forum was to unite the efforts, knowledge and experience of AR/VR-companies, business representatives and advertising agencies. The following industries were represented at the forum: industry, education, marketing, advertising, retail, real estate, medicine, cinema and animation, games and eSports [2].

Ukraine has not yet taken place in measures of such level dedicated to the issues of augmented reality — but the question of direction may be considered in thematic blocks, such as the annual conference InnoTech Ukraine (it was 23–24 March 2018) [6] that dedicated to trends of technological innovations. At InnoTech Ukraine will be equipped exhibition area with the presentation of the latest domestic and foreign developments regarding the Internet of things, robotics, AR/VR/MR-technology and 3D-printing.

According to Alla Wolf (member of the Performance Augmentation Lab, which is engaged in theoretical and practical studies of augmented reality technology) "true potential of augmented reality lies not in entertainment and games, but in new features that augmented reality opens for education and production" [15].

By analyzing the speed of the development of complementary (or virtual) reality technologies and the possibilities of their use (first of all, it is the visualization of the material and, as a consequence, elimination of cognitive overload), it can be argued that it is expedient and necessary for their use in the educational process. For example, the project "Virtual Museum of Computer Technology" was implemented at the Poltava School №9 and a manual was developed using the technology of complemented reality [11].

The fruitful work on the use of complementary reality technologies and teachers of the Kryvyi Rih National University Andrii M. Striuk, Viktoriia V. Tkachuk, Yuliia V. Yechkalo, and others [13, 16].

Undoubtedly, projects with the addition of reality have a huge future in the field of education, but their creation is restrained by such factors as: lack of specialists; the lack of measures at all-Ukrainian level to cover the achievements in this direction.

References

1. ARNext.ru: AR/VR konferentciia i khakaton AVRA MINSK DAYS (AR/VR conference and hackaton AVRA MINSK DAYS). http://arnext.ru/news/ar-vr-konferentsiya-i-hakaton-avra-minsk-days-22470 (2017). Accessed 31 Dec 2017.
2. AVRA DAYS Skolkovo. http://avradays.com (2017). Accessed 23 Oct 2017.
3. Azuma, R. T.: A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments. 6 (4), 355–385 (1997). doi: 10.1162/pres.1997.6.4.355
4. Brauzer dopolnennoi realnosti: ukraintcy khotiat obognat Google (Augmented reality browser: Ukrainians want to overtake Google). Kyivstar Business HUB. https://hub.kyivstar.ua/brauzer-dopolnennoy-realnosti-ukraintsyi-hotyat-obognat-google (2017). Accessed 20 Nov 2017.
5. Brockwell, H.: Forgotten genius: the man who made a working VR machine in 1957. TechRadar. https://www.techradar.com/news/wearables/forgotten-genius-the-man-who-made-a-working-vr-machine-in-1957-1318253 (2016). Accessed 12 Dec 2017.
6. Innotech Ukraine — IV International Forum of Innovation Technologies. https://innotech.ua/en (2018). Accessed 30 Jan 2018.
7. Kyivstar: Kvest u dopovnenii realnosti — vpershe v Ukraini (Quest in the augmented reality — the first time in Ukraine). https://kyivstar.ua/uk/mm/news-and-promotions/kvest-u-dopovneniy-realnosti-vpershe-v-ukrayini (2017). Accessed 16 Dec 2017.
8. Kyivstar: Kyivstar Reality. https://kyivstar.ua/en/mm/entertainment /reality (2018). Accessed 26 Jan 2018.

9. Kyivstar: Virtualni mandry Ukrainoiu 360 (Virtual tours of Ukraine 360). http://vr.kyivstar.ua (2017). Accessed 29 Dec 2017.
10. Live Animations: Useful information about IT company "Live Animations". https://liveanimations.org/en/about (2017). Accessed 13 Jan 2018.
11. Matviienko, Yu. S.: Zastosuvannia tekhnolohii dopovnenoi realnosti v osvitnii haluzi (Application of augmented reality technology in the educational field). In: Proceedings of the 3rd Ukrainian scientific and practical Internet conference of young scientists and students "The new information and communication technologies in education" (IISTE–2015), Poltava National Pedagogical University named after. V. G. Korolenko, Poltava, 18–19 November, 2015, pp. 163–165.
12. Minute of Life — World's 1st User Generated Augmented Reality Messenger. http://minuteoflife.com/en (2015). Accessed 14 Dec 2017.
13. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).
14. Morozyvo z multykom | Morozyvo Yeti vid Lasunka (Ice cream with cartoon | Ice Cream Yeti from Lasunka). http://yeti.lasunka.com/yeti_eng.html (2017). Accessed 15 Dec 2017.
15. Soroka, A.: Shcho take dopovnena realnist: istoriia ukrainskoi doslidnytsi (What is the augmented reality: the history of a Ukrainian researcher). BBC Ukraina. http://www.bbc.com/ukrainian/features-39057896 (2017). Accessed 13 Dec 2017.
16. Striuk, A., Rassovytska, M., Shokaliuk, S.: 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 (CEUR-WS.org), vol. 2104, pp. 412–419 (2018).

