Methodology of using mobile Internet devices in the process of biology school course studying

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Abstract. This paper considers the problem of using mobile Internet devices in the process of biology studying in secondary schools. It has been examined how well the scientific problem is developed in pedagogical theory and educational practice. The methodology of using mobile Internet devices in the process of biology studying in a basic school, which involves the use of the Play Market server applications, Smart technologies and a website, has been created. After the analyses of the Play Market server content, there have been found several free of charge applications, which can be used while studying biology in a basic school. Among them are the following: Anatomy 4D, Animal 4D+, Augmented Reality Dinosaurs – my ARgalaxy, BioInc – Biomedical Plague, Plan+Net. Their choice is caused by the specifics of the object of biological cognition (life in all its manifestations) and the concept of bio(eco)centrism, which recognizes the life of any living system as the highest value. The paper suggests the original approach for homework checking, which involves besides computer control of students' learning outcomes, the use of Miracast wireless technology. This demands the owning of a smartphone, a multimedia projector, and a Google Chromecast type adapter. The methodology of conducting a mobile front-line survey at the lesson on the learned or current material in biology in the test form, with the help of the free Plickers application, has been presented. The expediency of using the website builder Ucoz.ua for creation of a training website in biology has been substantiated. The methodology of organizing the educational process in biology in a basic school using the training website has been developed. Recommendations for using a biology training website have been summarized. According to the results of the forming experiment, the effectiveness of the proposed methodology of using mobile Internet devices in the process of biology studying in a basic school has been substantiated.

Keywords: school education, blended learning, smart technologies, website, biology.

1 Introduction

Specificity of the modern information society leads to a change of the ways of human life. This causes significant transformations in the educational system. Its transition to a qualitatively new state requires the optimization and management of the mechanisms of interaction of all the subjects of learning environment. Its peculiarity is the functioning of multi-vector information flows that need to be taken into account in the educational process. Within such a system of relations, all the subjects of the educational process interact with each other as active mutually influential participants. They interact with modern information technologies (IT) – social networks, Internet services, etc.

Modern ICT involve wide opportunities to the students' development. In consequence of the potential of mass interactivity, immersion, learning in joint activities, they become an effective tool of learning. The appropriateness of ICT use in the biology school course is caused by the specifics of the object of biological cognition (life in all its manifestations) and the concept of bio(eco)centrism, which recognizes the life of any organism as the highest value.

Biology studying at secondary education institutions in Ukraine is aimed at the formation of ten major key competences, among which are the following: information and digital competence and core competences in sciences and technologies. It is relevantly to form such competences by means of the use of modern mobile Internet devices in the educational process. We consider a computer, an interactive Smart Board, a multimedia projector, a smartphone, Google Chromecast adapter, and others to be the modern information devices.

A number of works of Ukrainian and foreign scientists (Yurii O. Doroshenko [1], Olena V. Komarova [5], Nadiia Yu. Matiash [6], Liudmyla P. Mironets [8], Yevheniia O. Nevedomska [12], Anatolii H. Shcherbakov [17], Tetiana V. Starova [4], Alla V. Stepaniyk [19], etc.), have dealt with the possibilities of using a computer in the process of teaching biology. In her study, Nadiia Yu. Matiash underlines the necessity of using a computer during biology school course to increase the effectiveness of the lesson and the efficiency of the learning process [6]. Alla V. Stepanyuk studies the problem of using computer learning tools in the methodological training of future biology teachers [19]. Yevheniia O. Nevedomska considers the positive and negative aspects of the use of computer technologies in the teaching biology while examining the levels of information and computer systems that form the quality criteria of the theoretical and practical implementation of pedagogical computer tools [12].

