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Professional Training of Teacher 4.0: Developing Digital Competency By Means of ePortfolio

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The purpose of this article is to present the experience of trainee teachers in implementing professional activities in the context of Industry 4.0, and developing the education model 4.0, which provides a change in technologies, forms and teaching aids focused on new requirements for educational results, and implementation of a lifelong educational trajectory.

The subject of the study is digital competency, which is the basic competency of Teacher 4.0, which allows teachers to systematically implement professional activities in a digital society, integrate knowledge and interdisciplinary skills.

The development of ICT competence is described in the process of training tutors (Bachelor degree in Education) at the Institute of Education, Psychology and Sociology of Siberian Federal University by means of electronic portfolio. The article substantiates methodological approaches and methodological solutions for the development of ICT competency, describes the levels of its formation in the electronic educational environment of a federal university by means of electronic portfolios.

The described experimental work discloses assessment of the effectiveness of the presented method for developing ICT competency of trainee tutors within mastering the systemically important IT disciplines. The article presents diagnostic tools, including a list of valid techniques for the component-wise assessment of the ICT competence level of trainee tutors.

The main results of the study can serve the basis for further developments in the field of effective training in different teaching specializations, taking into account the requirements of academic and professional standards in the context of digitalization of education and the development of electronic information educational environment.

Keywords: Industrial Revolution 4.0, Teacher 4.0, ICT competency, digitalization of education, Bachelor's degree, information educational environment, tutor, teacher training, electronic portfolio.

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Introduction

The development of digital Industry 4.0 and introduction of high-tech ICT systems in the field of education brings new requirements to teacher training. Digitalization of various spheres of human life makes the educational system reach a new level of pedagogical tasks, which include preparing students for the digital economy of the future, productive interaction in virtual and additional reality, work in an era of robotics and big data. Industry 4.0 has brought the new Education 4.0 paradigm, which focuses on the lifelong learning conception while developing education and skills, and “has made future learning more customized, hyper, intelligent, portable, worldwide and virtual” (Shahroom & Hussin, 2018).

Characterizing the future significant and noticeable effects of the transition to digital technologies from a social point of view, Klaus Shvab (Shvab, 2016) highlights the following: the emergence of a self-centered society based on individualization, and new forms of community involvement and coexistence.

According to the director of Mobile Electronic Education, President of the Institute of Mobile Educational Systems A. Kondakov, the drivers of modern education are new supranational standards, new requirements and requests of customers (family, business, society, and government), global competition between educational providers, and intrasystem innovators (schools, universities).

The basic competence model of the digital economy was developed as part of the state program Digital Economy of the Russian Federation (Daniliuk & Kondakov, 2018). *The core competence model* includes:

- requirements for the structure of basic and professional competences: the competency in forming a student group and the competence in solving non-mathematical tasks by means of mathematics;
- requirements for the systems (models) of basic and professional competences of the digital economy, based on motivation — goals — actions (external) — self-development (internal actions and the subjective result of the activity) — objective results — long-term results (consequences and effects of the activity);

– requirements for the conditions of the ongoing and continuous development of basic competences including a list of competences divided into groups: “competences in value choice”, “competences in planning and organizing activities”, “competences in carrying out activities”, “competences in self-government and self-development within activities”, “competences in managing the results of the performed activity”, “competences in assessing and recording the consequences and effects of activities”;

– requirements for the coordination of basic and professional competences to have a united competence structure for the digital economy, and a level differentiation of competences.

Thus, digitalization is becoming not only a priority in the development of education, but also determines new requirements for training specialists in new teaching professions who are ready to work in Industry 4.0.

The pedagogical specialization “Tutor” is included in the list of Emerging Jobs in education. The demand of the state, society and stakeholders in tutors who are able to apply relevant ICTs in their professional activity is associated with individualization of education, focus on the students’ individual characteristics and educational needs; open character of the educational environment, formation of personal learning environment (PLE), and development of e-learning and distance learning technologies. Thus, information and communication competence (hereinafter referred to as ICT competence) becomes of key importance in the context of implementing the basic model of competencies in the digital economy.

ICT competency formation of future teachers-tutors when studying at the university is necessary for successful performance of their professional functions in the context of Industry 4.0 and the development of information educational environment. Improving ICT competence is becoming an ongoing process that accompanies tutors in the digital educational environment throughout their professional career.