17. The poster of Kyiv 2017: buy tickets for concerts and performances in Kiev. Sale, order for Kontramarka.ua. https://kontramarka.ua/en (2017). Accessed 20 Nov 2017.
18. The Venture Reality Fund. http://www.thevrfund.com (2017). Accessed 21 Jan 2018.
19. V Proshedshuiu Piatnitcu Kiev Pogruzilsia V Dopolnennuiu Realnost Ili Kak Proshel Vtoroi Augmented Reality MeetUp 2.0 (In the Past Friday Kiev Plunged into the Augmented Reality Or How the Second Augmented Reality MeetUp 2.0 Passed). http://augmentedreality.com.ua/v-proshedshuyu-pyatnicu-kiev-pogruzilsya-v (2015). Accessed 15 Dec 2017.
20. Wikipedia: Google Cardboard. https://en.wikipedia.org/wiki/Google_Cardboard (2018). Accessed 22 Jan 2018.

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 297–303

УДК 004.9

The Cloud Technologies and Augmented Reality: the Prospects of Use

Maiia V. Popel[0000-0002-8087-962X] **and**
Mariya P. Shyshkina[0000-0001-5569-2700]
Institute of Information Technologies and Learning Tools of NAES of Ukraine, 9, M. Berlynskoho St., Kyiv, 04060, Ukraine
popelmaya@gmail.com, shyshkina@iitlt.gov.ua

Abstract. The article discusses the prospects of the augmented reality using as a component of a cloud-based environment. The *research goals* are the next: to explore the possibility of the augmented reality using with the involvement of the cloud-based environment components. The *research objectives* are the next: to consider the notion of augmented reality; to analyze the experience the augmented reality using within the cloud environment / system; to outline the prospects of the augmented reality using in educational institutions; to consider the technical conditions of the augmented reality use. The *object of research* is: the educational process in educational institutions of Ukraine of different levels of accreditation. The *subject of research* is: the educational process in a cloud-based environment in educational institutions of Ukraine. The *research methods* used are the next: analysis of scientific publications, observations. The *results of the research* are the next: on the basis of the analysis of scientific works, it has been established that the experience of the augmented reality using in the systems based on cloud technologies already exists. However, the success of such a combination has not yet been proven. Currently, laboratory tests are known, while the experiment was not carried out under natural conditions in control and experimental groups. It is revealed that the attraction of the augmented reality for the educators requires the development of new methodologies, didactic materials, updating and updating of the curriculum. The *main conclusions and recommendations*: the main principles of augmented reality use in the learning process are: designing of the environment that is flexible enough, attention should be paid to the teaching and didactic issues; adjusting the educational content for mastering the material provided by the curriculum; the research methods that can be used in training along with the elements of augmented reality are to be elaborated; development of adaptive materials; training of teachers, which will include augmented reality in educational practice.

Keywords: augmented reality, cloud computing, cloud technologies, cloud-based environment, component of the cloud-oriented environment.

Cloud services have long been attracting the brisk interest of scholars in all areas. The educational sciences have not become an exception. However, there was a problem of lack of the learning methods of these technologies use; the methods of designing of the specific environments for higher and secondary educational institutions of Ukraine, adapted to the needs of teachers and students, teachers and pupils. A plenty of works (e.g., [6–9, 13, 16]) were devoted to the solving of a number of problems concerning the cloud services educational implementation. The number of universities and institutions in Ukraine that use cloud services not only to save money, but to increase the efficiency and convenience of educational services providing is constantly increasing.

However, the classical methods and techniques of pedagogical science suffer changes related to the introduction of new learning tools. Pupils and students are interested in new technologies based on virtual and augmented reality. In addition, there is a point of view that the use of augmented reality in teaching activities will simplify the learning process, provide an opportunity to save money on demonstration materials and does not require the purchase of additional equipment (for example, the smartphone has almost every student and pupil).

According to the Michael A. Dougherty, Samuel A. Mann, Matthew L. Bronder, Joseph Bertolami, and Robert M. Craig [4] augmented reality — is a combination of real-world data and computer data to create a unified user environment. Real-world data can be collected using an appropriate data collection method such as by means of a camera or a chip of the phone. These data can be processed and merged with the data developed by the computer to create the user's environment. One of the most common forms of augmented reality is the use of video images taken and processed by a video camera, with the increased graphics from a PC or other image.

That is, for most institutions that have deployed the cloud environment, it would be possible to include into it the components of augmented reality, or link it with existing didactic material. Installing the module for learning using augmented reality in the cloud is to provide a more efficient exchange of information between teachers and developer services, students or pupils. By providing access to the augmented reality module through the cloud environments, you can solve the problem of the equipment of educational institutions with powerful computing devices. This reduces the cost of it's implementation.

Ji-Seong Jeong, Mihye Kim, and Kwan-Hee Yoo offer quite interesting developments [5]. The proposed system provides the delivery and exchange of various applications of educational content by integrating a number of functions necessary for the deployment of a learning media service environment in the cloud. Due to this, teachers and lecturers will be able to create various forms of educational content, including text, images, videos, 3D objects and virtual reality-based (VR) and augmented reality (AR) virtual scenes using an author's tool, driven cloud in a common format.

The authors offers to use them to develop the learning environment not only in schools but also in universities and institutes. The system may be adapted to the needs of each student / pupil, with the analysis of their benefits to the perception of new material, learning styles and content usage templates.

Research [1] shows that the augmented reality can be used to study, motivate and concentrate attention, in addition, interaction with the objects of the augmented reality improves the understanding and memorization. By creating an image of a 3D object, using the augmented reality, the teacher invites and attracts the attention of students, which is difficult to hold so long by means of other tools of learning (for example, traditional). In addition to these benefits, by involving augmented reality it will be possible to overcome the problems, repair and maintain of experimental equipment, students will be able to experiment without affecting the environment. Students are engaged with the augmented reality aspect and the opportunity to study the subject matter in the natural environment. Owing to augmented reality it becomes possible to make the virtual objects and the real world objects coexist, representing the object of a study, such as atomic structure that can be studied in a convenient representation, expanding the boundaries of space and time.