Theoretical aspects of mobile learning are disclosed by Vita A. Hamaniuk [3], Mariia A. Kislova [21], Liudmyla P. Mironets [8], Yevhenii O. Modlo [11], Olena O. Pavlenko [13], Serhiy O. Semerikov [9], Ekaterina O. Shmeltser [2], Vladimir N. Soloviev [20], Andrii M. Striuk [15], Viktoriia V. Tkachuk [22], Stanislav T. Tolmachev [10], Tetiana I. Zhylenko [24] and others. Models of presentation of knowledge and data of the subject discipline in the form of computer ontology are presented in the work of Ivan M. Tsidylo, Hryhorii V. Tereshchuk, Serhiy V. Kozibroda, Svitlana V. Kravets, Tetiana O. Savchyn, Iryna M. Naumuk and Darja A. Kassim [23]. However, the analysis of scientific and pedagogical works shows that the

practical aspect of using of mobile Internet devices for conducting educational studies in biology was not the subject of a separate study and remains quite weighty. Therefore, there is a contradiction between the innovative nature of the mobile Internet devices and the development of scientific and methodological support for their implementation in the educational process in biology.

The objective of this paper is to outline the possibilities, as well as the appropriateness of use of mobile Internet devices in the process of biology school course studying.

The objective was realized through the following tasks:

1. To clarify the state of development of the problem at the levels of pedagogical activity and personal property of students.
2. To analyze the content of the Play Market for availability of free applications that can be useful for studying biology in a basic school.
3. To develop and substantiate the methodology of using mobile Internet devices in the process of biology school course studying and to test experimentally its effectiveness in a basic school.

2   Methods

To achieve the abovementioned objective and tasks, a number of methods have been used, namely: theoretical – comparative analysis to find out different views on the problem, identify areas of study; modeling to develop a methodology for using mobile Internet devices in the process of biology school course studying; systematization and generalization to formulate conclusions and recommendations for improving the educational process in biology; empirical – generalization of pedagogical experience, scientific observation, interviews, questionnaires in order to determine the state of implementation of the problem in practice; pedagogical experiment, which provided verification of the effectiveness of the proposed methodology; statistical methods for analyzing and establishing the reliability of the study results.

Experimental research has been carried out on the basis of Ternopil general secondary schools No. 24, 26, Terebovlia general secondary school No. 1 (Ternopil region) and Sumy specialized school No. 7, 9, and 25 (Sumy region). Summative experiment involved 528 students and 212 biology teachers. Forming experiment lasted for two years (2016-2018) in 7-8 grades. 553 students (220 in control (C) and 333 in experimental (E) groups) participated in it.

Effectiveness of the proposed methodology was checked during the forming experiment. The students of experimental groups, grades seven and eight, were trained in accordance with the methodology we proposed, and students in the control groups were trained according to the traditional methodology. After the experimental training the diagnostic survey was carried out with the aim to determine the effectiveness of the proposed methodology. We used qualitative analysis, developed in the studies of Mikhail N. Skatkin and Volodar V. Kraevskii [18]. Separate quality indicators of the entirely learned knowledge were studied, namely: completeness, awareness,

consistency and systematicity. These indicators are most closely connected with the changes in students' knowledge that they have received using mobile Internet devices.

The indicator "completeness of knowledge" was determined by the amount of all the knowledge about the subject of study, which is provided by the curriculum. Students' answers were arranged in groups according to the following criteria: correct complete answer; correct incomplete answer; no answer. Correct complete answer encompassed all the knowledge about the object, which is provided by the curriculum in biology. In the correct incomplete answer only some part of the necessary knowledge was represented.

The indicator "awareness of knowledge" is characterized by understanding of links between knowledge, ways of acquiring knowledge, ability to justify them. Students' answers were also arranged in three groups: correct answer; incorrect answer; no answer. Consistency of knowledge assumes systematicity as its precondition and contains its certain characteristics. Therefore, the indicators "consistency and systematicity" were investigated together. Students' answers were arranged in four groups: correctly correlated concepts of different levels of generality; one violation was made in the ratio of concepts; two or more violations were made in the ratio of concepts; no answer. Validity of variance in indicators between separate groups was estimated with the help of χ^2 criterion.

3 Results and discussion

With the aim to study the state of the problem in the practice of biology teaching we carried out a survey of 212 biology teachers and 528 students of the city schools in Sumy and Ternopil regions. We analyzed the way teachers train students to work with different sources of information. Thus, 43.87% (93 teachers) train students how to work with the catalogue, 73.58% (156 teachers) train how to work with the textbook orientation apparatus, 24.53% (52 teachers) form the ability to search the necessary information on the Internet.

