RESEARCH ARTICLES

Teacher Education in Higher Education Systems during Pandemic and the Synergy of Digital Technology

La formación del profesorado en los sistemas de educación superior durante la pandemia y la sinergia de la tecnología digital

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Summary

In the modern world of education, the level of digital technology development plays a decisive role in the competitiveness of educational institutions. The transition to digital education is considered a key driving force for the development of any university. In recent years, pedagogical universities have made tangible progress in many areas of digital development. However, the introduction of digital technologies (DT) in the educational process reached its peak during the pandemic. This study aims to identify the distinctive features in the work of a teacher at a pedagogical university during the pandemic. The study revealed the following: the doubts of the teachers with no e-learning experience; didactically effective digital technologies in the educational process, the combined use of which ensures the synergistic effectiveness of e-learning; students' attitude towards the quality of the e-learning process during the pandemic. Given the identified problems and positive aspects, the results of the study can be used to further develop a strategy for the digitalization of teacher education. The study proved that effective digitalization of the educational process is possible under the condition of cooperative and systematic work of all participants.

Keywords: Pandemic; Teacher Education; Synergy of Digital Technology.

Resumen

En el mundo moderno de la educación, el nivel de desarrollo de la tecnología digital juega un papel decisivo en la competitividad de las instituciones educativas. La transición a la educación digital se considera un motor clave para el desarrollo de cualquier universidad. En los últimos años, las universidades pedagógicas han logrado avances tangibles en muchas áreas del desarrollo digital. Sin embargo, la introducción de tecnologías digitales (DT) en el proceso educativo alcanzó su punto máximo durante la pandemia. Este estudio tiene como objetivo identificar los rasgos distintivos en el trabajo de un docente en una universidad pedagógica durante la pandemia. El estudio reveló lo siguiente: las dudas de los profesores sin experiencia en e-learning; tecnologías digitales didácticamente eficaces en el proceso educativo, cuyo uso combinado asegura la eficacia sinérgica del e-learning; actitud de los estudiantes hacia la calidad del proceso de aprendizaje electrónico durante la pandemia. Dados los problemas identificados y los aspectos positivos, los resultados del estudio se pueden utilizar para desarrollar una estrategia para la digitalización de la formación docente. El estudio demostró que la digitalización efectiva del proceso educativo es posible bajo la condición de trabajo cooperativo y sistemático de todos los participantes.

Palabra clave: Pandemia; Formación del Profesorado; Sinergia de la Tecnología Digital.

Introduction

The main directions of the state educational policy in Russia are defined in the Federal Law "On Education in the Russian Federation" and in the National Doctrine of Education in the Russian Federation until 2025. The main strategic goal of Russian education is to ensure accessibility and improve the quality of education at all levels. Online education — which is a part of the state educational policy — has gained particular importance during the pandemic when everyone was forced to go online. To organize the educational process online, teachers used distance education technologies, various methods to deliver electronic educational content, and a wide range of tools and services for student-teacher communication.

Not all universities were ready for a fundamentally new format of work and teaching. According to the results of interviews, surveys, and questionnaires conducted among teachers of various Russian universities and an analysis of publications, only 10–25% of teachers were able to reorganize their work and educational process within a short time. However, for the vast majority of the teaching staff, this process was very painful due to several reasons: uneven level of the IT infrastructure development in universities; lack or poor provision of educational

resources and courses in e-format; lack of knowledge and inability to use digital technologies (DT) to solve the problems arising during educational activities; stress from having to work in unfamiliar environment and psychological fear of that environment; anxiety caused by the need to communicate with students and colleagues online.

Throughout the whole quarantine period, the teachers of the Herzen State Pedagogical University of Russia in St. Petersburg (HSPUR) and the North-Eastern Federal University in Yakutsk (NEFU) jointly carried out an experimental work to determine the following:

1. Conditions under which e-learning will be effective;
2. Synergistic effect of the combined use of DT in the educational process;
3. Relevant teacher education programs in the field of e-learning.