Augmented reality can be performed by means of [3]: marker position; geolocation; QR-code.

In the first case, the process is to associate 3D images, videos, or animations by means of the print mark of specific software. When a token passes through a webcam, the virtual layer contained in this token will be activated. As a result, if the marker perspective has changed, the virtual objects will change their orientation, and this will allow us to observe them in three-dimensional mode. Software programs such as Augmentaty, BlippAR, BuildAR and ARSights can be used for implementation in educational environments; these programs are intuitive and easy to use [15].

The second case is limited to the geolocation augmented reality, its purpose is to integrate augmented reality technologies, GPS, visual search system (CVS) and mapping (SLAM) [10, 11]. Such programs offer for users a structure for interacting with the city system, depending on their location at a certain point. By using the camera of their mobile device, the users my receive a physical image of the place and overlay the virtual layers of information that shows them. Users have a wide range of real-time data about upcoming events, history of the environment, institutions, etc. [12]

With regard to the third and last case, the use of augmented reality using QR codes, the interaction is perceived through a two-dimensional square form of the code that allows to store a large variety of alphanumeric combinations, which can then be visualized with a QR-reader installed on the mobile device; and it is through these codes that you can submit information [2].

Marcus Specht, Stefaan Ternier, and Wolfgang Greller identified the following technical components for mobile systems to work correctly with augmented reality [14]:

- flexible display systems, including system displays on the head, telephone camera and portable projectors. Media technologies are becoming more flexible and more profitable to produce. These technologies allow expanding the visibility of mobile users;
- sensor systems in mobile devices such as gyroscopes, GPS, electronic compasses, cameras, etc., microphones, and local area tracking systems;
- protocols and standards for the wireless network that support internal and external setup. They also provide access to multiplayer interaction in real-time augmented reality;
- mobile phones with computing power, allowing to visualize 3D objects and overlay in real time on an autonomous device;
- label tracking technology with six degrees of freedom, multi marker tracking and hybrid tracking system. This technology is also associated with one of the most studied areas of augmented reality;
- the binding of augmented reality information based on location, based on textbooks, and storytelling. There are examples where augmented reality is used to support learning for this augmented reality experience is to be associated with educational programs, projects, or at least with the structure of objectives and approaches;
- flexible augmented reality browsers based layer with integration with social networks. Basically, the augmented reality system should be based on existing information channels and can provide information to users as a new kind of user interface. Therefore, the realization of mobile virtual reality for learning should consist of open interfaces to existing content and services.

Consequently, the inclusion of augmented reality to create new learning situations is allowed with the use of several principles, such as: the design of the environment that is flexible enough to provide the introduction of augmented reality components avoiding the technical problems; great attention should be paid to educational and didactic issues; essential elaboration of educational content to achieve a high level of mastering material beyond the mere reproduction for the learners and to allow teachers, as well as students to develop their IT competence; explore the methods that can be used in training with the elements of augmented reality; development of adaptive materials that can be used in different formats; training of pedagogical staff that can incorporate the added reality into educational practices and use it.

References

1. Ab Aziz, N. A., Ab Aziz, K., Paul, A., Yusof, A. M., Mohamed Noor, N. S.: Providing augmented reality based education for students with attention deficit hyperactive disorder via cloud computing: Its advantages. In: 14th International Conference on Advanced Communication Technology (ICACT). PyeongChang, pp. 577–581 (2012).
2. Buzko, V. L., Echkalo, Yu. V.: Mozhlyvosti vykorystannia QR-kodiv u navchanni fizyky (The possibility of use of QR-codes in teaching physics). Naukovi zapysky, Seriia: Problemy metodyky fizyko-metematychnoi i tekhnolohichnoi osvity. 10 (1), 112–118 (2016).
3. Cabero, J., Barroso, J.: The educational possibilities of Augmented Reality. Journal of New Approaches in Educational Research. 5 (1), 44–50 (2016). doi: 10.7821/naer.2016.1.140
4. Dougherty, M. A., Mann, S. A., Bronder, M. L., Bertolami, J., Craig, R. M.: Augmented Reality Cloud Computing. US Patent 2010/0257252 A1, 7 Oct 2010.
5. Jeong, J.-S., Kim, M., Yoo, K.-H.: A Content Oriented Smart Education System based on Cloud Computing. International Journal of Multimedia and Ubiquitous Engineering. 8 (6), 313–328 (2013). doi: 10.14257/ijmue.2013.8.6.31
6. Markova, O., Semerikov, S., Popel, M.: CoCalc as a Learning Tool for Neural Network Simulation in the Special Course "Foundations of Mathematic Informatics". 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 (CEUR-WS.org), vol. 2104, pp. 388–403 (2018).