198 teachers (93,40%) use computer as a tool for biology teaching, an interactive Smart Board is used by 46 teachers (21,70%), 86 teachers (40,57%) use multimedia projector, a tablet and a smartphone is used by 10 teachers (4,72%), and 8 teachers (3,77%) use Google Chromecast Adapter. All the 212 teachers (100%) use computer during the preparation to the lessons. However, only 154 teachers (72,64%) give their students home task to search for the additional information on the Internet, and 198 teachers (93,39%) offer students to prepare presentations in the form of a report on the performance of a specific task. There are the following reasons for the inadequate use of modern mobile Internet devices by teachers in the educational process: insufficient level of their own computer literacy – 104 teachers (49,06%); lacking of material and technical as well as educational and methodological support for biology school course teaching – 148 teachers (69,81%); the reluctance of teachers to study life phenomena and processes using a computer – 52 teachers (24,53%). Only 10 teachers (4,72%) know that a mobile Internet device can be used as a tool for teaching biology.

The majority of students have shown moderate interest to the TV programs about nature (77,65%). Only 7,20% claimed that they are not interested in such programs at all. 60,23% of students like observing plants and animals and 16,10% demonstrate moderate interest in such an activity. 74,43% of students sometimes address the Internet sources to answer questions during the lesson and 19,70% of the students often address various information sources in this case. 5,87% of the students stated that they don't search for the answers in additional sources.

The majority of teenagers (87,31%) possess mobile Internet devices (smartphones, tablets), but they use them mainly for fun or socializing with peers in social networks. 18,56% of students know that a mobile Internet device can help in conducting a research both at school and beyond it, but only 4,55% of respondents use smartphones for this purpose.

However, the study of the practice of the secondary education institutions and personal practical experience show that the use of the Internet facilitates better learning of education material by students. At the same time the effectiveness of lessons increases significantly and it encourages students to study. The educational process is intensified through the increase of its informativeness. Due to this, students improve their ability to orient themselves in the information space and, in this case, the teacher acts as a mentor, consultant. All the above mentioned actualizes the necessity in the development of the methodology of using mobile Internet devices in the process of biology studying.

Our experimental methodology involves the use of the mobile Internet devices and mobile learning (M-learning) technology. It is caused by the main advantages of M-learning use, namely: bringing new technology into the classroom; possibility to use portable devices to support the learning process; possibility to use the technology as an additional tool for learning; as a useful add-on tool for students with special needs; available synchronous learning experience; allows widened opportunities for timing, location, accessibility and context of learning [16].

The challenges of introducing M-learning technology were also taken into account. Among them are as follows: accessibility and cost barriers for users; incompatibility of some mobile devices with other applications and devices; frequent changes in device models, technologies, functionality; number of file formats supported by a specific device; risk of distraction and fragmentation of learning; restriction of educational information visualization; required bandwidth for nonstop and fast streaming; tracking of results and proper use of the information and the lack of well-developed students' self-control skills; insufficient "technical" training of school teachers in creating of mobile application [16].

Smartphones and tablets based on the Android operating system allow you to use Internet resources and various free applications that are downloaded from the Play Market. Analyzing the Play Market, it has been found that it contains a lot of applications that are permanent helpers in the biology learning with the possibility of free downloading. All applications are installed on the teacher's smartphone, and using Google Chromecast adapter, they are displayed on the multimedia projector screen.

We present examples of educational applications, involved in our methodology.

The Anatomy 4D application carries students and anyone who wants to learn about the internal structure of the human body into an interactive 4D world of human anatomy, stunning visually. Anatomy 4D uses augmented reality and other cutting edge technologies [7] to create the perfect foundation for 21st century education. It is much more than an application, the Anatomy 4D takes viewers on a journey inside the human body and heart, revealing the spatial relations of our organs, skeleton, muscles, and body systems. It is a simple-to-use 3D learning environment is great for use in the classroom, or anytime.

The Anatomy 4D application enables: to learn about and explore the human body and heart in the smallest details; highlight various organs and systems separately. You can, for example, focus on just the musculoskeletal, digestive, or respiratory system; change the sex of the body under investigation; zoom in to study profoundly each organ or body part.