One of the modern means of informatization aimed at formation of the ICT competency of the tutor is an electronic portfolio (ePortfolio), the didactic potential of which is reflected in the Federal State Educational Standard for Higher Education, the National System of Teacher Growth of the Russian Federation, international documents and standards, and UNESCO Recommendations.

Despite the indisputable significance of the completed researches, the problem of developing theoretical and methodological approaches to the formation of the ICT competency of trainee tutors by means of ePortfolio in the context of informatization

of education and Industry 4.0 has not been sufficiently disclosed to date, and requires analysis to find specific ways to solve this task.

Theoretical background

Theoretical, methodological and fundamental problems of informatization and digitalization of education are presented in the works of Russian scientists V. V. Grinshkun (Grinshkun, 2014), S. G. Grigoryev (Grigoryev, Andriushkova, 2017), S. D. Karakozov (Karakozov, 2010), M. P. Lapchik (Lapchik, 2013), I. V. Robert (Robert, 2012) and others; and foreign researchers D. Garrison (Garrison 2004), R. Williams and K. Macklin (Williams, Macklin, 1988), M. Prensky (Prensky, 2010), S. Peipert (Peipert, 1989), A. Toffler (Toffler, 1980) and others.

In the context of traditional approaches to the modernization of teacher education, a number of trends that are related to the need to improve quality of educational process, ensure its continuity, individualization and personification are considered. Among them are informatization of education, use of innovative ICT, and development of ICT competency of trainee teachers.

However, in innovative approaches, not only scientists, but also politicians note that social relations are changing faster than technologies. Russian Deputy Prime Minister Olga Golodets at the panel session “Industry 4.0: an Evolving Social Contract for Economies under Rapid Change” admitted that in view of the transformation of social relations, a modern teacher should not only think about technical and social innovations, but also teach a child to live in a changing digital world (Golodets, 2017). Teacher 4.0 should create conditions for the development of creative thinking and action, and for the transformation of this creative action into a real result in the context of digitalization of education.

The problem of training tutors to perform their professional activities, including tutoring and building individual educational trajectories for students in the context of digitalization of education is directly related to the need to create interactive digital content, authentic methods of electronic, blended, distance learning for various disciplines, electronic educational resources and methodological training systems in general.

Methodological training of tutors in the context of Industry 4.0 is under-researched. Despite the ubiquity of e-learning and distance learning technologies, there is a shortage of systemic approaches and technological solutions in using cloud technologies, massive open online courses (MOOCs), and ePortfolio in the new pedagogical programs preparing students for new teaching jobs.

Taking into consideration the works of Russian researchers S. V. Paniukova (Paniukova, 2014), M. A. Pinskaia (Pinskaia, 2007), E. S. Polat (Polat et al., 2004), O. G. Smolyaninova (Smolyaninova, 2016), and foreign scientists H. Barrett (Barrett, 2005), J. Zubizaretta (Zubizarreta, 2004), V. Hwan (Hwan, 2014) and others, ePortfolio will be regarded an effective means of informatization, focused on the formation of ICT competency of trainee tutors, which is a significant component of the information educational environment (IEE) of the university.

S. L. Atanasian, S. G. Grigoryev, V. V. Grinshkun when describing the information educational environment of a pedagogical university outline the following components:

- organizational and methodological tools;
- a combination of hardware and software for storing, processing and transmitting information (Atanasian, Grigoryev and Grinshkun, 2009).

The relevance of the formation of ICT competency in the context of Industry 4.0 is confirmed by a number of documents, namely *Strategy of information society development* in Russia until 2030, Digital Economy national program for 2017–2024, the state program Information Society for 2011–2020, and Federal Target Program for the Development of Education for 2016–2020.

The Federal State Educational Standard of Higher Education, subject area 44.03.01 Pedagogical education (undergraduate level), Professional Standard of a Teacher and Professional Standard of a Specialist in Education (Tutor position) contain a new ideology for training tutors in the context of informatization of education and the 4th technological revolution to ensure productive professional activity.