The experimental group included students in Bachelor's and Master's programs "Teacher Education" and teachers of various departments at the HSPUR and NEFU.

Material and Methods

The issues of the education digitalization are relevant in the modern information society. Many foreign researchers study the problems of the digital competence development among students and teachers (Dooley, Ellison, Welch, Mindy Allen & Bauer, 2016; Martínez & Sánchez-Caballé, 2017; Rockinson-Szapkiw, Wendt, Whightin & Nisbet, 2016; Shihua Li, 2019) and the issues of e-learning in the system of higher education (Gomez & Sanchez, 2018; Perez-Escoda, Castro-Zubizarreta & Fandos-Igado, 2016). In their work, Al-Samarraie, Teng, Alzahrani, and Alalwan (2017) examined the level of students' and teachers' satisfaction with the e-learning systems offered by universities and colleges.

The experience of using modern visual tools such as infographics and video was reviewed by Robin (2016). In their work, Imran, Pireva, Dalipi, and Kastrati considered the possibility of using network tools in e-learning (2016); the question of using AI methods in e-learning was contemplated by Parsons, Vaughn, Scales, Gallagher, Parsons, Davis, and Allen (2017). A number of studies compare students' perceptions of digital and non-digital feedback modes in higher education (Phillips, 2019). Western authors provide examples of methods for assessing the willingness of university students to solve professional problems using e-learning technologies (Gunter & Reeves, 2017; Gray, 2018).

In his work, one of the leaders of the Worldwide CDIO Initiative addressed the issue of the education quality in the ever-changing world (Kamp, 2016). Along with the positive aspects, a number of researchers also note the shortcomings of the new flexible type of education (Yang, Chung, Hwang, Li & Yao, 2017). A number of studies discuss various aspects of changing the nature of pedagogical needs for innovative IT educational environments (Schulz, Ghislain & Reichert, 2014). However, the problem of the teacher education digitalization for the purpose of improving the quality of teacher training in extreme conditions is not fully reflected in the analyzed works.

A joint study was conducted by two research teams from the scientific pedagogical schools of HSPUR and NEFU during the period from March 17 to June 17, 2020. A pre-agreed subject of the study is associated with the complete transfer of the educational process into electronic format, which is a relevant problem for the Russian education system in the current extreme conditions. The tasks of the research were distributed among the participants and carried out on the basis of constant and multiple coordinated interactions, using modern tools for transmitting multimedia information obtained during the study. The collaborative nature of the work allowed the group of researchers to effectively use their scientific and pedagogical potential. The problem

was comprehensively studied given the synergy effect and the theoretical and practical knowledge, as well as the experience of the researchers in the field of e-learning technologies, distance learning technologies, didactics, and e-learning methods. Cooperative work of scientific and pedagogical teams was organized to carry out pedagogical research to study the processes of implementing changes in the new working conditions for teachers and students.

As part of the study, research teams completed the following tasks: analysis of digital technologies used for e-learning and communication with remote participants in the educational process; observation of the reformatted educational process in pedagogical universities of Russia; interviews with fellow teachers of pedagogical universities about the problems and fears they've experienced during such a rapid transition to e-learning. The results of this work indicated that more in-depth research is needed in order to answer the following questions:

- Do teachers have the necessary competencies in the field of e-learning?
- What problems and fears did teachers without e-learning experience have?
- Is the level of the IT development in pedagogical universities sufficient enough to restructure the traditional educational process into e-learning format?
- What are the dynamics of the transition to e-learning among students and teachers?
- Which stages of transition were the most difficult for the participants in the educational process?
- Which organizational mechanisms were failing?
- What are the reasons for negative feedback from participants in the educational process?
- What problems need to be addressed to improve the results?