The Animal 4D+ application brings you a new way of seeing animals in augmented reality, which unambiguously broadens students' horizons and understanding of animals, and their external structure. Using the Animal 4D+ alphabet cards, the animals spring to life making the acquaintance with them much better.

The Augmented Reality Dinosaurs – my ARgalaxy application helps students to dive into the world of dinosaurs. Augmented reality enables to feel oneself as a part of the fauna development history.

The BioInc – Biomedical Plague application is a complex biomedical simulator in which you make life or death decisions. The application acquaints students with various diseases and the ways of their transmission, shows more than 100 realistic biomedical conditions. The game is not only educative, but it also teaches a careful attitude to one's health and the value of human life.

The Plan+Net application is a powerful tool to identify plants in the photo. During an excursion the teacher takes a picture of an unknown plant by his smartphone and then using the mobile application analyzes the received information. After the work completing, plant details can be checked using printed version of a plant catalogue. Students can use such an educational application not only at biology lessons, but also during their individual work in the process of research at the centers of research and experimental activities.

The use of mobile Internet devices at a lesson at the stage of homework checking allows to diversify the forms of students' learning outcomes control. Thus, in addition to computer testing, Miracast wireless technology can be used for this purpose. This requires the owning of a smartphone, multimedia projector and Google Chromecast adapter. There is a great deal of educational content available on Google Play Market application of your smartphone, including programs for student' learning outcomes control. One of them is Plickers. This web server lets you survey your class at the lesson and conduct instant checks for understanding of the learned and current material in a test form.

To start working with it, it is necessary to download a free application Plickers to the teacher's smartphone. Then, in a separate application, prepare the tests and print a set of cards. One set of cards can be used for different classes. Each student is assigned a unique Plickers card that has a black and white image similar to a QR code. The

number of the card corresponds to each student (according to the list). Then you will need to take your smart device, choose the Plickers application.

Choose the class and necessary question from the list. The chosen on your mobile device question will be automatically displayed on the screen with the help of a projector. Using the scanner of your smartphone scan your students' cards and record their answers. Students should hold their cards so that the letter of the correct answer is located at the top. Colored highlighting helps quickly to find out how well the students answer the questions: grey marks the students who haven't answered yet, red means incorrect answers of students, and green stands for correct answers.

The use of smart technologies makes it possible to solve the following topical issues: use the latest IT in training; improve the skills of students' independent work in the Internet databases; improve the students' knowledge, skills and abilities; make the learning process more interesting and meaningful; develop creative potential; control through testing and a system of questions for self-control; increase the cognitive activity of students due to various video and audio information.

Smart Board is a touch screen, which allows you to manipulate anything on the screen using your fingers. It is connected to a computer. Multimedia projector, which is also a part of the board, transmits an image of the computer screen to the Smart Board. Smart Board acts as an interactive touch screen monitor for the computer. By touching the Smart Board, the user is able to click on buttons, highlight text and drop and drag items right from the Smart Board.

Smart Board helps the teacher to work with a variety of multimedia visual aids that allows you to display an object in a variety of ways. In the course of his work a biology teacher can use everything that the student is able to perceive clearly.

While working with the Smart Board, there is a rapid increase in the amount of visual information, which in its turn increases the quality and effectiveness of the lessons. Unique possibilities of Smart Board involve students in active cognitive activity and enhance their creative potential. There is a chance to work with a large amount of information at the lesson that creates the optimal conditions for students' individual research work in biology. Students work with computer models, during such work they can carry out experiments and check hypotheses.

During the work with the Smart Board a number of traditional didactic principles are being implemented: sequence, systematic character, scientific approach, visual training, students' activity and consciousness, connection of theory with practice, availability and duration of knowledge. The principles of visualization, availability and systematicity are realized through adding tables, video and audio materials, and analysis of materials of electronic textbooks during the explanation of new material. However, the interactive whiteboard is mostly used during the principle of visualization due to which you can present educational material in the form of schemes, dynamic algorithms or generalizing tables, which are a concise statement and a picture of the main conceptions of the material and its use at the lesson.