Psychological and pedagogical research presents various definitions of ICT competency (Lapchik, 2012, Khutorskoy and Khutorskaya, 2008, etc.). The authors see ICT competences as a construct of the person's internal resources (theoretical knowledge, practical skills, methods of activity) that allow using information and communication technologies in professional activities (in typical and non-standard situations). ICT competency implies a combination of ICT competences and personal and activity-based characteristics that determine the ability to effectively solve professional problems.

In the current version of the Federal State Educational Standard (FSSES of HE, Bachelor's degree in Education (subject area 44.03.01), a Bachelor of Education should have competences represented by two main groups defined in the Standard: a group of universal competences (UC) and a group of general professional competences (GPC). The third group of professional competences is established by the undergraduate

program on the basis of the Professional Standard of a Teacher in this particular area. Professional competences may be mandatory and (or) recommended (respectively, mandatory professional competences and recommended professional competences).

In the professional standard (Professional Standard of an Education Specialist), the generalized labor function of an education specialist is tutorial support for students. Among the significant labor functions of the tutor are the following:

- identification of students' individual characteristics, interests, abilities, difficulties, problems within the educational process;
- organization of the educational environment for students, including students with health limitations and disabilities, to implement individual educational trajectories and projects;
- organizational and methodological support for students, including students with health limitations and disabilities, aimed at implementing individual educational trajectories and projects.

These labor functions cannot be carried out in modern conditions of the digital environment without the appropriate professional ICT competency level of a tutor.

The existing definitions require clarification in connection with the approval of new requirements for ICT competency, presented in the Professional Standard for Teachers, and also with the development of information educational environment. The concept “professional ICT competency” is used as a basic term in the Professional Standard for Teachers, which means qualified use of ICT tools widely spread in the professional area for solving professional problems.

The analysis of foreign studies shows that the use of ICT tools by various educators in their professional activity does not meet the expectations of various participants of the educational process (Gill, Dalgarno and Carlson, 2015; Tondeur et al., 2015). The common ICT resources that are most often used by educators are the Internet, email, and word processing (Tezci, 2009).

In the context of Industry 4.0 development and modernization of education, the use of blended learning models aimed at formation of the ICT competency of trainee teachers of different areas of specialization is becoming increasingly important. Virtual Reality (VR) and Augmented Reality (AR) with computerized pleasures are in a general sense changing the flow of education and instructional advances landscape into new type of computerized teaching method and smart classroom (Shahroom & Hussin, 2018). The resources of the electronic information educational environment play a significant role in studying ICT competency of trainee tutors.

It should be noted that in the European project DigComp 2.0: The Digital Competence Framework for Citizens (DigComp 2.0), ICT competence is included in the definition of Digital Competence. Digital competence involves confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society.

Researchers define digital competence as a universal core competence that allows mastering other core competences (e. g., language, mathematics, general learning skills, creativity); it includes not only a list of ICT functional skills (DigComp 2.0). In accordance with the concept of the DigComp 2.0 project, digital competence is one of the so-called 21st century skills that should be acquired by all citizens to ensure their active social and economic participation in society and the economy.

On the basis of the conceptual model published in DigComp 2.0, eight levels of digital competency are presented, the eight levels of opportunities to use ICT applicable in the field of training and employment. The competence levels were determined taking into account the planned learning outcomes by means of action verbs in accordance with Bloom's taxonomy, as well as the content and structure of the European Qualifications Framework (EQF) (DigComp 2.1). The selected levels are described as 5 directions. These are 1. Information and data literacy; 2. Communication and collaboration; 3. Digital content creation; 4. Safety; 5. Problem solving.

The DigComp 2.0 model has become the foundation of digital competence for educators in Europe. The Ministry of Education of Spain, with the support of the National Institute for Educational Technology and Teacher Education (INTEF), has worked out the common framework for digital teaching competence based on DigComp (Portfolio of the Digital Teaching Competence, 2017), which is used as the basis for planning teacher professional development programs, such as MOOC, Noocs, and other digital resources. ePortfolio is used as an evaluation tool to assess digital teaching competence. The portfolio of the digital teaching competence is focused on the assessment of these competences, their development by means of continuous self-assessment and the reflection of previous training and education experience. The structure of the portfolio of the digital teaching competence (Portfolio of the Digital Teaching Competence, 2017) consists of the following elements:

1. The Digital Competence Biography;
2. The Self-Assessment Tool of Digital Competence;
3. The Teacher's Dossier;
4. The Digital Competence Passport.

