

Digital transformation of learning environment: aspect of cognitive activity of students

Olga P. Pinchuk^[0000-0002-2770-0838], Oleksandra M. Sokolyuk^[0000-0002-5963-760X],
Oleksandr Yu. Burov^[0000-0003-0733-1120] and Mariya P. Shyshkina^[0000-0001-5569-2700]

Institute of Information Technologies and Learning Tools of NAES of Ukraine,
9, M. Berlynskoho Str., Kyiv, 04060, Ukraine
{opinchuk100, sokolyuk62}@gmail.com,
{ayb, shyshkina}@iitlt.gov.ua

Abstract. Peculiar features of digital environment include: integration of ICTs; use of local and global networks and resources; support and development of qualitatively new technologies of information processing; active use of modern means, methods and forms of teaching in the educational process. The organization of activities in terms of digital learning environment provides appropriate changes in the interaction between subjects of the educational process.

Today, means and technologies of the information and communication networks (ICNs), in particular the Internet, which custom and operational-procedural properties were changed at the initial stage from closed local to open ones at present, become widespread. The development of ICNs (from closed local to open ones) changes the typology of learning environments. The following models of learning environments, which widely use ICT and ICN tools (with basic features that characterize them) are distinguished: using the local communication network for presentation of educational information; using the local communication network and open network resources; using open network resources; for independent use of open network resources directly in the classroom by a student; for use of open network resources by a student in the process of independent learning activity; for use by a student educational resources, specially created by a teacher, as well as resources of an open networks in his independent learning activity.

Keywords: cognitive activity, learning, learning (academic) environment, digital transformation, competencies, ICT.

1 Introduction

According to experts in the field of Economics 4.0 and modern production [8], consumer trends as a reaction of progressive groups of society to social challenges, leading to changes in the culture of behaviour, in 2019 will increasingly focus on various aspects of consumer and technology interaction. A modern person watches changes in technology and is forced to adapt to them both at the workplace and in

everyday life. The most noticeable are: evolution of customer interface, integration of devices, provision of access to software products, services and resources in the cloud. The speed of life leads to the gradual replacement of human labor with bots or programs. Robotics in mass production, processing and use of large volumes of data, rapid updating of knowledge, availability of information and, at the same time, the difficulty of converting it into knowledge – these and other signs of the information age lead to the need to make self-education a necessary element of every person's life.

Technologies are crucial in routine problems solving. Internet of things should ensure compatibility between all devices and provide mobility. However, the experience of typical tasks solving does not help to find effective solutions. Progressive ideas are born in the man's learning process of the world at the intersection of disciplines. Consequently, in our opinion, in modern conditions, a person armed with skills of rapid adaptation, working with data, productive communication, which is characterized by flexibility of thinking, the ability to concentrate, analyse, make conclusions, is able to create its own product, is ahead.

Here are some examples that we think, illustrate the rapid growth rate of transition in all areas of human life to digital technologies:

The number of people on the planet using the Internet is rapidly increasing.

So, according to [29] over the past 5 years, this growth is 6–9% per year.

Moreover, according to results of long-term study of consumer trends of Ericsson, based on an online survey of 5097 primarily Internet users, almost half of the respondents in the survey think that, for better or worse, the Internet of skills (AR/VR experience [30]) has replaced many of the simple pleasures of daily life, and as many as 42% say the Internet needs to be changed fundamentally if it is going to be a force for good in society again. 60% would like glasses with on-screen instructions that help you repair almost anything, and 56% even want to learn how to dance using an instructive AR experience [8].

Growth is the tempo of digital communication between people. So, the number of e-mail accounts in the world is about 5 billion, mostly at the expense of private ones. As of January 2019, the number of Facebook users, one of the most popular electronic social networks, is 2.320 billion people and has been steadily increasing ever since. By the way, as of December 2018, already 30.95% of Ukrainians use a social network. According to the company “Vhaschno” (<https://vchasno.com.ua>), which provides business services in docflow, storage and exchange of documents online appeared to be 70% cheaper than paper ones.

For example, in Ukraine, the official participant of the public procurement system ZAKUPKI.PROM.UA sent 316,100 documents per year, saving UAH 5,057,400.

At the beginning of 2019 (according to the site populationpyramid.net), with a total population of about 7.678 billion people, we have the following (Fig. 1).