The authors consider these questions to be the initial methodological prerequisites for the study. This study was based on many years of research and practical experience of the authors in the field of digitalization of teacher education and e-learning (Aksyutin, Vlasova , Gosudarev, Karpova & Zhukov, 2016; Barakhsanova, Vlasova, Golikov, Kuzin, Prokopyev & Burnachov, 2017; Barakhsanova, Savvinov, Prokopyev, Vlasova & Gosudarev, 2016; Vlasova, Goncharova, Aksyutin, Barakhsanova, Prokopyev & Kuzin, 2018; Vlasova, 2010; Vlasova, Avksentieva, Goncharova & Aksyutin, 2019; Vlasova, Goncharova, Barakhsanov, Ivanova, Karpova, Iljina & Sysoeva, 2019; Vlasova, Goncharova, Kuzin, Karpova, Iljina, Gosudarev & Avksenteva, 2019). These works prove that the following conditions should be created for the successful implementation of e-learning in a higher pedagogical school:

- Purposeful, consistent, and adjustable staff training for effective work in digital educational environment, in which teachers can make innovative technological decisions;
- Encouragement to master new digital techniques and methods of working with digital educational resources;
- Development and implementation of adaptive training programs with an emphasis on e-learning, which is based on a stack of modern and constantly changing digital technologies.

The comprehensive study consists of three parts. The first part is devoted to the problems and fears that teachers had during the emergency transition to the e-learning format of education. The second part explores digital technologies needed for the implementation of e-learning process that were most in demand during the pandemic (among the teachers with and without e-learning experience). The third part studies the weekly changes in the students' opinion about the quality of the e-learning process (from March 17 to June 17, 2020). For this, students in Bachelor's and Master's programs were interviewed.

Results

The results of the research can be used for further systematic work to correct and avoid in the future the errors that were made and identified during the "global experiment," in which all

educational organizations of our country took part. Extreme situations, including those in the field of education, always contribute to the development and implementation of new strategies, methods, tools, educational technologies, and solutions. The experience gained during the pandemic has shown that pedagogical universities need not only to keep up with the advance of IT but also to look for ways to develop in this difficult time for the teacher education system. To ensure this development, all participants in the educational process need to learn how to adapt and optimize their managerial and educational activities in the new digital learning environment.

The theoretical analysis and the results of the experiment showed that the new digital reality in teacher education brings a number of problems that need to be addressed. These problems include: lack of knowledge and inability to work with digital technologies in the educational process; unwillingness to familiarize oneself with new technologies and systems; teaching staff often lacks young people who know how to work in a digital environment; lack of IT crash courses for teachers.

Theory and practice confirm that students (future teachers) and teachers should use digital technologies, services, and tools in order to prepare themselves for work in a digital educational environment. Such environment with elements of artificial intelligence was developed specifically for the professional activities of teachers and used during the pandemic (https://inftech.spb.ru). Its effective use in the educational process is confirmed by the results of the experiment.

In the first part of the study, 32 teachers rated the types of fears they've experienced while organizing and giving e-lessons on a scale from 1 to 10. The experimental group included 15 women and 17 men aged 25 to 56 years from the Herzen State Pedagogical University of Russia (HSPU) and the Pedagogical Institute of North-Eastern Federal University (NEFU). The obtained data were averaged and ranked (Table 1). During the experiment, it was checked whether the rank sequences of the types of fear coincide. The following hypotheses were formulated:

- H_0: The correlation between the ordered lists of fear types in the HSPU group and the NEFU group does not differ from 0.
- H_1: The correlation between the ordered lists of fear types in the HSPU group and the NEFU group is statistically significantly different from 0.

Table 1 shows the calculations of the Spearman's rank correlation coefficient and a comparison of the ordered lists of fears in two experimental groups.

Table 1.
Calculations of the Spearman's rank correlation coefficient and a comparison of the ordered lists of fears in two experimental groups.