7. Markova, O. M., Semerikov, S. O., Striuk, A. M.: The cloud technologies of learning: origin. Information Technologies and Learning Tools. 46 (2), 29–44 (2015).
8. Merzlykin, O. V., Semerikov, S. O.: Perspektyvni khmarni tekhnolohii v osviti (Prospective Cloud Technologies in Education). In: Proceedings of the scientific and practical workshop on Cloud Technologies in Modern University, Cherkasy, 24 Mar 2015, pp. 31–33. ChDTU, Cherkasy (2015).
9. Merzlykin, O. V.: Khmarni tekhnolohii yak zasib formuvannia doslidnytskykh kompetentnostei starshoklasnykiv u protsesi profilnoho navchannia fizyky (Cloud technologies as tools of high school students' research competencies forming in profile physics learning). Thesis for the degree of candidate of pedagogical science, Institute of Information Technologies and Learning Tools of the NAPS of Ukraine (2017).
10. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).
11. Morkun, V., Semerikov, S., Hryshchenko, S., Slovak, K.: Environmental Geo-information Technologies as a Tool of Pre-service Mining Engineer's Training for Sustainable Development of Mining Industry. In: Ermolayev, V., Bassiliades, N., Fill, H.-G., Yakovyna, V., Mayr, H. C., Kharchenko, V., Peschanenko, V., Shyshkina, M., Nikitchenko, M., Spivakovsky, A. (eds.) ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer 2017, 13th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2017), Kyiv, Ukraine, 15–18 May 2017. CEUR Workshop Proceedings (CEUR-WS.org), vol. 1844, pp. 303–310 (2017).
12. Semerikov, S. O., Striuk, M. I., Moiseienko, N. V.: Mobilne navchannia: istoryko-tekhnolohichnyi vymir (Mobile learning: historical and technological dimension). In: Konoval, O.A. (ed.) Teoriia i praktyka orhanizatsii samostiinoi roboty studentiv vyshchykh navchalnykh zakladiv (Theory and practice of organization of independent work of

students of higher educational institutions), pp. 188–242. Knyzhkove vydavnytstvo Kyreievskoho, Kryvyi Rih (2012).

13. Shokaliuk, S. V., Markova, O. M., Semerikov, S. O.: SageMathCloud yak zasib khmarnykh tekhnolohii kompiuterno-oriientovanoho navchannia matematychnykh ta informatychnykh dystsyplin (SageMathCloud as the Learning Tool Cloud Technologies of the Computer-Based Studying Mathematics and Informatics Disciplines). In: Soloviov, V. M. (ed.) Modeling in Education: State. Problems. Prospects, pp. 130–142. Brama, Cherkasy (2017).
14. Specht, M., Ternier, S., Greller, W.: Dimensions of Mobile Augmented Reality for Learning: A First Inventory. The Journal for the Research Center for Educational Technology. 7 (1), 117–127 (2011).
15. Striuk, A., Rassovytska, M., Shokaliuk, S.: 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 (CEUR-WS.org), vol. 2104, pp. 412–419 (2018).
16. Striuk, M. I., Semerikov, S. O., Striuk, A. M.: Mobility: a systems approach. Information Technologies and Learning Tools. 49 (5), 37–70 (2015).

Педагогіка вищої та середньої школи
2019. Випуск 51. С. 304–315

УДК 373.2:159.922.76]:004.9

Using the Augmented Reality to Teach of Global Reading of Preschoolers with Autism Spectrum Disorders

Tamila H. Kolomoiets[1[0000−0002−7321−0901]] and Darja A. Kassim[2]
[1] Kryvyi Rih State Pedagogical University, 54, Gagarina Ave., Kryvyi Rih, 50086, Ukraine
tamilak2561@gmail.com
[2] Kryvyi Rih Metallurgical Institute of the National Metallurgical Academy of Ukraine, 5, Stephana Tilhy St., Kryvyi Rih, 50006, Ukraine

Abstract. Over the last decade a significant increasing of the number of children with autism spectrum disorders (ASD) in the world is marked. Ukraine is no exception. High rates of disease ASD require finding the new ways of correcting these groups of children. *The aim of the research*: to substantiate feasibility of using of the augmented reality's technologies to teach of global reading in a special education of autistic children. In the course of the study an experiment, descriptive and comparative analysis methods, generalization, logical *research method* were used. *Results of the research*: it is shown that, it is expedient to use technologies of the augmented reality in the educational and correctional process of children with ASD to teach them of global reading. Using the augmented reality reveals a number of new opportunities, the promising of which is an interaction with the artificial world through mobile devices, which are more accessible and predictable for the special development of autistic children. At the initial stage of teaching of global reading, the instrument of augmented reality is used in a set of successive task groups. The first of these is aimed at the development of visual perception, the formation of the ability to analyze, isolate and generalize, navigate in space. The second and third set of tasks included the teaching of children to understand the meaning of words, the correlation of words with images presented on the screen of gadgets. At the final stage, namely, teaching of global reading, the technology of augmented reality has opened unlimited possibilities for using of various text materials and virtual images to them. *Conclusions*: a) an analysis of experimental work with preschoolers with ASD suggests that the use of augmented reality in teaching of global reading of children helps to increase the efficiency of the educational and correctional process; b) the technology of the augmented reality has allowed rising to a qualitatively new level of mastering of global reading by autistic children; c) prospects for further experimental research will be the implementation of the proposed methodology and obtaining its effectiveness and efficiency in practice.

Keywords: children with autism spectrum disorders (ASD), preschoolers, augmented reality's technologies, global reading, correctional education.

1 Introduction

A significant increase of interest of researchers, physicians, doctors, educators to the problem of autism spectrum disorders (ASD) of children has been marked over the past decade. This is due to the rapid increase in the number of children with autism from 1 to 1000 cases to 1–100 (Dennis Ougrin, Great Britain) [2, p. 24]. The American Center for Disease Control and Prevention estimates the prevalence of autism in the United States as a single case for 88 children. Indicator of autism prevalence is steadily increasing by 29% annually. Ukraine is no exception. According to the Ministry of Health of Ukraine, the incidence of ASD from 2006 to 2015 increased by 2.5 times. Differences in numerical indicators are related to the lack of survey technologies and, according to Ihor A. Martsenkovskyi, with the late diagnosis of the disease in the country. Most cases of ASD are diagnosed at the age of 30–50 and 58–71 months [2, p. 59]. Late detection of autistic disorders negatively affects to their treatment and psychological and pedagogical correction.