Technological changes in science, economics and society lead to social, political and cultural changes. These changes cause new problems, the solution of which takes time. Social systems unavoidably experience periods of economic decline and growth while educational systems go through reforms. Changes in education, among other things, cause some contradictions. The following should be identified:

1. At the level of *the global information space*: between innovative updates of information and communications technologies as well as networking technologies from one side and the slow reaction of the state and the educational system to these trends on the other side.
2. At the level of *the national educational system*: between the emergence of the latest technology, technology and the new generation of means for training, management and scientific research and late response of education managers to the choice, implementation and spread of innovation.
3. At the level of *the educational institution*: between the need to develop a modern educational environment and the conservatism of leaders and pedagogical staff in the period of innovation transformations.

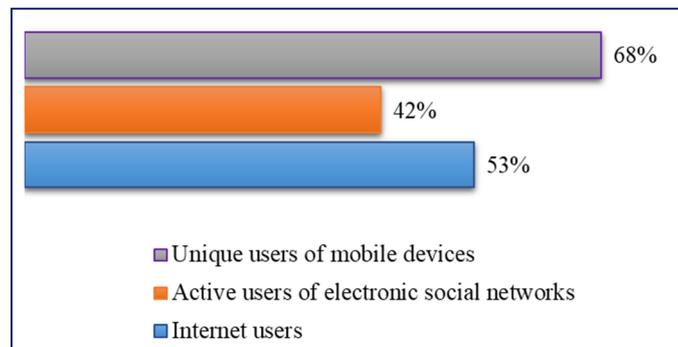


Fig. 1. The share of users from the total population by selected groups

The dynamics of factors' development of external and internal environment directly affects the development of the innovative capacity of educational institutions and its implementation in the educational process. This requires a substantial transformation of the education system based on:

- psychological, pedagogical and didactic principles of digital education;
- new approaches to the selection of educational content;
- principles of flexibility and adaptability of pedagogical systems;
- principles of equal opportunities for all parties of the educational process;
- new forms, methods, technologies and means of teaching and learning that are implemented in modern educational environments.

We have analysed demographic trends, namely of world (PopulationPyramid.net): proportion of so-called millennials (age from 20 to 40 years old) – the most productive population, teenagers and young people (from 10 to 19 years old) who will take jobs in a few years. Millennials make up 30% of the world's population. Despite some differences in distribution, in Ukraine, the proportion of the Millennials does not have any statistical difference (28.7%). The proportion of people aged 10–19 years to 16.1%. For Ukraine, this percentage is much lower – 9%. Among the features the Millennials obtain, psychologists mention: short-term concentration, pragmatic thinking,

intelligibility in information, orientation on trends and social networks, extra-territorial activity (want to act “here and now”).

The next generation will live and work under somewhat different conditions, including: high level of automation for production processes, job cuts, competition in design of things, machine intelligence and 5G networks, rapid loss of actuality of acquired skills, etc. Transformation of society, primarily, will be associated with the development of new technologies. Information and communication technologies change the nature of relations within society, including within the sphere of education. These technologies cause a lot of changes in the economic, political, social and cultural spheres and, as a result, form new requirements for the field of education, laying the foundations of its new architecture. These bases include the results of the MEP-revolution in education (Ronald M. Harden [4]); virtualization and gamemization of education (Elizabeth Corcoran [7], Jane McGonigal [12]); The new achievements of cognitive psychology (Robert L. Solso, M. Kimberly MacLin, Otto H. MacLin [28]) and the possibility of their use for the formation and development of cognitive skills and abilities.

Global Education Futures Initiative connects the development of new education practices with active use in the educational process:

- unique approaches and access to carriers of key competencies;
- modern educational, in particular a digital, environment that supports the whole education / learning process, as well as the development of courses, interaction with communities, etc.;
- individual educational trajectory of each student (with possibility of full asynchronous education, with combination of educational process and extracurricular activities, with tutoring of this trajectory by mentors);
- flexible assessment system focused on supporting student’s motivation;
- resources (students and teachers) for individual and group learning experiments;
- flexible architecture of educational institutions, which allows to realize a large number of educational formats for independent and group activities of students;
- horizontal education in communities, including the use of electronic networks;
- joint learning processes with real-life carriers.

Due to widespread use of mobile devices with access to the Internet there are changes in the organization of training. The boundaries between formal and informal education become less clear.