№	Fears	HSPU's rank	NEFU's rank	d
1	Online public speaking	1	1	0
2	No internet connection	2	2	0
3	Students' absence from class	7	15	-8
4	Looking bad on webcam	18	17	1
5	Inability to speak clearly	17	18	-1
6	Lack of skills in video conferencing	11	9	2
7	Inability to interact with students and colleagues online	12	13	-1
8	Lack of necessary equipment at home	3	5	-2
9	New software	10	11	-1
10	No IT consultant nearby	9	12	-3

11	Disapproval from management	16	16	0
12	The need to constantly learn new technologies	8	3	5
13	New methods of testing students	4	4	0
14	No culture of online collaboration	14	14	0
15	Inability to learn quickly	13	7	6
16	Employment termination	15	8	7
17	Negative impact on the quality of education	6	6	0
18	Not enough time to prepare for a lesson	5	10	-5

To determine the empirical value of the Spearman's correlation coefficient $r_{s\ emp}$, the following formula was used:

$$r_{s\ emp} = 1 - \frac{6 \cdot \Sigma(d^2)}{n(n^2-1)} = 0{,}773 \qquad (1)$$

The critical r_s values were determined using a table of critical values of the sample rank correlation coefficient. The study had 18 measurements (n = 18), therefore:

$$r_{s\ cr} = \begin{cases} 0{,}47\ (\rho \leq 0.05) \\ 0{,}60\ (\rho \leq 0.01) \end{cases}$$
$$r_{s\ emp} < r_{s\ cr}$$

Based on this, hypothesis H_1 is accepted.

The correlation between the ordered lists of fear in the two groups reaches the level of statistical significance and is positive. The fears experienced by the interviewed teachers are the same at the significance level of both 5% and 1%.

The second part of the experiment involved teachers with e-learning experience between the ages of 25 and 56, with 50% of the group being over 40. The teachers of the HSPU and NEFU were asked what digital technologies for the implementation of e-learning process turned out to be most in demand during the pandemic (on a scale from 1 to 10)? A group of teachers with no e-learning experience was also asked this question.

Table 2 presents the average values obtained for each digital technology in the group of teachers with e-learning experience ("reference series") and the individual values of one of the teachers without such experience ("individual series"). The researchers set the task to determine how an individual profile of a teacher without e-learning experience correlates with the reference profile.

Table 2.
Assessment of the demand for 18 digital technologies during the pandemic. Average reference scores of the teachers with e-learning experience (n = 57) and individual scores of a teacher without e-learning experience.

№	Technology	Average reference scores of the teachers with e-learning experience	Individual scores of a teacher without e-learning experience
1	Webinar hosting	9,82	17

2	Creating tests in Google Forms	7,34	7
3	Using QR codes to register students in the classroom	6,42	4
4	Using QR codes to test students	6,42	4
5	Presenting information using infographics	5,38	5
6	Creating polls using Mentimeter	4,93	4
7	Creating screencasts	8,96	9
8	Video recording	8,27	11
9	Collaborative document editing	9,73	19
10	Messengers	6,38	18
11	Micro-learning	7,67	4
12	Creating e-learning courses	8,58	15
13	Creating presentations	9,01	18
14	Creating longreads	7,45	3
15	Creating graphic objects	7,37	8
16	Creating student's web-portfolio	8,03	13
17	Storing full-text digital educational materials in special repositories	7,92	10
18	VR and AR	2,11	1

Table 3 shows the calculation of the Spearman's correlation coefficient between the reference and individual profiles of the most popular digital technologies in the e-learning process during the pandemic.

Table 3.
Calculation of the Spearman's correlation coefficient between the reference and individual profiles of the most popular digital technologies in the e-learning process during the pandemic.