As noted by Martsenkovskyi, children autistic disorders is connected with violations of neurodevelopment and they are characterized by qualitative deviations in social reciprocity, verbal and non-verbal communication, preceptor violations and stereotypical forms of behavior [2].

Symptoms of communication disorder are occurred in a delay or complete absence of spoken language, using of linguistic stamps and the lack of need for communication with outside world. The peculiarities of autistic children's speech correction, learning them for global reading are little studied. Currently, there is no scientific methodology for teaching of global reading of children with autism and poor speech.

According to the analysis of the practice of educational-rehabilitation centers, teachers teach children with ASD reading by analytical-synthetic sound-letter method, by the method of Glenn Doman and Bronislava D. Korsunskaia [1]. Multiple tasks are considered as a prerequisite for the formation of skills and abilities of reading.

Thus, there is a need to develop an experimental method of global reading's teaching of children with autism and delay of linguistic development.

A number of domestic and foreign scientists: Nadezhda S. Zhukova, Iryna P. Lohvinova, Larisa G. Nurieva, Elena M. Mastiukova, Mariia K. Sheremet engage by the researches of speech disorders, reading skills of autistic children.

2 The Aim of the Study

The aim of the study is to identify, select and test the teaching method for global reading using the technology of the augmented reality of preschool children with ASD, which significantly improves of the effectiveness of correctional educational processes.

3 Results and Discussion

Under the augmented reality, they understand the technology of addition, the introduction of virtual information to real-life, which allows perceiving it as a part of real life [3]. If you use high-quality content, then a person is artificially formed erasing the border between the artificial world and reality. This tool causes a maximum of emotions, and also allows interacting with the investigated object [5].

Disorders of the autism spectrum are considered by scientists as a combination of total (pervasive) development, characterized by qualitative violation of communication, social interaction, limited interests and stereotypical forms of behavior. Such children do not show interest in communicating with others without understanding the motives of their behavior. Instead, they prefer to interact with mobile devices, set a close connection with them, since the result of their actions is always predictable for them. Thus, using of augmented reality technologies, as the means of learning, most closely corresponds to the peculiarities of the perception and thinking of autistic children.

The immortality of social interaction, as one of the three main domains of clinical disorders, is decisive in autistic disorders. One of the manifestations of this domain — a qualitative violation of communication — includes a delay or complete lack of speech, limited nonverbal communication, and inability to initiate and maintain a conversation. A completely different communication takes place with gadgets, during which the child there is a strong and deep emotional empathy, a sense of enthusiasm, a willingness to cooperate, and thus learn. At the initial stage of using augmented reality, the language of children with ASD is aimed at satisfying their own needs. Virtual communication contributes to the development of impulsive speech as the basis for the formation of expressive speech.

Delay of linguistic development of children with autistic disorders, as well as children with underdeveloped speech, is related to the immortality of a synthetic type of synthetic activity, which leads to a low level of formation of their abilities: to distinguish tempo-rhythmic characteristics of speech, component of the structure of words; to comprehend and memorize the text; to establish systems of relationships between words.

According to the results of Valentyna V. Tarasun's research, demerits of successive syntheses were discovered in fewer children with underdeveloped speech (US), characterized by autistic children, which caused underdevelopment of their special abilities: to reproduce a certain sequence of rhythmic sounds and melodies; to form a system of sounds, syllables; to carry out linguistic communication and the actual statement [6].

At the same time, the good visual memory of the child with ASD, the ability to perceive the graphic image of the word and correlate it with the real objects of the surrounding world create positive learning environment for global reading.

In view of the fact that in the scientific literature we have not been able to find a special method of teaching global reading of children with ASD, we have developed such a method for children from 4 to 8 years of age using the technology of augmented reality. Using of the augmented reality in the correctional educational processes reveals a number of new possibilities. The advantages of technology include [5]:

- strong emotional responses, since the emergence of virtual objects causes children a state of admiration and surprise, which contributes children's interest and motivation for learning;
- interactivity, which contributes to better memory;
- possibilities of interaction with the artificial world by means of mobile devices, which is a significant advantage of the augmented reality to the virtual reality;
- possibility to conduct virtual classes.

Consequently, the target model of a teaching method formation of global reading using the augmented reality technology of children with autistic spectrum disorders takes the form (Fig. 1).

All the work on developing formation of global reading skills of autistic children using augmented reality consisted of several stages (Fig. 2).

Initially, methods and techniques aimed to formulate simultaneous synthesis of a clear schematization of internal experience were used, which is the basis of linguistic knowledge. Another trend in educational and correctional work focused on the successive structures of synthesis of certain elements at successive rows (Valentyna V. Tarasun).