2 Related work

In previous studies, we analysed and compared new technologies, educational models, their impact on formation of learning environments, that are increasingly used in general education institutions, allowing us to address the issue of expanding student access to learning resources, and expanding opportunities for collaboration and cooperation [27]. In order to organise approaches to formation of learning environment in which ICTs and the Internet are actively used, a comparative analysis of different

models of learning environments has been conducted on the main features that characterize these models [17].

Problems of use of network technologies for conducting educational studies on natural sciences course in general secondary educational establishments, formation of system of knowledge by means of network technologies are studied [32].

Problems of projecting of informational and educational environment for the education of high school students on the basis of technologies of electronic social networks are investigated. The possibilities of using information and communication technologies and technologies of electronic social networks in the system of general secondary education are revealed [26]. The scientific and methodological foundations of formation of subject competences taking into account the basic principles of practical and personally oriented learning are proved. Forms and methods of studying which promote increase of formation level of pupils' subject competence are elicited [18]. The problems of increasing information and communication competence of all participants of the educational process are looked into. Possible changes in the teaching method, when new objects appear in the system of learning tools – services of electronic social networks, are analysed. It is paid attention to change of emphasis from communication network to organization of productive discussion and collaboration with cooperative learning methods for students [16], [19].

The authors of the article revealed results of research on solving the current psychological and pedagogical problems of designing information and educational environment, different models of using electronic social networks in teaching senior students, development of certain elements of computer-oriented methodological systems, evaluation of educational process results in the open information and educational environment of training students and the critical problem of users' safety on the Internet, the formation and development of information and communication competencies of all participants of the educational process. A number of methods, related to: the formation of safe and responsible use of social networks and critical evaluation of Internet content; using electronic social networks to provide group interaction; organization of independent work of pupils (on an example of physics) and design and research activity of students (on an example of mathematics); prediction of aggressive behaviour of pupils; support for the education of disable children; the organization of informal education of youth are suggested. Much attention is paid to changing the emphasis from network communication to productive discussions creation, as well as from collaboration to cooperative learning methods [20].

3 Research methodology

Currently, the Cabinet of Ministers of Ukraine approved the Concept of development of digital economy and society in Ukraine in 2018–2020 [5]. In fact, this is a roadmap for digital transformation of Ukrainian economy. The document defines key policies, priority areas, initiatives and projects of “digitalization” of Ukraine for the next 3 years. In particular, this is “digitization of educational processes and stimulation of digital transformations in the education system”.

The release of revised wording of key competencies for lifelong education coincided with the adoption of the Concept [10]. Mathematical competence and competence in science, technology and engineering (mathematical competence and competence in science, technology and engineering) and digital competence are determined as key. [9].

The formation of above key competencies is possible on the basis of modern educational technologies using ICT tools, electronic educational resources, electronic social networks, which allow to reduce the educational load and simultaneously to intensify the educational process, in particular, from natural and mathematical disciplines, providing learning and cognitive activity with creative, research orientation.

Furthermore, opportunities for individualization and differentiation of training increase, opportunities for self-education skills form, metasubject and subject skills, ability to put the knowledge into practice through the wide introduction into the interactive process of studying individual work of students are developed.

The means and technologies of the ICN, including the Internet, forming a computer-technological platform of educational, in particular learning environment of modern education, primarily open, transform the traditional educational environment into “an environment of computer-mediated communication – an integrated education and information environment with distributed educational resources and a communicative infrastructure of supporting educational communities of different types” [23].

It is understood that a considerable part of the didactically grounded and specially organized educational and cognitive activity of students is carried out on the Internet, has specific features [22], transforming into a modern form of training due to a number of factors:

1. The Internet is a network of information environment of modern society, and its role as a source of scientific and educational information is obvious.
2. A new generation of students takes the Internet not just as a social cultural phenomenon of our time, as well as parallel, often leading environment. Any activity in such environment, including an independent educational and cognitive, is taken by a young person with an interest, that increases the motivation for this type of activity. The Internet is becoming an informational environment for training and self-education.
3. Internet environment as an informational and informational and educational environment has a significant potential for self-development of the individual.
4. Thanks to its unique properties (virtuality, turnover of operations, plurality of spaces, etc.), the Internet creates a comfortable environment of life that completes the internal and external space of an individual, and can act as a space of experiment.

From the didactic point of view, the logic of the learning process also changes. The traditional structure of learning process consists of the following steps: “getting information – understanding – memorization – reproduction – application (mostly by model)”.