№	Technology	Technology rank in the reference profile	Technology rank in the individual profile	d
1	Webinar hosting	1	4	-3
2	Creating tests in Google Forms	12	11	1
3	Using QR codes to register students in the classroom	13	13	0

4	Using QR codes to test students	13	13	0
5	Presenting information using infographics	16	12	4
6	Creating polls using Mentimeter	17	13	4
7	Creating screencasts	4	9	-5
8	Video recording	6	7	-1
9	Collaborative document editing	2	1	1
10	Messengers	15	2	13
11	Micro-learning	9	13	-4
12	Creating e-learning courses	5	5	0
13	Creating presentations	3	2	1
14	Creating longreads	10	17	-7
15	Creating graphic objects	11	10	1
16	Creating student's web-portfolio	7	6	1
17	Storing full-text digital educational materials in special repositories	8	8	0
18	VR and AR	18	18	0

Table 2 presents the ratings of the teachers with and without e-learning experience. The teachers with e-learning experience rated digital technologies on a scale from 1 to 10. The scores in the individual profile were measured on a scale from 1 to 20. After ranking, both measurement scales were converted into a single scale, in which the unit of measurement was 1 rank, and the maximum value was 18 ranks.

A higher value was assigned a lower rank in order to determine the value of a particular technology for teachers with and without e-learning experience. The ranking results are presented in Table 3. Digital technologies are listed in the order that reflects the reference profile.

The following hypotheses were formulated:

• H_0: The correlation between the individual profile and the reference profile does not differ from 0.

• H_1: The correlation between the individual profile and the reference profile is statistically significantly different from 0.

The matched rank lists contain groups of the same rank. Therefore, corrections were made for the same ranks T_a and T_b before calculating the rank correlation coefficient:

$$T_a = \frac{\sum(a^3 - a)}{12} = 0.5$$

$$T_b = \frac{\sum(b^3 - b)}{12} = 5.5,$$

where a is the volume of each group of equal ranks in the reference profile, and b is the volume of each group of equal ranks in the individual profile.

To calculate the empirical value of r_s, the following formula was used:

$$r_s = 1 - 6\frac{\sum d^2 + T_a + T_b}{n(n^2 - 1)} = 0{,}678$$

Critical r_s values were determined using a table of critical values of the sample rank correlation coefficient. For n = 18,

$$r_{s\,cr} = \begin{cases} 0.47 & (\rho \le 0.05) \\ 0.60 & (\rho \le 0.01) \end{cases}$$

$$r_{s\,emp} > r_{s\,cr}$$

According to the calculation results, the hypothesis H_0 is rejected. The correlation between the individual profile of a teacher with no e-learning experience and the reference profile of a teacher with e-learning experience is statistically significant ($\rho \le 0.05$) and positive. Teachers' opinions are consistent with each other.

The third part of the experiment studies the changes in the students' opinion about the quality of e-learning. Since the start of the pandemic (March 17th) and until June 17th, 2020, teachers with e-learning experience have conducted a weekly review of the educational process in e-format. This analysis helped track changes in students' opinion about the quality of e-learning. The experimental group included students in Bachelor's and Master's programs.

The survey results confirm that the quality of teachers' work with e-learning experience and the organization of the educational process have increased. The weekly data on the number of participants are presented in Table 4.

Table 4.
Number of survey participants by week.

Week	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of participants	28	34	48	44	53	57	61	55	64	68	59	70	68

The obtained instantaneous time series satisfies the requirements for the initial information for sampling by the specified method, namely: the range levels are comparable and equidistant from each other; the time series is of sufficient length; there are no missing observations in the time series; the levels of time series do not contain anomalous values.

After analyzing the initial information for compliance with the requirements, the indicators

of the dynamics of development were calculated and analyzed. A model was built for predicting the quality improvement of the educational process in e-format. This model shows that during the pandemic, teachers constantly enhanced their performance, increased their knowledge and skills in using a variety of digital technologies to solve a wide range of educational tasks, self-organized, and developed their time management skills.

