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## Formation of digital literacy components of future teachers in the course of studying the university-wide discipline “Digital Technologies in Education”

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**Abstract.** *Problem statement.* Development of informatization of education occurs under the influence of large-scale penetration of digital technologies into all spheres of modern society. Considering this influence, it becomes important to identify and take into account the current level of digital literacy of future teachers and, based on its analysis, develop a scientific and methodological justification for determining the structure and content of the discipline destined for preparing future teachers to work in the context of digital transformation of education. The article presents a study aimed at substantiating the need for a differentiated approach to teaching the discipline “Digital Technologies in Education” studied by students of the pedagogical direction of training within the framework of bachelor’s degree program. *Methodology.* Theoretical and methodological analysis and generalization of fundamental scientific works on the research problem and processing of testing results are used. Experimental work is carried out on the basis of Vyatka State University. The pedagogical experiment involves 111 bachelors in the field of study 44.03.05 “Pedagogical education (with two training profiles)”, profile “Subject training. Teaching and education technologies”. A differentiated approach to organizing the study of the discipline “Digital Technologies in Education” is considered as an innovative method for developing digital literacy of future teachers. At the stage of diagnostics and assessment of the formation of digital literacy of bachelors, an original test is used, aimed at identifying the level of formation of five components of digital literacy of future teachers: information, computer, communication and media literacy, as well as attitudes towards technological innovations. The Pearson’s  $\chi^2$  (chi-square) criterion is used as a statistical processing method. Differentiation of the content of the discipline and division of students into subgroups occurs on the basis of an analysis of the results of input diagnostics, during which the most acute deficiencies in the formation of one of the five components of the student’s digital literacy are identified. *Results.* Statistically significant differences in the qualitative changes that occurred in the level of the digital literacy index of students in the experimental

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group trained in accordance with the proposed approach were revealed ( $\chi^2 = 9.570$ ;  $\alpha < 0.05$ ). *Conclusion.* The use of a differentiated approach to studying the discipline “Digital Technologies in Education” helps to increase the level of digital literacy of future teachers. This approach, based on identifying and taking into account the most acute deficiencies in the development of digital literacy components, will allow to increase the students’ own digital literacy index, as well as to form their readiness to use digital educational tools in future pedagogical activities in order to increase the level of digital literacy of schoolchildren.

**Keywords:** teacher training, informatization of education, digital literacy, digital technologies in education

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## Формирование компонентов цифровой грамотности будущих педагогов в ходе изучения общеуниверситетской дисциплины «Цифровые технологии в образовании»

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**Аннотация.** *Постановка проблемы.* Развитие информатизации образования происходит под влиянием масштабного проникновения цифровых технологий во все сферы деятельности современного общества. С учетом этого влияния становятся значимыми выявление и учет текущего уровня сформированности цифровой грамотности будущих педагогов и на основе его анализа — разработка научно-методического обоснования для определения структуры и содержания дисциплины, направленной на подготовку будущих педагогов к работе в условиях цифровой трансформации образования. Представлено исследование, направленное на обоснование необходимости применения дифференцированного подхода к преподаванию дисциплины «Цифровые технологии в образовании», изучаемой студентами педагогического направления подготовки в рамках программы бакалавриата. *Методология.* Применяется теоретико-методологический анализ и обобщение фундаментальных научных работ по проблеме исследования, обработка результатов тестирования. Опытно-экспериментальная работа проводится на базе Вятского государственного университета. В педагогическом эксперименте принимают участие 111 бакалавров

направления подготовки 44.03.05 «Педагогическое образование (с двумя профилями подготовки)», профиль «Предметное обучение. Технологии обучения и воспитания». Дифференцированный подход к организации изучения дисциплины «Цифровые технологии в образовании» рассматривается как инновационный метод развития цифровой грамотности будущих педагогов. На этапе диагностики и оценки сформированности цифровой грамотности бакалавров применяется авторский тест, направленный на выявление уровня сформированности пяти компонентов цифровой грамотности будущих педагогов: информационной, компьютерной, коммуникативной и медиаграмотности, а также отношения к технологическим инновациям. Методом статистической обработки служит критерий  $\chi^2$  (хи-квадрат) Пирсона. Дифференциация содержания дисциплины и разделение обучающихся на подгруппы происходит на основе анализа результатов входной диагностики, благодаря которой выявляются наиболее острые дефициты в формировании одного из пяти компонентов цифровой грамотности обучающегося. **Результаты.** Выявлены статистически достоверные различия в качественных изменениях, произошедших в уровне индекса цифровой грамотности студентов экспериментальной группы, обучаемых в соответствии с предложенным подходом ( $\chi^2 = 9,570$ ;  $\alpha < 0,05$ ). **Заключение.** Применение дифференцированного подхода к изучению дисциплины «Цифровые технологии в образовании» способствует повышению уровня цифровой грамотности будущих педагогов. Такой подход, основанный на выявлении и учете наиболее острых дефицитов развития компонентов цифровой грамотности, позволит повысить собственный индекс цифровой грамотности студентов, а также сформировать их готовность к применению цифровых образовательных инструментов в будущей педагогической деятельности с целью повышения уровня цифровой грамотности школьников.

