RESEARCH ARTICLE

European Journal of Education and Pedagogy
www.ej-edu.org

Approaches to Develop Digital Competences to Create a Portrait of the Graduate of the Future

Irina P. Menshikova, Petr I. Beloborodov, Irina N. Primakova,
Alexey V. Glazyrin, Dmitriy V. Teplov, and Kseniya V. Shipareva

ABSTRACT

The purpose of this article **is to analyze pedagogical technologies that are used to develop digital competencies and digital literacy in primary, middle, and high schools.** ***Analysis of the problem field of research*** **shows that increasing modernization of the industry associated with the processes of digitalization and automatization of technological lines to significant changes in the labor market, as well as adjustments in the portraits of graduates of both schools and higher education institutions. Transformation to an information and digital society causes other ways of presenting information as well as an emphasis on the development of relevant universal competences: critical and analytical types of thinking; ability to work and systematize large volumes of information; leadership skills, as well as the basics of time-management for organizing and planning independent work.** ***The novelty of the work*** **lies in the description of the real experience of modernization of the educational process in the private educational organization "Funscool", evaluation of the advantages and disadvantages of applied technologies compared to similar examples in secondary education in Russia or Europe, USA. At the same time, the analysis was carried out both for real-time and distance learning formats.** ***Research methodology and methods*****: in writing the article methods of induction and deduction, methods of comparative analysis and synthesis of information were used, the analysis of various forms of questionnaire survey was carried out.**

Keywords: digitalization, digital literacy, digital economy, pedagogical technologies.

Published Online: January 25, 2023

ISSN: 2736-4534

DOI:10.24018/ejedu.2023.4.1.541

Irina P. Menshikova*
Educational group "Funscool", Director of the structural division "Funscool Burdenko", Russia
(e-mail: ira.menshikova@gmail.com)

Petr I. Beloborodov
Educational group "Funscool", structural division "Funscool Burdenko", teacher of Physics, Russia
(e-mail: belpetigoo@mail.ru)

Irina N. Primakova
Educational group "Funscool", structural division "Funscool Burdenko", teacher of Mathematics, Russia
(e-mail: irapri@yandex.ru)

Alexey V. Glazyrin
Educational group "Funscool", structural division "Funscool Burdenko", teacher of IT and programming, Russia
(e-mail: aglazyrin93@yandex.ru)

Dmitriy V. Teplov
Educational group "Funscool", structural division "Funscool Burdenko", English teacher, Russia
(e-mail: d.teplov86@gmail.com)

Kseniya V. Shipareva
Founder of the educational group "Funscool", Russia
(e-mail: kseniyashipareva@gmail.com)

****Corresponding Author***

I. INTRODUCTION

The modern world is often viewed in terms of complexity. In the past the term vuca-world (volatile/uncertain/complex / ambiguous) was used. Recently a new abbreviation banni (brittle/anxious/non-linear/incomprehensible) has begun to be used. Global changes in the field of industry are connected with the process of automatization and digitalization of technological lines (Konanchuk, 2013; Roux, 2018). It has become obvious that specialists who will be in demand in the labor market in 10–15 years should have developed digital competencies. Nowadays a lot of government programs all over the world are aimed at the implementation of digital technologies in the economy and social spheres: for example, many efforts have been spent for modernization of the educational programs in high school and higher education by the course "Artificial Intelligence" (Toichkin, 2019; Vaseyskaya, 2018).

The purpose of this article is to analyze pedagogical technologies that can be used to develop digital competencies (Konanchuk, 2013; Roux, 2018; Toichkin, 2019; Vaseyskaya, 2018).

Analysis of the problem field of research aims to systematize stages of modernization of the educational process in primary, middle and high schools, which take place during transformation to distance learning or blended (hybrid) learning formats, as well as the integration of interactive learning formats for the development of digital competences.

A. Research Methodology and Methods

A comparative analysis of literature and educational programs has been conducted. Such methods have been used as: comparative analysis of the problem of forming digital literacy, as well as methods of survey and pedagogical observation.

II. Results and Discussion

The development of digital literacy has recently been noted among the key tasks in the educational process. By digital literacy we mean a basic set of knowledge, skills, and attitudes, which allows a person to effectively solve problems in the digital environment (Konanchuk, 2013; Roux, 2018; Toichkin, 2019; Vaseyskaya, 2018). At the same time, digital literacy contains some significant digital components, which manifest themselves in the development of relevant types of digital competencies.