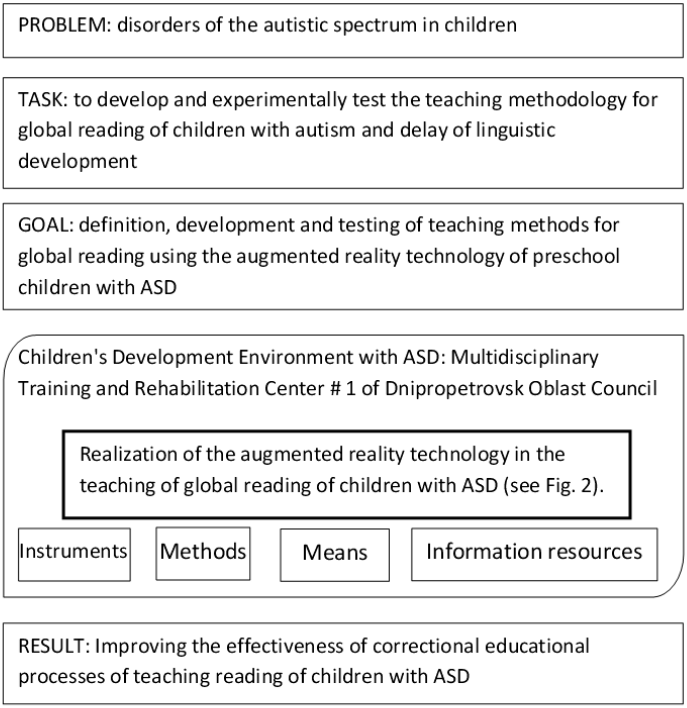


Fig. 1. The target model of a teaching method realization of global reading using the augmented reality technology of children with ASD

Children were offered a set of tasks for the development of simulative and successive structures. Give examples of some groups of exercises and tasks. The first group of tasks involves the development of visual perception of children, forming of the ability to analyze, isolate and generalize, navigate in space:

1. Selection of a figure from a homogeneous background (the sample of Revo d'Allon) — green objects on a green background.
2. Naming contour-depicted objects imposed on each other (figure of Walther Poppelreuter).
3. Classification of objects according to the logical categories proposed by the teacher: a car, a table, a sweater, a pear, a cup, a skittle, socks, etc.

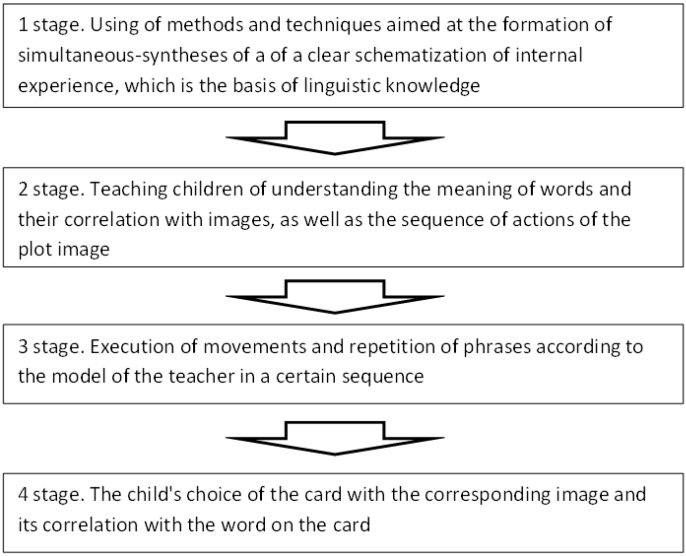


Fig. 2. Stages of the implementation of the augmented reality technology in the teaching of global reading of children with ASD

4. Memorization of four subject drawings offered by the teacher, followed by a search in a bunch of other pictures.
5. Finding the differences between two mirrored figures.

The augmented reality can be used as shown in Fig. 3 during performing the exercise of this group.

The second group of tasks included teaching children to understand the meaning of words and their correlation with images, as well as the sequence of actions of the plot image.

1. Understanding of the antonyms and synonyms: sweet — bitter, big — small, wide — narrow, long — short; "What can stand?"; "What can be called a leg?"; "What can be: cold, bitter, heavy, and useful?".
2. Finding and showing the ruler by a pointer, showing a pointer by a ruler; showing a pencil by a pointer, showing a pointer by a pencil.
3. Understanding of the sentences of the convertible design: Show where on the picture: "Sasha makes the feeder. Feeder is made by Sasha". "A girl reads a book. The book is read by the girl".

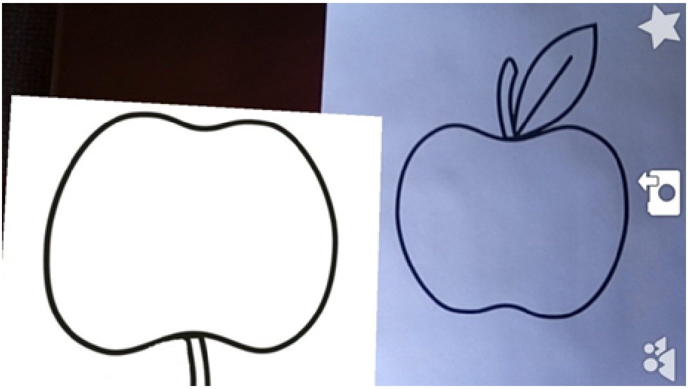


Fig. 3. Screenshot of Task 5

4. Understanding the images of a series of pictures and locating them according to the plot content.
5. Correlation of the subject's image on the picture and its graphic representation on the icon.
6. Correlation of the object and its image. Selection of pairs (Fig. 4).