The modern structure is different: “getting information – understanding – application (creative) – analysis – evaluation – creation”. It is this logic and structure of the process

of educational and cognitive activity that underlies the system-activity and competence approaches and ensures dynamic activity of students.

Having agreed with the researchers [25], [2] we define cognitive activity as an element of the holistic process of learning, which is a purposeful, systematically organized, managed external or independent interaction of a student with the surrounding reality, which results in mastering, on the level of reproduction or creativity, a system of scientific knowledge and ways of activity.

Cognitive activity is carried out throughout the life of a person, in all types of activities and social relationships, in particular, when students perform various subject-practical actions in educational process. However, only in the process of learning the cognition gets a clear form in a special, particular only for person, educational and cognitive activity.

Basic components of cognitive activity:

- content (knowledge, expressed in concepts or images of perception and conceptualisation);
- operational (various actions, operation of skills, techniques);
- resultative (new knowledge, methods of decision making, new social experience, ideas, views, abilities and personal features).

The main types of educational and cognitive activity of students in the Internet-oriented informational and educational environment include: search activity; practical development of new technologies; creating new content; Internet communication for cognitive purposes; learning using Internet resources.

Forms of educational and cognitive activity in the informational and educational environment are determined by the organization and / or self-organization of information and communication interaction and informative and cognitive activity of students. Formation and sustainable development of cognitive abilities of a person throughout his life is an indispensable element of any educational process.

4 Results and discussion

From the perspective of the revised Bloom's taxonomy [1], during the study we systematized the types of educational and cognitive activity of students [17] in the Internet environment in accordance with the categories of cognitive processes (Table 1).

Criteria, levels and other indicators of productivity of educational and cognitive activity in modern conditions are determined by the new paradigm of education of the information society. All the tools that make it possible to evaluate and control educational and cognitive activity get disturbed. The combination of information and communication technologies and means of communication networks form new solutions that can affect the basic processes in the educational system: the formation and development of competencies, fixing achievements, assessing the quality of learning, creating a positive motivation and promoting self-dependence in educational

and cognitive activities. On the basis of such technologies, new educational instruments are offered [11].

Table 1. Types of educational and cognitive activity

Cognitive processes	Educational and cognitive activity of students in the Internet environment
Remember	Research activity with use of Internet resources: <i>identification;</i> <i>recognition.</i>
Comprehend	Mastering of new technologies: <i>mastering communication technologies based on non-verbal forms of communication;</i> <i>feedback on the results of the activity.</i>
Apply	Practical use Internet resources: <i>work with different sources of information;</i> <i>independent study of new material;</i> <i>training and testing process learning.</i>
Analyze	Development of critical thinking: <i>self-control and self-correction;</i> <i>formation of skills of classification.</i>
Evaluate	Internet communication for cognitive purposes: <i>feedback in the process of peer assessment;</i> <i>ranking;</i> <i>verification; reviewing.</i>
Design	Creating of new content: <i>publication;</i> <i>formation of a portfolio;</i> <i>production of a new solution;</i> <i>implementation of a new process.</i>

The effectiveness of educational and cognitive activity of students is determined by the new paradigm of education of the information society. It recognizes all the tools that make it possible to carry out the educational and cognitive activity of the students, its evaluation and control.

- *Translation of reference experience or practice* – transfer of verbal knowledge (or self-studying), the transfer of non-verbal knowledge through communication with the carrier, the transfer of non-verbal knowledge through training skills. The tools include online multimedia libraries, multi-user online courses, e-books, YouTube educational channels [6], subject blogs [21], virtual mentors, simulators [14], virtual simulators [13], and robot-mentors.
- *Independent getting of experience* through testing, research / experiment implementation, creative individual or group project. They are implemented in gaming environments, quests, in alternate reality, work-competitions, virtual laboratories [15], discussion scientific communities, social networks, and others.

- *Fixation and assessment of students' learning achievements* – testing, prognosis of educational trajectory based on the profile of achievements [3], end-to-end continuous monitoring (in particular, monitoring behaviour in the game forms within the alternate reality).
- *Tools*: personal competency profile, personal virtual portfolio, creation and stress test of the virtual world or digital model.
- *Encouragement and motivation* of students for educational activities is carried out through: competitive gaming models (gamification), reputational capital management system, preventive outcome management (achievement prognosing systems), gaming adaptive models [24], state monitoring systems (which control the quality of experiences in the educational process).