Statement of the problem

In the context of Industry 4.0 and digitalization of education, the set of labor functions and labor actions performed by a tutor is changing. The new significant functions of a teacher include coordinating the educational process, developing individual educational trajectories, a corrective function, individual assessment, diagnosing, support, educational projects management, checking the effectiveness of current tasks and other. The ICT competency of the trainee tutor involves mastering new teaching aids to solve professional problems by means of ICT resources. The analysis of the practical experience of tutors working with various participants of the educational process indicates *the existing contradictions* associated with the scarcity of the required level of ICT competency which impedes its development.

Methods

The research undertaken to study ICT competency of teachers and its levels involved a complex of theoretical and empirical methods. It included a systematic and comparative analysis of psychological, pedagogical, educational, methodological, scientific and technical sources of information connected with the research problems, generalization, drawing a hypothesis, content analysis of the existing Russian and foreign standards for teacher training taking into account the development of ICT competency of a tutor, validated psychological and pedagogical diagnostic tools for measuring the students' ICT competency level, and student surveys.

Assessing diagnostic tools include a number of valid techniques to assess the ICT competency level (Table 1).

Table 1. Diagnostic tools of the formative experiment

ICT competency component	Assessment methods
Cognitive operational Tool-based and activity-based	Modified digital literacy assessment tool "Microsoft Digital Literacy Test"
Communicative	"Assessment of communicative skills" by L. Michelson (adapted by Yu. Z. Gilbukh)
Motivational and target-based	Method for assessing students' learning motivation (by A. A. Rean and V. A. Yakunin) modified by M. Ts. Badmaeva
Reflexive and evaluative	Modified questionnaire by A. V. Karpov devoted to identifying reflective personality; self-assessment of the readiness to use ePortfolio tools to form ICT competency
Personality-related and creative	"Assessment of personal creativity" method (by E. E. Tunik)

Discussion

As a result of the study, the content of the definition was clarified. The ICT competency of trainee tutors are an integrative, dynamic personal quality that determines the ability to consciously integrate ICT technologies into professional and social activities for the productive solution of professional tasks, implementing tutorial support for students (designing individual educational trajectories, interacting with various participants of the educational process, pedagogical support for students' reflection of the results of implementing individual educational trajectories, curriculum, and projects) in information educational environment in accordance with professional standards and the demands of the modern information society.

In accordance with the theoretical and methodological foundations of the competency-based approach, and taking into account specific features of the tutor activity, the following components in the structure of ICT competency were identified: cognitive operational, tool-based and activity-based; communicative; motivational and target-based; Reflexive and evaluative; personality-related and creative (Fig. 1).

Following the guidelines for the design of academic programs, taking into account the studied components of the ICT competency (cognitive operational, tool-based and activity-based; communicative; motivational and target-based; Reflexive and evaluative; personality-related and creative), relying on the experience of other researchers, we focus on the three levels of its development, namely, the reproductive (low) level, the productive (medium) level, and the constructive (high) level (Belov, 2014; Arnautov, 2017). Moreover, each level of the competency is determined in accordance with the degree of development of its components. The assessment indicators of the ICT competency level at the example of trainee teachers (Bachelor degree program in Education) are presented in Table 2.

In the course of study it was detected that ePortfolio can act as one of the means of ICT competency formation within the modern process of university electronic information and educational environment development that meets the requirements of modern standards, when implementing blended learning models. The effective development of ICT competency takes place when supported by individual ePortfolios worked out within the IT disciplines mastered by trainee teachers (Bachelor in Education training program) which involves work with electronic courses as part of the blended learning model.

The module structure of the content for the disciplines ("E-portfolio in personal and professional development", "E-portfolio technology", "E-portfolio in education