Our methodology involves the use of a website as a means of increasing the effectiveness of the learning process. Nowadays any teacher can create a website. There are hundreds of different website building platforms and website builders. You can get

either free or for the payment information-technological base and real resource in the form of electronic space, modules, templates, control systems.

Site pages can be simple static file sets or created by a special computer program on the server. It can be either custom-made for a specific site, or be a ready-made product designed for a specific class of sites. The structure of a website consists of two parts: internal and external. The internal part of the structure is represented by the headlines, sub sections, site sections, labels and other navigation elements. The external part of the structure of a website is a scheme of the content blocks, that is, how the header, the main content, the comment block, and other elements of the site are located. A well designed website layout, where convenient and interesting interface is combined with actual information is a very important point in the development of this resource and it is better perceived by users [14].

Having analyzed the functions and tasks of various websites, we chose the website builder Ucoz.ua. The appropriateness of this website builder choice is caused by the fact that it contains all the necessary components for creating namely a training website and allows to create multifunctional universal websites free of charge. It involves a sufficiently large number of educational category templates, with an appropriate interface, convenient ways to add and edit existing web pages, site management options from both the control panel and the admin panel that rejects force majeure during learning, because if you have problems with logging into the admin panel, the teacher will be able to manage the site through the control panel. This builder contains a specific, comprehensible control panel which requires registration and has a definite password used to log. It will protect the site against hacking, illegal spreading of information which is stored on it, as the website administrator has certain copyrights.

In the context of experimental learning we have developed a methodology for organizing a biology teaching process in a basic school using various mobile Internet devices. We used them variously at lessons of different types: at the introductory lesson, to activate the cognitive process and to report new knowledge; at the lesson of studying new material in order to expand and deepen the students' knowledge; at the generalizing lesson or for final control and correction of knowledge.

Mobile Internet devices were used at different stages of the lessons: at the stage of actualization basic knowledge: tests (Plickers), video clips (Smart Board), models of objects and phenomena (Smart Board); at the stage of learning activity motivation: coloured drawings, animated snippets, virtual biological experiments (Augmented Reality Dinosaurs – my ARgalaxy, Animal 4D+ application, website; at the stage of learning new material: photos, slideshows, animated plots (Anatomy 4D), interactive models (website), video clips (Smart Board); at the stage of summing up of the studied material: multiple-choice tests (Plickers), pictures, establishment of sequence of biological processes (Smart Board); at the stage of generalization and systematization of obtained knowledge: thematic control with automatic verification (Plickers), control – diagnostic tests (website).

They were also used in various forms of learning: during the class work and practical classes (website); during virtual excursions (Smart Board); during students' individual work and research (website); while doing students' homework (website, mobile applications).

Using a training website in biology learning process greatly facilitates student-teacher interaction. It is advisable to use a training website to prepare students for independent work on the tasks that the teacher places in advance in the suitable section on the website. At the lesson preceding the lesson of generalization and systematization of knowledge, the home assignment will be as follows: the students should refer to the website, the address of which is reported by the teacher, and in the section "Preparing for independent work" do the assigned tasks (there may be different variants). At the lesson of generalization and systematization of knowledge it is necessary to do the tasks placed on the site, or to use them as a plan for the survey of students. Thus, students can revise, generalize, systematize the obtained knowledge and fill in the gaps. By using the website in preparation for the students' independent work, we give them more time to prepare and diversify the process, which will then have a positive impact on the learning outcomes.

Using a website is also productive at the lesson that precedes practical work. Biology teaching involves performing such practical work that requires certain conditions that cannot be created in the classroom. For example, the curriculum contains practical work on the theme "Determining the threshold of auditory sensitivity" as a part of the topic "Sensory systems". For the fairness of the experiment and obtaining accurate results, it is better to ask students to carry out this practical work at home with the help of their parents, and to place the plan of work and instructions how to carry it out in the section "Practical work" on the website before conducting it and, to discuss the results at the stage of actualization knowledge at the next lesson.

It is convenient to place some research themes on this training website, as this will help students to prepare for students' conferences, because they will be able to get the theme at the beginning of the academic year and work on it throughout the year and after that to defend it at conferences.