The current list of digital competencies is specified in many government laws all over the world (and also in Russia). It includes five key competencies of the digital economy:

1) Communication and cooperation in a digital environment.
2) Self-development under conditions of uncertainty.
3) Creative thinking.
4) Information and data management.
5) Critical thinking in a digital environment (Arhipova, 2022).

Among the different models of digital competencies, we can distinguish 3 main ones:

1) *Digital Competences model* (DigComp 2.0) (Vuorikari, 2016).
2) *UNESCO digital skills model* (Stiven, 2020);
3) *Basic model of digital economy competences* (Berntzen, 2001).

A. Model of the Digital Competences 2.0

One of the most cited models is the DigComp 2.0 model of digital competencies (Vuorikari, 2016), which provides a typology of digital competencies depending on the type of tasks to be performed:

1) Information literacy (example of competencies: searching for relevant information and comparing it).
2) Computer literacy (example of competencies: using a computer and similar devices).
3) Media literacy (example of competencies: searching for news and fact-checking).
4) Communicative literacy (example of competencies: using modern means of communication).
5) Technological innovation (example of competencies: working with gadgets and applications).

B. UNESCO Digital Skills Model

According to UNESCO Digital Skills Model, digital skills or competencies can be divided into several subclasses (Berntzen, 2001):

Functional digital skills (or user skills), which allow users to access and perform basic operations. User skills include basic and psychomotor skills. Examples of basic skills include the ability to operate various technical devices, files, Internet, online services, and applications. Among psychomotor there are such skills as: the ability to type on keyboard, work with touch screens.

Among higher-level skills, *vocational skills* are highlighted, which means using digital technology for empowerment and transformation, such as software development.

In addition to skills, digital competencies include awareness and attitudes toward the use of technology.

C. Basic Model of Key Competencies of the Digital Economy

Basic model of digital economy competences is a system of identification, fixing, systematization, storage, and actualization of information about the key competences of the digital economy, including a generally accepted language of their description and mechanisms of coordination (data exchange protocols) between different models. Basic Model of Digital Economy Competences establishes a unified structure of key and professional competencies based on the general theory of activity: values-target (subject)-action (Berntzen, 2001).

The list of key competencies is established based on the analysis of activity structure in the complex digital world.

The list of key competencies of the digital economy:

1) Communication and cooperation in the digital environment.
2) Self-development under uncertainty.
3) Creative thinking.
4) Information and data management.
5) Critical thinking in a digital environment.

Only 27% of Russians have a high level of digital literacy (NAFI) (Berntzen, 2001). Obviously, digital literacy needs to be developed both in higher education and schools. Still there is a question: how the educational process should be modernized, and which types of pedagogical technologies can be used for this purpose.

Concerning the question of integrating digital technologies into the educational process, artificial intelligence (AI) seems to be the most promising direction. The ability of AI to make connections between disparate data sources will help students identify areas in which they need real-time consultation or additional assistance. As a result, AI allows developing an individualized educational track for each pupil based on his or her strengths, weaknesses, abilities, and the results of assigned tasks. Predictive analytics and machine learning also have significant potential for developing social and emotional skills essential for learning process, as they allow teachers to personalize the learning process by analyzing both qualitative and quantitative data to assist pupils in developing these skills (Stiven, 2020; Berntzen, 2001).

Despite the potential of AI, some serious challenges should be taken into account, especially with regard to equality of opportunity, such as access to the Internet and the ability to share data. Today, about 43% of the world's population does not have access to the Internet. Moreover, some AI programs may violate human rights. Of great importance when integrating AI into the educational process are the issues of safety of using AI mechanisms, taking into account ethical aspects, which are now actively discussed in most countries (Stiven, 2020; Berntzen, 2001).

Artificial intelligence will play an important role in solving another serious problem faced by specialists in the field of educational technology: the implementation of personalized knowledge assessment. Taking into account Bloom diagram, nowadays most forms of formative and summative assessments focus on testing knowledge, understanding information; a smaller number on the ability to analyze information and apply it to solve problem cases, and single examples of forms focus on the ability to synthesize information and design an experiment or investigation. Moreover, most of the existing assessment forms do not take into account the possibility to quantify the level of development of universal and professional competencies, which makes it difficult to draw a portrait of a graduate.