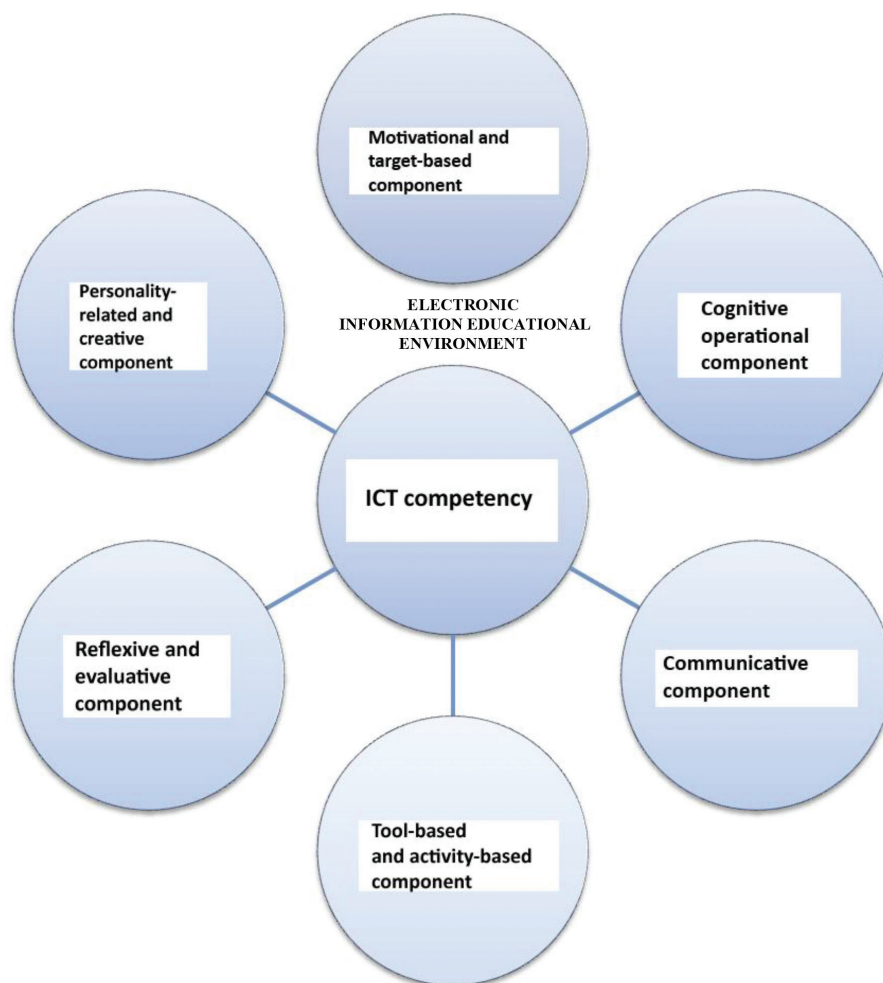


Fig. 1. Structural components of ICT competency of a trainee tutor

and employment”) was substantiated and developed; the module structure focuses on the ICT competency development of trainee tutors by means of ePortfolio, and includes *basic*, *practice-oriented*, *personal* and *professional* modules. The basic module reflects the main directions of using ePortfolio as a means of informatization of education involving ICT in professional activity; it provides a description of online resources and tools for creating an individual ePortfolio. The practice-oriented module includes the description of specific features of communication used by a trainee tutor in the IEE (ePortfolio as a means of communication). The development of the personal and professional module allows trainee tutors using ePortfolio for designing individual educational trajectories and implementing pedagogical support for students’ reflection.

Table 2. Criteria for assessing the level of ICT competency development worked out for trainee tutors

Structural components	Criteria to assess the level of ICT competency
1. Motivational and target-based	1.1. Understanding the importance of using ICT, including ePortfolio in professional activity; 1.2. Motivation for using ICT in professional activity(including ePortfolio); 1.3. Network etiquette (including information security), protection of personal data in ePortfolios
2. Cognitive activity-based	2.1. Understanding the nature and content of information; 2.2. Reviewing, searching and selecting data, information and educational content to create and develop an ePortfolio; 2.3. Evaluation and management of data, information and content by means of ePortfolio
3. Communicative	3.1. Interaction by means of ICT in information and educational environment (IEE); 3.2. Exchange and mediation by means of ICT in IEE; 3.3. Collaboration using ICT, including ePortfolio, in IEE
4. Tool-based and activity-based	4.1 Development of educational content by means of ePortfolio; 4.2. Development of an ePortfolio; 4.3. Integration and processing of educational (e-learning) content by means of ePortfolio;
5. Reflexive and evaluative	5.1. Design and evaluation of individual progress, individual educational trajectory by means of ePortfolio; 5.2. Assessing adequate use of ICT; 5.3. Assessing pedagogical support of students' reflection of the results of individual educational trajectories being implemented, curricula, and projects by means of ePortfolio
6. Personality-related and creative	6.1 Creative use of ICT in professional activity; 6.2. Identification of individual needs, creative character of using ICT by means of ePortfolio; 6.3. Identifying ICT competency deficiencies