The trend in students' opinions about the quality of the e-learning process is shown in Figure 1, where Y_t is the number of students, who believed that the quality of educational process was constantly improving and t is the number of the week.
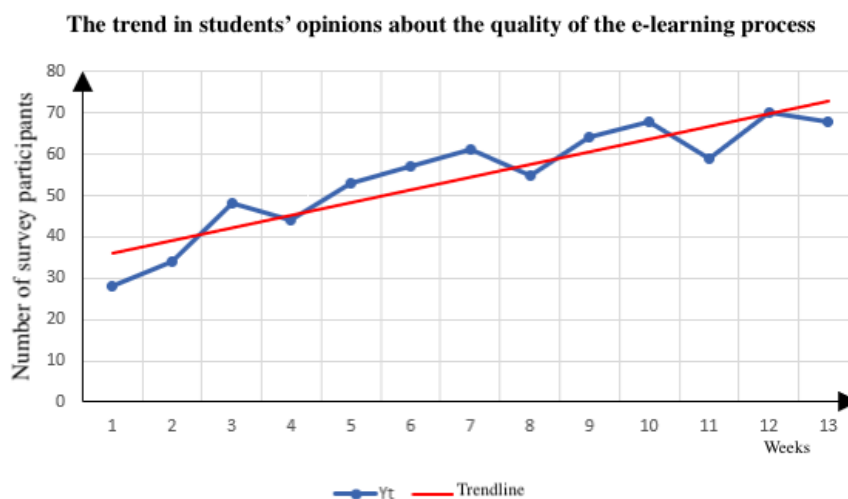

Figure 1. The trend in students' opinions about the quality of the e-learning process

The following formula was used to determine the autocorrelation coefficient of the first-order series' levels:

$$r_t = \frac{\sum_{t=2}^{n}(Y_t - \overline{Y_1}) \cdot (Y_{t-2} - \overline{Y_2})}{\sqrt{\sum_{t=2}^{n}(Y_t - \overline{Y_1})^2 \cdot \sum_{t=2}^{n}(Y_{t-1} - \overline{Y_2})^2}} = 0,832 \, ,$$

$$\text{where } \overline{Y_1} = \frac{\sum_{t=2}^{n} Y_t}{n-1}$$

$$\overline{Y_2} = \frac{\sum_{t=2}^{n} Y_{t-1}}{n-1}$$

The value of the autocorrelation coefficient and the graphical representation of the time series allow us to conclude that the interest contains an almost linear trend. Therefore, a linear function can be used to model its trend:

$$y = a + bt$$

To calculate the *a* and *b* parameters of the linear trend, the least squares method was used and the following system was solved:

$$\begin{cases} na + b\sum t = \sum Y \\ a\sum t + b\sum t^2 = \sum Yt \end{cases}$$

Using the formulas resulting from the system, the parameters are found:

$$b = \frac{\overline{Yt} - \overline{Y} \cdot \overline{t}}{\overline{t^2} - \overline{t}^2}$$

$$a = \overline{Y} - b\overline{t}$$

As a result, the following trend is obtained:

$$Y_t = 33.15 + 3.05t$$

This confirms the results of the experiment, in which students of the two universities participated. On average, the number of students, who believed that the quality of e-learning improved, increased weekly by more than 3 people.

In the new digital economy, teacher education cannot effectively operate on the basis of the old model, using only traditional processes, techniques, educational technologies, and tools.

Discussion

The restrictions related to the pandemic gave Russian teacher education a new impetus for development. Pedagogical universities were forced to actively use digital technologies, which — when used together — produce a synergistic effect and increase the efficiency of both teachers and students.

The study allows us to talk about the synergy of new educational solutions built on the combined use of digital technologies and provides the basis for the restructuring of methods, which are based on the collaborative use of digital tools and solutions. Practice, especially during the pandemic, has shown that collaborative work and collaborative educational projects are effective if a teacher works in a team of professionals. This condition helps to significantly increase the efficiency of work, reduce fears of using new digital technologies, and to open up a new range of opportunities in teacher education in general and for teachers and students in particular. At the same time, it is obvious that the synergistic efficiency of the educational activities is impossible without a well-established IT infrastructure, developed individually for each university with the aim of comfortable, safe, and successful training of future education specialists. Synergistic efficiency allows the educational system to maintain its viability and proficiency even in difficult situations of an emergency transition to a fundamentally different work format, such as e-learning.