If we consider the experience of modernization of the educational process in Europe and U.S.A, the innovative approach as BYORD - bring your own device - has been recently applied in companies and institutions. Initially, this approach involves changing the local regulations of companies and educational organizations and implies the possibility of using software by employees and students on personal computers (Berntzen, 2001).

The second characteristic feature of the digitalization of the educational process in middle and high schools in Europe and USA is the active development of cloud storage and LMS-systems (learning management system). LMS-systems can be used both to organize the educational process (development of curriculum, programs of disciplines, the system of evaluation or analysis of students' works), and to regulate the processes of financial and logistical equipment of the organization (audit, payroll, equipment procurement, etc.) (Fjeldly, 2000). Quite a large emphasis has recently been made on the development of virtual communities-clubs of interests and hobbies among students; various chat rooms and platforms to keep parents informed or create alumni (Fjeldly, 2002; Soldatova, 2014).

The third feature is the launch of network programs in distance or blended (hybrid) learning formats (Berntzen, 2001; Fjeldly, 2000; Fjeldly, 2002; Soldatova, 2014). Many students have the opportunity to be trained with the involvement of staff from other schools or universities, as well as scientific educational organizations (Basharina, 2020). As an alternative, the possibility of re-crediting the educational results of massive open online courses (MOOC)-is being considered.

Much work has been done to develop software for the development of remote laboratories, which would allow us to connect remotely to certain types of equipment and conduct research. As an example, LabsLand remote laboratory has equipment in Spain, Brazil, and Australia. Schools can enter into cooperation and conduct research, which allows the development of real practical skills of pupils (Basharina, 2020).

Using the experience obtained in the private school FunsCool we'd like to analyze the pedagogical technologies applied for the development of digital competences. FunsCool educational model integrates a competency-based approach, which takes into account 3 types of competencies:

1) *Hard Skills*-those professional competencies and fundamental knowledge that will later be applied in the chosen professional sphere.
2) *Soft skills*-universal ("flexible") competencies required in any professional spheres and connected with the development of communication skills, leadership and teamwork skills (ability for collaboration)
3) as well as *Digital Skills*-a new type of digital competencies, which include both knowledge in the field of computer literacy and the ability to use appropriate digital tools.

In the direction of the development of digital competencies (Digital skills) systematic work is carried out both in primary, middle and high schools. The formation of digital literacy is laid down in the classes of computer science and mathematics, as well as algebra and geometry, depending on the age group of pupils. Due to the capabilities of digital educational content (DEC), which is a unified database of materials and courses from leading educational online services, lesson materials methodologically complement each other (Kuzminov, 2020). For example, the simultaneous use of multiplatform software for dynamic mathematics GeoGebra and a library of electronic educational materials 1C: Lesson allows for the development of imaginative and abstract thinking of students and transition from traditional lesson formats to project-based model. The online environment "Mathematical constructor" on the platform of 1C: Lesson allows to create drawings right in the classroom, with precise constructions and a variety of different combinations of shapes. Electronic educational platforms as well as massive open online courses (MOOCs) allow organizing various activities in the classroom: for example, to work with multimedia objects of different levels of complexity in online or offline discussions (Jansen, 2020). The solution of pedagogical tasks is also diverse: it is the study of educational material in a more accessible, visual and interesting way for students, and differentiation of the pace of the lesson and ways of explaining the material. Resources for consolidation, control and self-control, presented on digital platforms, allow organizing practical classes with the aim of controlling and correcting the assimilation of educational material, with the possibility of checking and self-checking, analysis and discussion of errors. There are opportunities for virtual investigations and experiments, which allows students to understand meta-disciplinary connections. Most lessons at all grade levels are taught using a variety of information resources and tools: video and audio materials, digital libraries, and VR labs. For example, at the lessons of the environment as well as natural sciences the practice-oriented approach is carried out both through laboratory works and research in a face-to-face format and in the application of training in virtual laboratories (Jansen, 2020; Atchoarena, 2017; Tenório, 2022). Experiments in virtual laboratories help to simulate difficult and/or unsafe conditions, and also allow a critical comparison of the real experimental results with the predicted ones.