The study disclosed that in the process of mastering the systemically important IT disciplines by means of ePortfolio, the development of ICT competency of trainee tutors is more effective if the disciplines:

provide for:

1) basic information literacy, systematic use of ePortfolio within the learning process and professional activities of a trainee tutor;

2) the form and tools for demonstrating learning outcomes/competencies developed within separate discipline modules, separate disciplines, practical sessions, and within the academic program in general (state final examination);

3) feedback and systematic reflection by means of ePortfolio tools used by a trainee tutor, including various resources of electronic information educational environment, such as sites, forums, webinars, conferences and others;

4) support for independence and learning motivation by means of an electronic training course worked out to help master the discipline;

implement:

5) the principle of continuity in presenting and using didactic and methodological functions of ePortfolio;

6) the principle of practical orientation and continuity between various types of practical sessions being implemented, and disciplines of the curriculum.

The experiment consisted of the following steps:

1) planning (projecting methods, development of assessment and diagnostic tools, formation of control and experimental groups, and justification of their homogeneous character);

2) screening (consisted of assessing the level of ICT competency before the experiment takes place in the control and experimental groups);

3) conducting the experiment (aimed at implementing the developed method in teaching systemically significant IT disciplines (“ePortfolio in personal and professional development”, “ePortfolio technology”, “ePortfolio in education and employment”) in the experimental groups within SibFU learning process);

4) generalizing (represented processing and comparative analysis of the experimental results, working out the conclusions).

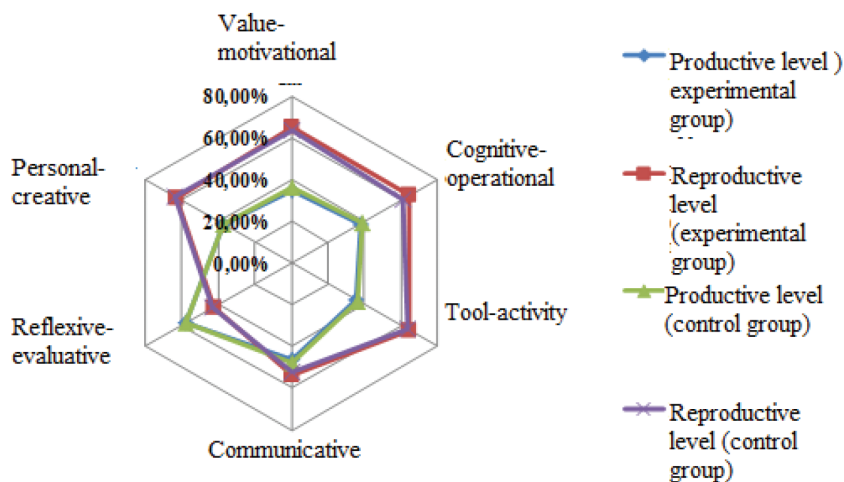


Fig. 2. The results of assessing the level of ICT competence of trainee tutors in the experimental and control groups at the beginning of the experiment

The both groups show the absence of significant differences in ICT competency level before the experiment takes place. The obtained results of the comparative analysis of the ICT competency level in the in the experimental group of tutors (71 people) and control group of tutors (69 people) demonstrated a significant positive dynamics in the experimental group (Fig. 2).

The obtained results of the experiment have confirmed the effectiveness of the method worked out for the ICT competency development of trainee tutors by means of ePortfolio in the context of Industry 4.0 and within implementing the model of Education 4.0.