The website can store all the theoretical information necessary for conducting lessons so that the student can access it at any time. This way of placement is convenient for students who were absent from the lesson, as they can independently study the material which was missed in the home environment.

The results of examination of the effectiveness of the proposed methodology of using mobile Internet devices in the process of biology studying, which are reflected in the change of students' knowledge quality of experimental classes (E) and control classes (C), are presented in the table 1.

Analyzing the data of table 1, we can see that the results of examination of the students' knowledge according to the indicator "completeness of knowledge" showed that the students of E classes mastered the material much better. 91,0% of the students of these classes gave correct complete answers. Whereas in C classes such answers were given only by 61,8% of students. 1,8% of the students of E classes and 5,5% of the students of C classes did not answer the questions. The students of E classes comprehend acquired knowledge better than the students of C classes. 87,7% and 33,6% of students answered correctly respectively. 10% of the students of C classes do not understand the difference in the ways of acquiring knowledge and means of their justification (indicator "awareness of knowledge").

544

Table 1. Results of examination of the students' knowledge quality of the program material in biology

Indicators of knowledge quality	Answer groups	Number of students, whose answers correspond to the arranged groups			
		Control classes		Experimental classes	
		Number of students	%	Number of students	%
Completeness	correct complete answer	136	61,8	303	91,0
	correct incomplete answer	72	32,7	24	7,3
	no correct answer	12	5,5	6	1,8
Awareness	correct answer	74	33,6	292	87,7
	incorrect answer	124	56,4	32	9,6
	no answer	22	10,0	9	2,7
Consistency and systematicity	correctly correlated concepts of different levels of generality	60	27,3	182	54,7
	one violation was made in the ratio of concepts	60	27,3	74	22,2
	two or more violations were made in the ratio of concepts	66	30,0	55	16,5
	no answer	34	15,4	22	6,6

The results according to the indicator "consistency and systematicity" showed that the quality of acquiring knowledge by the students of E classes is higher than that of the students of C classes. 54,7% of the students of E classes correlated correctly the notions of different levels of generality. In C classes, such answers constitute only 27.3%. The majority of the students in C classes (15.4%) compared to (6.6%) in E classes did not answer the question.

Thus, the comprehensive analysis of the results of the forming experiment allowed us to conclude that proposed by us methodology of using mobile Internet devices in the process of biology school course studying is effective. For greater reliability of the obtained conclusions, a statistical analysis of the results of the quality of students' mastering the knowledge in biology was carried out using the χ^2 criterion. It confirmed that to study using experimental methodology enhances the quality of students' mastering the knowledge in biology.

4   Conclusions and prospects for further research

Modern ICT allow to create a single information environment, the basis of which is integrated computer networks and communication systems, which gives an opportunity to accompany and coordinate educational processes. When introducing mobile Internet devices into the educational process in biology, the principle of reasonable conservatism and continuity must be observed. The computer cannot substitute a teacher in the process of teaching; it is only a means of broadening possibilities to

master new knowledge. The teacher always has to play the key role in any educational innovation.

The methodology of using mobile Internet devices in the process of biology studying in a basic school involves the use of the mobile applications, smart technologies and a website. It is relevantly to use free Android applications while studying biology in a basic school. They are as follows: Anatomy 4D, Animal 4D+, Augmented Reality Dinosaurs – my ARgalaxy, BioInc – Biomedical Plague, Plan+Net. Their choice is caused by the specifics of the object of biological cognition (life in all its manifestations) and the concept of bio(eco)centrism, which recognizes the life of any organism as the highest value. During homework checking it is advisable to use Miracast wireless technology besides computer control of students' learning outcomes. This demands the owning of a smartphone, a multimedia projector, and a Google Chromecast type adapter. It would be appropriate to use the website builder Ucoz.ua for creation of a training website in biology.