5 Concluding remarks and future work

The transformation of modern society and education, particularly related to the development of new technologies, especially information and communications and networking. The digital transformation of education covers the creation of a modern computer-based environment that supports learning and self-education, creation of a system of informational and educational and game resources, flexible structure of educational institutions, which allows to fulfil a large number of educational formats and supports the advancement of students with individual educational trajectories, development of mechanisms of education in communities, including the use of electronic networks, formation of unique approaches to formation of key competencies, in particular digital one.

Formation of key competencies for lifelong education, including mathematical competence and competence in science, technology and engineering, is possible on the basis of modern educational technologies using ICT tools, electronic educational resources, electronic social networks, which allow to reduce the training load and, at the same time, to intensify the training the process, in particular, from science and mathematic disciplines, providing educational and cognitive activities with creative, research orientation.

The Internet environment as an informational as well as informational and educational environment has a significant potential for self-development of a personality due to peculiarities such as virtuality, turnover of operations, plurality of spaces, etc. It creates a comfortable environment for cognitive activity and can act as a space for an educational experiment.

The main types of educational and cognitive activity of students in the Internet-oriented informational and educational environment include: search activity; practical development of new technologies; creating new content; Internet communication for cognitive purposes; use of Internet resource for educational purposes.

From the perspective of the revised Bloom's taxonomy, during the study we systematized the types of educational and cognitive activity of students in the Internet environment in accordance with the categories of cognitive processes: remember, comprehend, apply, analyse, evaluate, design.

The revolution in digital content complicates separation of academically meaningful, scientifically grounded, truthful from false and, at times, dangerous. Individual training extends to new features. At the same time, the essence of the educational process and its quality survive little changes. According to the authors, there are approaches to change this state, in particular, learning related to real life; training in projects; free choice of training tools; reflection and a two-way evaluation of the result (for example, parents and teachers, teachers and students). We consider further research in solving the problems of using digital simulations in the educational and cognitive activity of students to be relevant.

References

1. Anderson, L.W. (ed.), Krathwohl, D.R. (ed.), Airasian, P.W., Cruikshank, K.A., Mayer, R.E., Pintrich, P.R., Raths, J., Wittrock, M.C.: *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. Addison Wesley Longman, New York (2000)
2. Belikov, V.A., Romanov, P.Iu.: *Osnovy uchebno-poznavatelnoi deiatelnosti studentov kolledzha: metodicheskie sovery obuchaiushchimsia po formirovaniuu bazovykh uchebnykh umenii (Fundamentals of educational and cognitive activities of college students: methodological advice for students on the formation of basic educational skills)*. INFRA-M, Moscow (2019)
3. Bilousova, L., Kolgatin, O., Kolgatina, L.: *Pedagogical Diagnostics with Use of Computer Technologies*. In: Ermolayev, V., Mayr, H.C., Nikitchenko, M., Spivakovsky, A., Zholtkevych, G., Zavileysky, M., Kravtsov, H., Kobets, V., Peschanenko, V. (eds.) *Proceedings of the 9th International Conference on ICT in Education, Research and Industrial Applications: Integration, Harmonization and Knowledge Transfer*, Kherson, Ukraine, June 19-22, 2013. *CEUR Workshop Proceedings* **1000**, 209–220. <http://ceur-ws.org/Vol-1000/ICTERI-2013-p-209-220.pdf> (2013). Accessed 21 Nov 2018
4. Bin Abdulrahman, K.A., Mennin, S., Harden, R.M., Kennedy, C.: *Routledge International Handbook of Medical Education*. Routledge, New York (2016)
5. Cabinet of Ministers of Ukraine: *Pro skhvalennia Kontseptsii rozvytku tsyfrovoy ekonomiky ta suspilstva Ukrainy na 2018–2020 roky ta zatverdzhennia planu zakhodiv shchodo yii realizatsii (On Approval of the Concept for the Development of the Digital Economy and Society of Ukraine for 2018–2020)*. <https://www.kmu.gov.ua/ua/npas/proshvalennya-koncepciyi-rozvitku-cifrovoyi-ekonomiki-ta-suspilstva-ukrayini-na-20182020-roki-ta-zatverdzhennya-planu-zahodiv-shodo-yiyi-realizaciyi> (2018). Accessed 11 Feb 2018
6. Chorna, O.V., Hamaniuk, V.A., Uchitel, A.D.: *Use of YouTube on lessons of practical course of German language as the first and second language at the pedagogical university*. In: *CEUR Workshop Proceedings (CEUR-WS.org)* (2019, in press)
7. Corcoran E.: *Gaming education*. Radar. <http://radar.oreilly.com/2010/10/gaming-education.html> (2010). Accessed 17 Aug 2019
8. Ericsson ConsumerLab: *10 Hot Consumer Trends 2019*. <https://www.ericsson.com/en/trends-and-insights/consumerlab/consumer-insights/reports/10-hot-consumer-trends-2019> (2018). Accessed 31 Dec 2018
9. European Commission: *Annex to the Proposal for a Council Recommendation on Key Competences for Lifelong Learning*.