During the pandemic, work efficiency was significantly reduced due to the fact that the vast majority of teachers lacked the skills to work in a digital environment and didn't have enough time to master new tools and restructure the educational process. Furthermore, universities were unable to provide teachers with the necessary technical support, and it was impossible to train teachers in such a tight timeframe. All that was offered to the staff in the form of support was brief consultations, briefing webinars at the department level, and recommendations and

instructions for working with various technologies and tools provided on the websites of educational organizations.

Undoubtedly, this was a consequence of force majeure circumstances that forced pedagogical universities to mobilize the entire range of available resources and ensure a massive emergency transition to e-learning. The introduction of this type of training requires a long-term systematic training of the entire teaching staff, careful design and planning of the educational process in the online environment, and the development of fully-fledged online courses. It is a large project that involves the creation of a flexible, interactive, and adaptive online environment with a built-in system for monitoring the improvement of knowledge and skills among students.

Conclusion

The digitalization of the education system has gradually occurred over the past few years and has become most relevant during the pandemic. The study showed that the work of pedagogical universities in the new conditions contributed to the acceleration of digitalization. The initial chaos acted as a creative and organizing principle, a constructive mechanism for the evolution of the teacher education system. It pushed pedagogical universities towards accelerated digitalization by means of internal reserves.

Educators and educational managers strive to learn how to organize and implement digital education, develop a fundamentally different educational strategy, and encourage teamwork with an emphasis on digitalization. A number of problems accompanies this work and the main one is the unpreparedness of the teaching staff to implement a new educational model that is based on the synergy of digital technologies, various forms of interaction with students, collaborative work, and dynamic adaptation to constantly changing working conditions. But it cannot be denied that the digital transformation of teacher education is one of the most important areas of development that will help make a new technological breakthrough in the education system.

References

Aksyutin, P.A., Vlasova, E.Z., Gosudarev, I.B., Karpova, N.A., Zhukov, N.N. (2016). *Corporate e-learning. Educational and Methodical Complex of the Network-Based Master's Program*. St. Petersburg: HSPU Publishing House.

Al-Samarraie, H., Teng, B.K., Alzahrani, A.I., Alalwan, N. (2017). E-learning continuance satisfaction in higher education: a unified perspective from instructors and students. *Studies in Higher Education*, 1-17.

Arnott, L., Palaiologou, I., Gray, C. (2018). Digital devices, internet-enabled toys and digital games: The changing nature of young children's learning ecologies, experiences and pedagogies. *British Journal of Educational Technology*, *49*(5).

Barakhsanova, E.A., Savvinov, V.M., Prokopyev, M.S., Vlasova, E.Z., Gosudarev, I.B. (2016). Adaptive education technologies to train Russian teachers to use e-learning. *IEJME—Mathematics Education*, *11*(10), 3447-3456.

Barakhsanova, E.A., Vlasova, E.Z., Golikov, A.I., Kuzin, Z.S., Prokopyev, M.S., Burnachov, A.E. (2017). Peculiarities of quality management of teachers' e-learning training in the Arctic regions. *Education*, *38*(55), 25.

Bernard, R.R. (2016). The Power of Digital Storytelling to Support Teaching and Learning. *Digital Education*, *30*, 17-29.

Gunter, G.A., Reeves, J.L. (2017). Online professional development embedded with mobile learning: An examination of teachers' attitudes, engagement and dispositions. *Br J Educ Technol*, *48*, 1305–1317.

Gutierrez Gomez, J.A., Serrano Sanchez, J.L. (2018). An Analysis on Information Digital Searching, Access and Discrimination Processes in Future School Teachers. *Digital Education*, *34*, 76-90.

Imran, A.S., Pireva, K., Dalipi, F., Kastrati, Z. (2016). *An Analysis of Social Collaboration and Networking Tools in eLearning*. In: Zaphiris, P., Ioannou, A. (eds). *Learning and Collaboration Technologies. LCT 2016. Lecture Notes in Computer Science, vol 9753*. Cham: Springer.