Conclusion

Within the research the essence of the content, and the structure of the ICT competency of trainee tutors was considered in the context of Industry 4.0 and the model of Education 4.0; the ICT competency being necessary for effective professional activity in the modern digital society. The separate components of the competence related to implementing tutor support for students are identified, such as projecting individual educational trajectories, interacting with various participants of the educational process, pedagogical support of students' reflection on implementing individual educational trajectories, curricula, and projects in IEE in accordance with the requirements of the professional standards and the demands of the modern information society. The result of the analysis of the academic international standards of ICT competency and Russian Professional Standards for Tutors, the ICT competency levels and the ICT competency assessment criteria for graduates of the bachelor's program — future tutors — are determined. The research detected that one of the methodological solutions for the implementation of the organizational and pedagogical conditions for the effective ICT competency development of trainee tutors was using the method worked out for mastering modular IT disciplines distributed within the whole period of training. The modular structure of the content of the systemically significant IT disciplines (“ePortfolio in personal and professional development”, “ePortfolio technology”, “ePortfolio in education and employment”), focused on the development of ICT competency of trainee tutors by means of ePortfolio, has been substantiated and worked out. The modular content of these disciplines was described: basic, practice-oriented, personal and professional modules were defined. The results of the experiment confirmed the effectiveness of the suggested method. Most trainee tutors demonstrated the productive and constructive levels of ICT competency (Fig. 3).

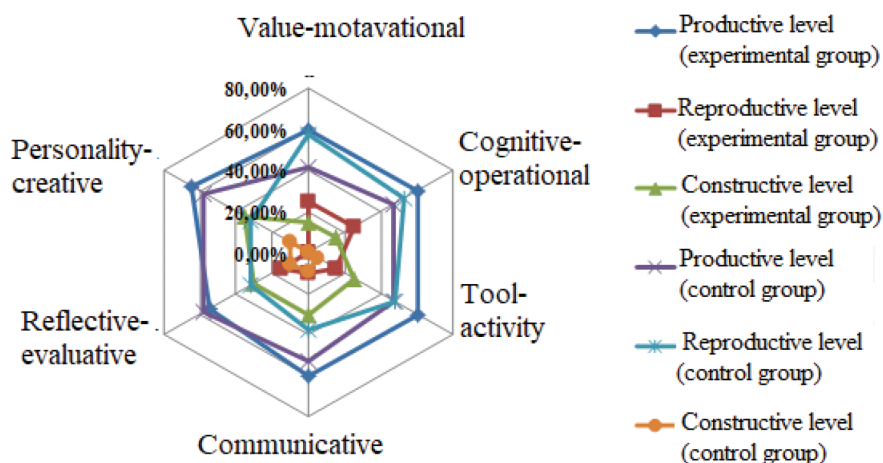


Fig. 3. The results of assessing the level of ICT competency of trainee tutors in the experimental and control groups at the end of the experiment

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Подготовка «педагога 4.0»: развитие цифровой компетентности средствами е-портфолио

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Цель данной статьи: представление опыта подготовки будущих педагогов для профессиональной деятельности в условиях Индустрии 4.0 и развития модели образования 4.0, обеспечивающей изменение технологий, форм и средств обучения, ориентированных на новые требования к результатам образования, реализацию непрерывной образовательной траектории.

Предметом исследования стала цифровая ИКТ-компетентность как базовая компетентность «педагога 4.0», позволяющая педагогам системно реализовывать профессиональную деятельность в цифровом обществе, интегрировать знания и междисциплинарные навыки.

Развитие ИКТ-компетентности описано в образовательном профиле подготовки будущих педагогов «Тьютор Института педагогики, психологии и социологии Сибирского федерального университета». В статье обоснованы методологические подходы и методические решения по развитию ИКТ-компетентности, показаны уровни ее сформированности в электронной образовательной среде федерального университета с использованием электронного портфолио.

Изложена опытно-экспериментальная работа по оценке результативности разработанной методики развития ИКТ-компетентности будущих педагогов-тьюторов при освоении системообразующих дисциплин информатического цикла. Представлен диагностический инструментарий, включающий перечень валидных методик для покомпонентной оценки уровня сформированности ИКТ-компетентности выпускников.

Основные результаты исследования могут служить основой дальнейших разработок в области эффективности обучения будущих педагогов различных профилей с учетом требований академических и профессиональных стандартов в условиях цифровизации образования и развития электронной информационно-образовательной среды.

Ключевые слова: индустриальная революция 4.0 (Industrial Revolution 4.0), педагог 4.0, ИКТ-компетентность, цифровизация образования, бакалавриат, информационная образовательная среда, тьютор, педагогическое образование, электронный портфолио.

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Научная специальность: 13.00.00 — педагогические науки.