- <https://ec.europa.eu/education/sites/education/files/annex-recommendation-key-competences-lifelong-learning.pdf> (2018). Accessed 11 Feb 2018
10. European Commission: Proposal for a Council recommendation on Key Competences for Lifelong Learning. <https://ec.europa.eu/education/sites/education/files/recommendation-key-competences-lifelong-learning.pdf> (2018). Accessed 11 Feb 2018
 11. Luksha, P.: Global Education Futures Agenda, 2013. [http://www.globaledufutures.org/images/people/Global%20Education%20Futures%20Agenda%20\(2014\)-ilovepdf-compressed.pdf](http://www.globaledufutures.org/images/people/Global%20Education%20Futures%20Agenda%20(2014)-ilovepdf-compressed.pdf) (2014). Accessed 11 Feb 2018
 12. McGonigal, J.: *Reality is Broken: Why Games Make Us Better and How They Can Change the World*. Penguin Books, New York (2011)
 13. Modlo, Ye.O., Semerikov, S.O., Nechypurenko, P.P., Bondarevskiy, S.L., Bondarevska, O.M., Tolmachev, S.T.: The use of mobile Internet devices in the formation of ICT component of bachelors in electromechanics competency in modeling of technical objects. In: CEUR Workshop Proceedings (CEUR-WS.org) (2019, in press)
 14. Modlo, Ye.O., Semerikov, S.O.: Xcos on Web as a promising learning tool for Bachelor's of Electromechanics modeling of technical objects. In: Semerikov, S.O., Shyshkina, M.P. (eds.) Proceedings of the 5th Workshop on Cloud Technologies in Education (CTE 2017), Kryvyi Rih, Ukraine, April 28, 2017. CEUR Workshop Proceedings **2168**, 34–41. <http://ceur-ws.org/Vol-2168/paper6.pdf> (2018). Accessed 21 Oct 2018
 15. 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.) 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 **1844**, 319–326. <http://ceur-ws.org/Vol-1844/10000319.pdf> (2017). Accessed 21 Oct 2018
 16. Pinchuk, O.: Perspective analysis of use of electronic social networks in learning environment. In: Ermolayev, V., Spivakovsky, A., Nikitchenko, M., Ginige, A., Mayr, H.C., Plexousakis, D., Zholtkevych, G., Burov, O., Kharchenko, V., Kobets, V. (eds.) Proceedings of the 12th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer, Kyiv, Ukraine, June 21-24, 2016. CEUR Workshop Proceedings **1614**, 680–686. http://ceur-ws.org/Vol-1614/paper_54.pdf (2016). Accessed 11 February 2018
 17. Pinchuk, O.P., Sokolyuk, O.M.: Indyvidualizatsiia navchalnoho seredovyscha uchnia zasobamy Internet (Individualization of the student's learning environment by means of the Internet). *Zb. nauk. prats Kamianets-Podilskoho natsionalnoho un-tu. Seriiia pedahohichna* 19, 35–37 (2013)
 18. Pinchuk, O.P.: Formuvannia predmetnykh kompetentnosti uchniv osnovnoi shkoly v protsesi navchannia fizyky zasobamy multymediinykh tekhnolohii (Formation of subject competencies of primary school students in the process of teaching physics through multimedia technologies), Dissertation, National Pedagogical Dragomanov University (2010)
 19. Pinchuk, O.P.: Perspective analysis of use of social networks as learning tools in learning environment. *Information Technologies and Learning Tools* 54(4), 83–98 (2016). doi:10.33407/itlt.v54i4.1482
 20. Pinchuk, O.P.: Zvit pro vykonannia naukovo-doslidnoi roboty “Formuvannia informatsiino-osvitnoho seredovyscha navchannia starshoklasnykiv na osnovi tekhnolohii elektronnykh sotsialnykh merezh” (ostatochnyi) (Report on the implementation of the research work “Developing of information and educational learning environment of senior