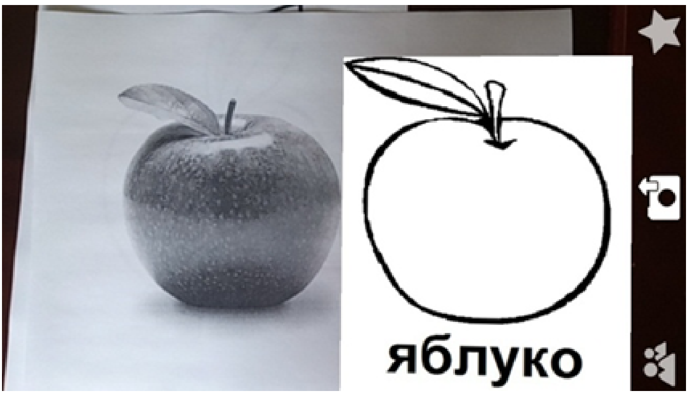


Fig. 4. Screenshot of Task 6

The third group of tasks required the children to execute movements and to repeat the phrases according to the model of the teacher in a certain sequence:

1. Imitation of the teacher's model of the kinetic melody with the successive change of the three positions of the hand: the palm — the fist — an edge.
2. Making exercises for the fingers of the hands of the teacher's model: the first finger — the second finger; the first finger — the third finger; the first finger — the fourth finger; the first finger — the fifth finger and vice versa.
3. Execution of articulation movements: dynamic and static.
4. Repetition of simultaneously proposed pairs of words, or series of words: cup — table; field — flowers; goat — spit — dew ([koza — kosa — rosa]); cancer — poppy — the roof ([rak — mak — dakh]).
5. Repetition of the proposed images on two pictures in series in memory: the apple is small — the apple is large; a thin book — a thick book, etc. (Fig. 5).

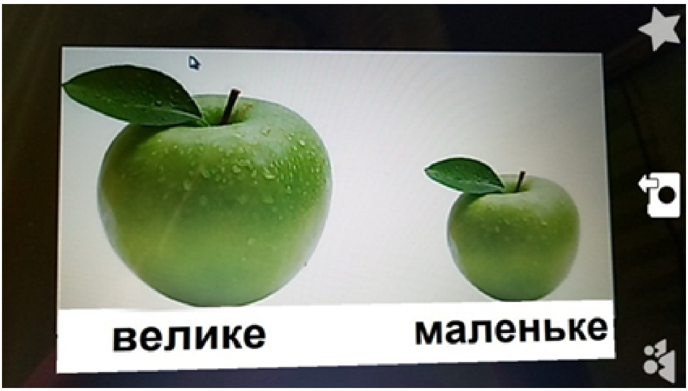


Fig. 5. Screenshot of Task 5

Illustrations (by Inna V. Koroleva, Larisa G. Nurieva) were included in the program of work for autistic children [4]. Cards of transparent material with contours of words and numbers were selected on a game field with icons depicting a certain type of movement or subject matter (Elephant is going, the turtle is creeping, the blue ball is one, two yellow balls).

After the successful formation of regulatory visual movements, vestibular projections, optical and kinesthetic sensations, the development of sensorimotor abilities and successive structures at the mental level, learning for global reading became the next stage in working with autistic children.

The ability of children with ASD to perceive and memorize the schematic images well, their sequence, allowed us to offer them graphic images of words — the method of global reading. The main purpose of global reading teaching was the tasks of developing of impressive, narrative, free reading. Successful implementation of the assignments of global reading was provided, first of all, by the selection the words and images familiar to children of four years old (vocabulary which found in children during the survey) for reading.

Cards with words of red color (letters in the size from 2 to 5 cm) by the Doman method were used previously. Every day a new set of 5 words for reading was offered to children. These were engrams (names of loved ones, the heroes of animated films), words that meant everyday items, parts of the body, and so on.

The tasks were offered in a certain sequence for proper understanding and remembering of images on the card. At first, the child remembered the inscriptions on the cards and learned to pick their pairs. At the next stage, the pupils mastered the ability to recognize and select the inscription on the card (nouns, verbs, adjectives), to match with the sample (Fig. 6).

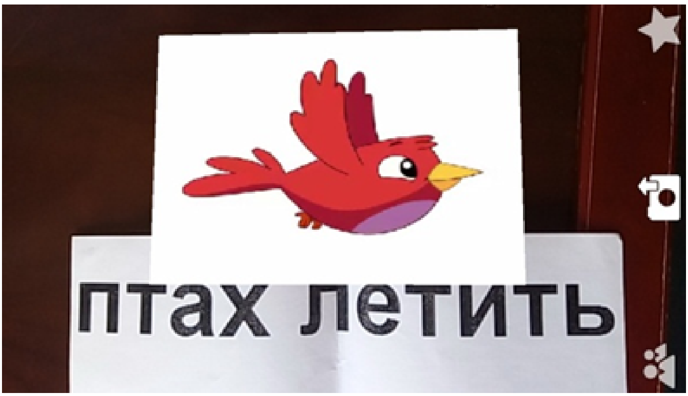


Fig. 6. Screenshot of Task

When learning lexical themes: "Clothes", "Toys", "Food", "Dishes", etc. the teacher laid out the cards with words and called them. The next task required the child to select a card with the corresponding image and its correlation with the word on the card. As a result of the application of such techniques, five-year-old children with ASD quickly mastered the vocabulary of program topics.

By the global method of reading, children quickly and with great interest master the words antonyms (sweet — bitter, high — low, merry — sad) and paronyms (sac — cancer, ([sak — rak]), goat — spit ([koza — kosa])).

Gradually, the tasks were complicated by the transition of reading the phrases, depicted in the pictures (a large ball — a small ball, an empty bucket — a full bucket). The children liked to pick up incompatible, funny, absurd phrases and words-actions to them.