Based on the synthesis of the obtained data, recommendations for the use of a biology training website were developed: the use of the website should not be the only means of training; each lab work using a training website must be preceded by a mandatory introductory instruction; the information in the sections should be precisely matched to the relevant theme of the lesson; the answers to the questions for self-examination should be mandatory checked, either in the course of group activity at the lesson or individually, in order to trace the gaps in the knowledge of a particular student; take into account wishes of the students, because in order to enhance their academic performance, socialization and improvement, such a training website is created.

The educational process which involves the use of mobile Internet devices encourages the independent work of each student, creates a favorable communication situation and conditions for the development of creative abilities of the individual, which are especially important for each student; increases the motivation and cognitive activity of students, improves the individualization, differentiation and intensification of the learning process, broadens and deepens interdisciplinarary links, systematizes and integrates knowledge of certain subjects, organizes systematic and reliable control, avoids subjectivism in assessment.

Further studies need to be carried out in order to investigate the following problems: the impact of the use of mobile Internet devices on the formation of students' general competencies in the process of biology studying, the model of students' bioethical behaviour; preparing of future biology teachers to model educational activities using mobile Internet devices.

References

1. Doroshenko, Yu., Semeniuk, N., Semko, L.: Biolohiia ta ecolohiia z kompiuterom (Biology and ecology with a compiuter). Shkilnyi svit, Kyiv (2005)
2. Kanivets, O.V., Kanivets, I.M., Kononets, N.V., Gorda, T.M., Shmeltser, E.O.: Augmented reality mobile application developments for help to performance tasks from projection drawing. CEUR Workshop Proceedings **2547**, 262–273 (2020)
3. Kazhan, Yu.M., Hamaniuk, V.A., Amelina, S.M., Tarasenko, R.O., Tolmachev, S.T.: The

use of mobile applications and Web 2.0 interactive tools for students' German-language lexical competence improvement. In: Kiv, A.E., Shyshkina, M.P. (eds.) Proceedings of the 7th Workshop on Cloud Technologies in Education (CTE 2019), Kryvyi Rih, Ukraine, December 20, 2019, CEUR-WS.org, online (2020, in press)

4. Komarova, E., Starova, T.: Majority values of school biological education in the context of education for sustainable development. In: Semerikov, S., Chukharev, S., Sakhno, S., Striuk, A., Osadchyi, V., Solovieva, V., Vakaliuk, T., Nechypurenko, P., Bondarenko, O., Danylchuk, H. (eds.) The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). Kryvyi Rih, Ukraine, May 20-22, 2020. E3S Web of Conferences **166**, 10029 (2020). doi:10.1051/e3sconf/202016610029

5. Komarova, O.V., Azaryan, A.A.: Computer Simulation of Biological Processes at the High School. CEUR Workshop Proceedings **2257**, 24–32 (2018)

6. Matiash, N.Yu.: Pohliad na problemu kompiuteryzatsii navchalnoho protsesu (Look at the problem of computerization of education). Biolohiia ta khimiia 4, 55–56 (2004)

7. Mintii, I.S., Soloviev, V.N.: Augmented Reality: Ukrainian Present Business and Future Education. CEUR Workshop Proceedings **2257**, 227–231 (2018)

8. Mironets, L.P., Torianyk, V.M.: Vykorystannia suchasnykh informatsiynykh prystroiv pid chas kontroliu navchalnykh dosiahnen uchniv z biolohii (Use of modern information tools in the process of control of pupils' educational achievements in biology). Proc. New Ukrainian School: Theory and Practice of Integrated Approach Realization, 17–18 May 2018, Ternopil, pp. 95-98. Vektor, Ternopil (2018)

9. Modlo, Ye.O., Semerikov, S.O., Bondarevskyi, S.L., Tolmachev, S.T., Markova, O.M., Nechypurenko, P.P.: Methods of using mobile Internet devices in the formation of the general scientific component of bachelor in electromechanics competency in modeling of technical objects. CEUR Workshop Proceedings **2547**, 217–240 (2020)

10. Modlo, Ye.O., Semerikov, S.O., Nechypurenko, P.P., Bondarevskyi, S.L., Bondarevska, O.M., Tolmachev, S.T.: The use of mobile Internet devices in the formation of ICT component of bachelors in electromechanics competency in modeling of technical objects. CEUR Workshop Proceedings **2433**, 413–428 (2019)