- students' training on the base of e-social networks" (final)). IITZN NAPN Ukrainy, Kyiv. <http://lib.iitta.gov.ua/709868/> (2017). Accessed 11 Feb 2018
21. Prykhodko, A.M., Rezvan, O.O., Volkova, N.P., Tolmachev, S.T.: Use of Web 2.0 technology tool – educational blog – in the system of foreign language teaching. In: CEUR Workshop Proceedings (CEUR-WS.org) (2019, in press)
 22. Raitckaia, L.K.: Optimizatsiia uchebno-poznavatelnoi deiatelnosti studentov v Internetserede (Optimization of educational and cognitive activity of students in the Internet environment). *Vestnik MGIMO-universiteta* 1(28), 18–21 (2013)
 23. Rozina, I.N.: Pedagogicheskaia kompiuterno-oposredovannaia kommunikatsiia kak prikladnaia oblast komunikativnykh issledovani (Pedagogical computer-mediated communication as an applied area of commutative research). *Obrazovatelnye tekhnologii i obshchestvo* 8(2), 257–264 (2005)
 24. Shapovalova, N., Rybalchenko, O., Dotsenko, I., Bilashenko, S., Striuk, A., Saitgareev, L.: Adaptive Testing Model as the Method of Quality Knowledge Control Individualizing. In: Ermolayev, V., Mallet, F., Yakovyna, V., Kharchenko, V., Kobets, V., Kornilowicz, A., Kravtsov, H., Nikitchenko, M., Semerikov, S., Spivakovsky, A. (eds.) Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2019), Kherson, Ukraine, June 12-15 2019, vol. II: Workshops. CEUR Workshop Proceedings **2393**, 984–999. http://ceur-ws.org/Vol-2393/paper_328.pdf (2019). Accessed 30 Jun 2019
 25. Slastenin, V.A., Kashirin, V.P.: *Psikhologiya i pedagogika (Psychology and pedagogy)*. Akademiia, Moscow (2010)
 26. Sokolyuk, O.M.: Inclusion of social networking services in the existing model of organization of students' learning. *Information Technologies and Learning Tools* **55**(5), 55–66 (2016). doi:10.33407/itlt.v55i5.1494
 27. Sokolyuk, O.M.: *Informatsiino-osvitnie seredovyshe navchannia v umovakh transformatsii osvity (Information and educational environment in the conditions of transformation of education)*, Naukovi zapysky. Seriya: Problemy metodyky fizyko-matematychnoi i tekhnolohichnoi osvity 12(3), 48–55 (2017)
 28. Solso, R.L., MacLin, M.K., MacLin, O.H.: *Cognitive psychology (7th ed.)*. Pearson Education New Zealand, Auckland (2005)
 29. Statista: Global digital population as of July 2019 (in millions). <https://www.statista.com/statistics/617136/digital-population-worldwide> (2019). Accessed 17 Aug 2019
 30. Syrovatskyi, O.V., Semerikov, S.O., Modlo, Ye.O., Yechkalo, Yu.V., Zelinska, S.O.: Augmented reality software design for educational purposes. In: Kiv, A.E., Semerikov, S.O., Soloviev, V.N., Striuk, A.M. (eds.) Proceedings of the 1st Student Workshop on Computer Science & Software Engineering (CS&SE@SW 2018), Kryvyi Rih, Ukraine, November 30, 2018. CEUR Workshop Proceedings **2292**, 193–225. <http://ceur-ws.org/Vol-2292/paper20.pdf> (2018). Accessed 31 Dec 2018
 31. Tokarieva, A.V., Volkova, N.P., Harkusha, I.V., Soloviev, V.N.: Educational digital games: models and implementation. In: CEUR Workshop Proceedings (CEUR-WS.org) (2019, in press)
 32. Zhuk, Yu.O. (ed.), Sokoliuk, O.M., Dementiivska, N.P., Sokolova, I.V.: *Internet-orientovani pedahohichni tekhnolohii u shkilmomu navchalnomu eksperymenti (Internet Oriented Educational Technologies in School Teaching Experiment)*. Atika, Kyiv (2014)