Since the 5th grade, there are several specific tracks with deep studying of certain disciplines. "The Engineering and IT" track focuses on extra hours of mathematics and programming. Olympiad training is carried out in the framework of special courses "Olympiad computer science" (6 levels) and "Olympiad training." In-depth study of computer science and programming can be continued in engineering and IT tracks in the 10th grade. At the same time from the 7th grade the study of elective disciplines from partner universities is carried out. Thus, in cooperation with the Russian Technological University (MIREA), pupils have the opportunity to study different programming languages organized by Samsung IT School and Yandex Academy Lyceum, as well as the opportunity to take part in excursions to the Interinstitutional training center “Industry 4.0: Digital Robotics Production” and the research center “Smart Manufacturing Systems”-mega laboratories of the Institute of Artificial Intelligence. In cooperation with the Financial University under the Government of the Russian Federation, pupils can be trained in various programming languages such as Python for example.

In addition to the main educational program from the 1st grade, pupils can attend elective modules, which are included in the early career guidance program, and which aim to develop relevant professional competencies. There are 7 modules in total:

1) Technical Skills (engineering direction).
2) Art Skills (art and design).
3) Mind Skills (logic and combinatorics).
4) Health Skills (medicine and bioengineering).
5) Language Skills (linguistic skills).
6) Social Skills (social and humanitarian field).
7) Science Skills (scientific direction).

Three of the modules (Technic Skills, Mind Skills, and Science Skills) include such subjects as 3D modeling, programming (Python), and robotics. Fundamentals of 3D modeling is created for pupils with an interest to study technical and natural-science disciplines. Studying this subject allows us to develop creative and abstract ways of imagination, as well as to solve the problems associated with the insufficient level of algorithmic and systematic types of thinking. Equipment and software are differentiated depending on the age group: for pupils of 7–9 years old the accent is made on the development of practical skills in using 3D pen, as well as recreating a three-dimensional image according to the scheme. Older age groups (ages 10–14 and/or 15–17) work with software such as: Autodesk Tinkercad, Lego Digital Designer (10–14 years) and Blender, KOMPAS 3D, FreeCAD. Among the relevant educational outcomes are the acquisition of knowledge in the field of computer 3D design graphics, as well as an initial introduction to the specifics of such professions as design engineer, process engineer, designer, etc.

The main goal of the robotics course is to develop an interest in engineering disciplines. In primary school pupils develop the ability to program through robot control, as well as develop the ability to think creatively and systematically plan their activities from hypothesis to prototype release. Robotics uses an interdisciplinary approach and allows making obvious relationships with other disciplines, such as mathematics, science, and logic. The subject-program and calendar-based planning include activities in which pupils defend their projects: the presentation format allows them to develop the ability to express their ideas in a clear logical sequence, to argue their point of view, to analyze the situation and to find answers to questions independently. Teamwork develops a number of “flexible” competencies: communication and collaboration skills, time management, self-discipline, and the ability to interact in a team in different roles. LEGO Education WeDo 2.0 constructors are used as learning tools. Pupils assemble a flowchart from the ready-made elements responsible for different functionalities of the robot, which allows the robot to perform the task set in the lesson. With the acquisition of new math and science knowledge, pupils are able to perform more complex robotics tasks. The development environment is also changing with grades. EV3 Classroom application is a basic tool to the LEGO MINDSTORMS Education EV3 starter kit. The programming language in EV3 Classroom is based on Scratch.

It should be noted that the digitalization of the educational process is also aimed at increasing pupils’ motivation. So, in the organization of hybrid (blended) formats of the lessons it has become very popular to apply visiting virtual museums and exhibitions. Perspective tools for blended formats of the lessons are based on various techniques of gamification and use of game applications for educational purposes (game applications such as kahoot, quiz, quizlet). Replacement of the standard forms of frontal questioning by the use of game applications causes a positive dynamic in pupils’ progress.

An important issue to be considered in modernizing the educational process and emphasizing the development of digital competences is the issue of harmonious development of the child's personality, as well as psychological safety and stability when functioning in various virtual spaces. Any educational organization must provide modernization of safety policies with the focus of cybersafety.