Kamp, A. (2016). *Engineering Education in a Rapidly Changing World*. Delft: TUDelft.

Li, T.H.S. (2019). A comparative study of digital informal learning: The effects of digital competence and technology expectancy. *British Journal of Educational Technology*.

Martínez, E.P., Sánchez-Caballé, A. (2017). La integración de las redes sociales para el desarrollo de la competencia digital en la educación superior. Universitas Tarraconensis. *Revista de Ciències de l'Educació*, *1*(1), 50-65.

McMunn Dooley, C., Ellison, T.L., Welch, M.M., Allen (Teachers), M., Bauer (Teachers), D. (2016). Digital Participatory Pedagogy: Digital Participation as a Method for Technology Integration in Curriculum. *Journal of Digital Learning in Teacher Education*, *32*(2).

Parsons, S.A., Vaughn, M., Qualls Scales, R., Gallagher, M.A., Ward Parsons, A., Davis, S.G., Pierczynski, M., Allen, M. (2017). Teachers' Instructional Adaptations: A Research Synthesis. *The Review of Educational Research (RER)*.

Perez-Escoda, A., Castro-Zubizarreta, A., Fandos-Igado, M. (2016). Digital Skills in the Z Generation: Key Questions for a Curricular Introduction in Primary Schools. *Comunicar*, *24*(49), 71-79.

Rockinson-Szapkiw, A., Wendt, J., Whighting, M., & Nisbet, D. (2016). The predictive relationship among the community of inquiry framework, perceived learning and online, and graduate students' course grades in online synchronous and asynchronous courses. *The International Review of Research in Open and Distributed Learning*, *17*(3).

Schulz, R., Ghislain, M.I., Reichert, F. (2014). Supporting teachers' needs within and through E-learning systems. *Web and Open Access to Learning (ICWOAL), 2014 International Conference on. IEEE*.

Tracii, R., Henderson, M., Phillips, M. (2019). Feedback modes matter: Comparing student perceptions of digital and non-digital feedback modes in higher education. *British Journal of Educational Technology*, *50*(3).

Vlasova, E.Z. (2010). Didactic potential of e-learning technologies. *Universum: a herald of the Herzen University*, *1*, 113-116.

Vlasova, E.Z., Avksentieva, E.Y., Goncharova, S.V., Aksyutin, P.A. (2019). Artificial intelligence - The space for the new possibilities to train teachers. *Espacios*, *40*(9), 17.

Vlasova, E.Z., Goncharova, S., Aksyutin, P., Barakhsanova, E.A., Prokopyev, M.S., Kuzin, Z. (2018). Effective adaptive training of students in Russian pedagogical universities to use e-learning technologies. *Espacios*, *39*(23).

Vlasova, E.Z., Goncharova, S.V., Barakhsanov, V.P., Ivanova, E.A., Karpova, N.A., Iljina, T.S., Sysoeva, A.S. (2019). Digital transformation of the pedagogical education in the Russian Federation. *Dilemas contemporáneos: Educación, Política y Valores*, *7*(S10), 52.

Vlasova, E.Z., Goncharova, S.V., Kuzin, Z.S., Karpova, N.A., Iljina, T.S., Gosudarev, I.B., Avksenteva, E.Yu. (2019). Artificial intelligence. the area of adaptive possibilities for methodological innovations in pedagogic education. *Dilemas contemporáneos: Educación, Política y Valores*, *7*(S10), 9.

Yang, C.Y., Chung, T.Y., Hwang, M.S., Li, C.Y., Yao, J.F.J. (2017). *Learning Performance Evaluation in eLearning with the Web-Based Assessment*. In: Kim, K., Joukov, N. (eds). *Information Science and Applications 2017. ICISA 2017. Lecture Notes in Electrical Engineering, vol 424*. Singapore: Springer.