11. Modlo, Ye.O., Semerikov, S.O., Shajda, R.P., Tolmachev, S.T., Markova, O.M., Nechypurenko, P.P., Selivanova, T.V.: Methods of using mobile Internet devices in the formation of the general professional component of bachelor in electromechanics competency in modeling of technical objects. In: Kiv, A.E., Shyshkina, M.P. (eds.) Proceedings of the 7th Workshop on Cloud Technologies in Education (CTE 2019), Kryvyi Rih, Ukraine, December 20, 2019, CEUR-WS.org, online (2020, in press)

12. Nevedomska, Ye.O.: Kompiuterni tekhnolohii pid chas navchannia biolohii (Computer technologies in the process of biology studying). Biolohiia ta khimiia v shkoli 4, 10–14 (2007)

13. Pavlenko, O.O., Bondar, O.Ye., Yon, B.G., Kwangoon, Ch., Tymchenko-Mikhailidi, N.S., Kassim, D.A.: The enhancement of a foreign language competence: free online resources, mobile apps, and other opportunities. CEUR Workshop Proceedings **2433**, 279–293 (2019)

14. Pirohov, V.M., Horlo, A.M., Mintii, I.S.: Software development of the algorithm of adaptating of the website design for people with color-blindness. CEUR Workshop Proceedings **2292**, 103–108 (2018)

15. Rassovytska, M.V., Striuk, A.M.: Mechanical Engineers' Training in Using Cloud and Mobile Services in Professional Activity. CEUR Workshop Proceedings **1844**, 348–359 (2017)

16. 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, pp. 188–242. Knyzhkove vydavnytstvo Kyreievskoho, Kryvyi Rih (2012)

17. Shcherbakov, A.H.: Kompiuterne testuvannia – vazhlyvyi metodychnyi instrument suchasnoho vchytelia (Computer testing is an important methodological tool of a contemporary teacher). Kompiuter u shkoli ta simi 4, 30–31 (2006)

18. Skatkin, M.N., Kraevskii, V.V. (eds.): Kachestvo znanii uchashchikhsia i puti ego sovershenstvovaniia (The quality of students' knowledge and ways to improve it). Pedagogika, Moscow (1978)

19. Stepaniuk, A.V.: Vykorystannia kompiuternykh zasobiv navchannia v metodychniy pidhotovtsi maibutnikh uchyteliv biolohii (The use of computer learning tools in methodological training of future biology teachers). Pedahohichnyi almanakh 12(1), 58–64 (2011)

20. Tkachuk, V., Semerikov, S., Yechkalo, Yu., Khotskina, S., Soloviev, V.: Selection of Mobile ICT for Learning Informatics of Future Professionals in Engineering Pedagogy. CEUR-WS.org, online (2020, in press)

21. Tkachuk, V., Yechkalo, Yu., Semerikov, S., Kislova, M., Khotskina, V.: Exploring Student Uses of Mobile Technologies in University Classrooms: Audience Response Systems and Development of Multimedia. CEUR-WS.org, online (2020, in press)

22. Tkachuk, V.V., Shchokin, V.P., Tron, V.V.: The Model of Use of Mobile Information and Communication Technologies in Learning Computer Sciences to Future Professionals in Engineering Pedagogy. CEUR Workshop Proceedings **2257**, 103–111 (2018)

23. Tsidylo, I.M., Tereshchuk, H.V., Kozibroda, S.V., Kravets, S.V., Savchyn, T.O., Naumuk, I.M., Kassim, D.A.: Methodology of designing computer ontology of subject discipline by future teachers-engineers. CEUR Workshop Proceedings **2433**, 217–231 (2019)

24. Zhylenko, T.I., Martynova, N.S., Shuda, I.A., Chykalov, Ye.A., Kuzmuk, D.A.: Auto Checker of Higher Mathematics – an element of mobile cloud education. In: Kiv, A.E., Shyshkina, M.P. (eds.) Proceedings of the 7th Workshop on Cloud Technologies in Education (CTE 2019), Kryvyi Rih, Ukraine, December 20, 2019, CEUR-WS.org, online (2020, in press)