Over the past few years, the number of active young Internet users has increased by 2.5 times (Atchoarena, 2017; Tenório, 2022). It is extremely important for everyone: parents and teachers-to work together to create a safe and accessible environment for children and youth wherever they are: at home, at school, in public places, such as libraries or Internet cafes.

If we briefly discuss the prospects of higher education and digital technologies within the concept of educational track “kindergarten, school, higher education,” we should highlight a new format of online universities. The Minerva Project is a startup university where there are no lectures or exams, and the educational process is based on the technology of the flipped classroom. All classes are held exclusively online, with a large share of various online communication formats.

III. Conclusion

The article presents an analysis of pedagogical technologies and methods used for the development of digital competencies and the formation of digital literacy in primary, middle and high schools. Using the example of the modernization of the educational process in the particular school the main directions for the formation of digital literacy have been described. It has been demonstrated the possibility of using game applications, as well as remote and virtual laboratories to organize practical classes in the study of natural science disciplines. Peculiarities of curriculum’s changes have been discussed.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

References

Arhipova, S.M., Pylyavina, N.S. (2022). Post Covid world. Influence of pandemic situation on the job market and formation of professional competences. *Economy, financials, and justice*, 12(3), 1–8.

Atchoarena, D., Selwyn, N., Chakroun, B., Miao, F., West, M., Coligny, C. (2017). *Working Group on Education: digital skills for life and work*. UNESCO.

Basharina, O.V., Yakovlev, E.V. (2020). Formation of the bases of digital safety as a component of digital competence. *Innovative development of professional education*, 2(26), 31–36.

Berntzen, R., Standman, J.O., Fjeldly, T.A., Shur, M.S. (2001). Advanced solutions for performing real experiments over the internet. *International Conference on Engineering Education*, 6, 21–26.

Fjeldly, T.A., Shur, M.S., Shen, H., Ytterdal, T. (2000). AIM-Lab: A system for remote characterization of electronic devices over the internet. *Source IEEE Xplore. Conference: Devices, Circuits and Systems*.

Fjeldly, T.A., Strandman, J.O., Berntzen, R. (2002). Lab-on-Web–A comprehensive electronic device laboratory on a chip assembled via internet. *International conference on engineering education*, 10, 1–5.

Jansen, R., van Leeuwen, A., Janssen, J., Conijn, R., Kester, L. (2020). Supporting learners' self-regulated learning in massive open online courses. *Computers & Education*, 146, 103771.

Konanchuk D., Volkov A. (2013). The era of "Greenfield" in education. Investigations SEDeC. *Center for Educational Development of Moscow School of Management SKOLKOVO (SEDeC)*, 1, 1–50.

Kuzminov, Ya. I. (2020). Digital transformation and scenarios for the development of society. *Modern analytics of education*, 16(46), 4–92.

Soldatova, G.Y., Rasskazova, E.I. (2014). Psychological models of digital competences of Russian teenagers and their parents. *National psychological journal*, 2(14), 27–35.

Stiven, D. (2020). *Artificial intelligence in education: Changes in the education rhythms. Analytical report IITO UNESCO*. UNESCO Institute of informational technologies in education.

Tenório, K., Dermeval, D., Monteiro, M. (2022). Exploring design concepts to enable teachers to monitor and adapt gamification in adaptive learning systems: a qualitative research approach. *International Journal of Artificial Intelligence in Education*, 2, 867–891.

Toichkin, N.A. (2019). Modern trends of personnel training for the digital economy in the education system of the Russian Federation. *International Journal of Humanities and Natural Sciences*, 12(39), 146–150.

Roux, I., Nagel, L. (2018). Seeking the best blend for deep learning in a flipped classroom–viewing student perceptions through the community of inquiry lens. *International journal of educational technology in Higher Education*, 15(6), 1–28.

Vaseyskaya, N.O., Glukhov, V.V. (2018). The principles of organizing the educational system for personnel training in a digital economy. *St. Petersburg State Polytechnical University Journal*. *Economics*, 11(2), 7–16.

Vuorikari, R., Punie, Y., Carretero, G.S., Van den Brande, G. (2016). *DigComp 2.0: the digital competence framework for citizens. Update phase 1: The conceptual reference model*. Luxembourg Publication Office of the European Union.