An integral part of this phase was making books illustrated by photographs of children and their loved ones, favorite animals, who performed various actions by children together with parents. Each page of the book was signed by phrases, and later with sentences (I am playing, my mother is reading, the dog is asleep, I am eating a watermelon.).

Until the next stage of reading the sentence, for children 6 years the type has decreased to the usual and its color has changed from red to black.

A successful practice in the global reading method of sentences was using of nouns, verbs and colored cards for the recording (nouns on a yellow background, verbs — on a green background).

Quite easily, children fulfilled the teacher's commands using one verb and different nouns ("Show the doll", "Show hands", "Show the table") and pick up the corresponding cards at the same time.

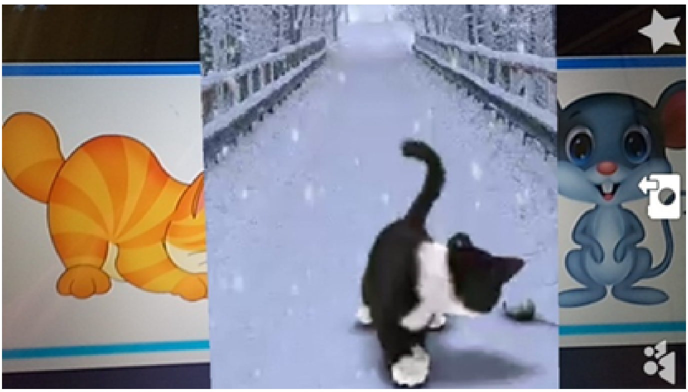


Fig. 7. Screenshot of Task

Alternatively, when reading verbs, the cards on which objects were already depicted to compose sentences were used, and the children took the word-action written on the card. Such a task was difficult and therefore uninteresting for children, but using of the augmented reality "animated" the heroes of the picture, allowed not only to show the story, but illustrate the actions of the heroes as in cartoons, which children like (Fig. 7).

4 Conclusions

The analysis of the two-year experimental work with preschoolers with ASD (middle and senior groups) suggests that the proposed program of teaching global reading was completely taken up by children. Approbation of the methodology of teaching global reading using the augmented reality of preschool children with ASD showed the positive results. The technology of augmented reality allowed combining the real and virtual objects to interact with them in real time. It became possible to enhance the interest and motivation to conscious activity, the formation of new values in the knowledge of the surrounding world. Observation of realistic images stimulated cognitive processes, which led to a qualitatively new level of assimilation and processing of information by autistic children.

Thus, the application of augmented reality technology helped to improve the efficiency of correctional and developmental training for children with special educational needs.

Prospects for further experimental research will be the implementation of the proposed methodology and obtaining its effectiveness and efficiency in practice.

References

1. Korsunskaia, B. D.: Chtenie kak tcel i sredstvo v sisteme doshkolnogo obucheniia glukhikh (Reading as a goal and means in the system of preschool education for the deaf). Defektologiia. 1, 39–47 (2007).

2. Martcenkovskii, I. A. (ed.): Ocherki detskoi psikhiatrii. Autizm (Sketches of child psychiatry. Autism). NeuroNEWS (2014).

3. Modlo, E. O., Echkalo, Yu. V., Semerikov, S. O., Tkachuk, V. V.: Vykorystannia tekhnolohii dopovnenoi realnosti u mobilno oriientovanomu seredovyshchi navchannia VNZ (Using technology of augmented reality in a mobile-based learning environment of the higher educational institution). Naukovi zapysky, Seriia: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity. 11 (1), 93–100 (2017).

4. Nurieva, L. G.: Razvitie rechi u autichnykh detei: metodicheskie razrabotki (Development of speech in autistic children: methodological developments). Terevinf, Moscow (2016).
5. Sekerin, V. D., Gorokhova, A. E., Shcherbakov, A. A., Iurkevich, E. V.: Interaktivnaia azbuka s dopolnennoi realnostiu kak forma vovlecheniia detei v obrazovatelnyi protcess (Interactive alphabet with augmented reality as a form of involving of children in the educational process). Otkrytoe obrazovanie. 21 (5), 57–61 (2017).
6. Tarasun, V. V.: Preventyvne navchannia doshkilnykiv z porushenniamy movlennievoho rozvytku (Preventive training for preschool children with speech development disorders). Pravda Yaroslavychiv, Kyiv (1998).

ISSN 2304–4470

Педагогіка вищої та середньої школи : зб. наук. праць. / голов. ред. В. А. Гаманюк. — Кривий Ріг, 2018. — Вип. 51. — 316 с.

Наукове видання

ПЕДАГОГІКА ВИЩОЇ ТА СЕРЕДНЬОЇ ШКОЛИ

ЗБІРНИК НАУКОВИХ ПРАЦЬ

Випуск 51

Свідоцтво про державну реєстрацію друкованого засобу масової інформації КВ № 22419–12319ПР видане 22.11.2016 р.

Підписано до друку 20.12.2018.
Формат $60 \times 84\frac{1}{16}$. Папір офсетний. Друк офсетний.
Ум.-друк. арк. — 19,75. Наклад — 100 прим.

Адреса редакції та видавця:
Видавничий центр
Криворізького державного педагогічного університету
50086 Кривий Ріг, просп. Гагаріна, 54.
Тел.: +38 (056) 470-13-34 +38 (096)-34-85-160
E-mail: kdpu@kdpu.edu.ua
prorektor_science@kdpu.edu.ua
https://journal.kdpu.edu.ua/