**Ключевые слова:** подготовка педагогов, информатизация образования, цифровая грамотность, цифровые технологии в образовании

**Вклад авторов:** авторы внесли равный вклад в подготовку публикации.

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**Problem statement.** Informatization of education is one of the main factors in its further development. In recent years, the challenges facing the informatization of education have been addressed in the context of the digital transformation of a significant part of human activity. Technologies of the fourth industrial revolution (artificial intelligence, virtual and augmented reality, big data, blockchain, etc.) are being introduced everywhere. The educational process is undergoing significant changes due to the digital transformation of teaching aids, management tools, and instruments that ensure interaction between subjects of the educational process [1; 2].

Under the influence of factors external to the education system, the goals of education are being revised – adjustments are being made to federal state educational standards, and new requirements for educational results in the form of digital competencies appear in them, the formation of which should be the focus of the efforts of specialists in the field of modern education. In scientific and methodological publications, the issues of systemic convergence of pedagogical science and digital technologies as a set of theoretical and methodological foundations and methodological solutions, through which the goals of informatization of education can be achieved in the context of its digital transformation, are subject to ever deeper understanding [3].

The conditions of professional activity of a modern teacher are changing worldwide: the pedagogical BYOD concept (Bring Your Own Device) that supports this trend is actively spreading and being implemented in the activities of educational organizations [4]. As a rule, such devices are laptops, tablets, and smartphones of students, which are connected to a common resource using network technologies. If certain requirements are met, this approach can create a so-called ‘smart classroom’.

The inclusion of gadgets and the Internet in the educational process, the spread of the lifelong learning concept, and the blended learning format, as noted by S.E. Bahji and his colleagues, significantly transform traditional communication models between a teacher and a student [5]. These changes create new opportunities and methods for developing digital literacy in students, including students of higher education institutions [6].

The study by O.G. Smolyaninova and E.A. Bezyzvestnykh emphasizes the importance of introducing modern educational technologies focused on an activity-based approach [7]. T.A. Bindyukova and O.A. Mudrakova emphasize the necessity of adapting curriculum content, methodological approaches, to keep pace with ongoing changes in the education system, scientific developments, social norms, and the cultural richness of contemporary society [8].

Conducting classes in new conditions requires modern educational technologies and special teaching methods, which must be equipped with the future teacher [9]. However, the cornerstone of the efficacy of the teachers teaching techniques in the virtual educational sphere lies in his competency in digital literacy as an innovative type of literacy, which involves searching, evaluating, and using various sources of information to form a comprehensive substantive understanding of a specific issue, topic or situation [10; 11].

V.P. Borisenkov, O.V. Gukalenko and N.Kh. Rozov note that attempts to reform the education system without paying attention to the reform of pedagogical education are doomed to failure [12]. In this direction, a range of measures is already being implemented in our country – from amending regulatory documents and developing concepts to implementing them at the project level.

The Federal State Educational Standard of Higher Education, based on which the training of teaching staff at the bachelor’s level is carried out, is supplemented by general professional competence associated with understanding

the principles of functioning of modern information technologies and the ability to apply them in the field of professional activity, in connection with the approval of which disciplines aimed at developing the digital literacy of future teachers appeared in the country's universities. An example of such a discipline is "Digital Technologies in Education", which was implemented within the walls of the Vyatka State University. In this study, the digital literacy of future teachers is interpreted as an integrative readiness and ability of an individual to safely and effectively use digital technologies and Internet resources to perform professional tasks in the context of virtual communication and network interaction. Through conscious and active development of new social experiences, the identified areas of professional activity strive to assist all participants in education in their self-development and self-realization [13]. This approach resulted in the development of a structure and identification of essential digital literacy components for students of pedagogical specialties within the modern educational context [14].

The authors included the following in the list of mandatory components of the concept of 'digital literacy':

1) *information literacy*: the ability to skillfully deal with information by searching for it, critically assessing it, systematizing and classifying it, and creating one-of-a-kind digital content;

2) *computer literacy*: the ability to solve professional problems by employing computer technology, equipment, technical resources, and specialized software;

3) *media literacy*: the ability to work with digital content of various types (texts, sounds, pictures, videos, etc.);

4) *communicative literacy*: the ability to effectively communicate through modern digital channels;

5) *attitude to technological innovations*: the ability to adapt to the latest tools for personal and professional use, ensuring efficient navigation of the digital realm.

The review of the previously cited scientific works helps us to identify the need for additional study of the issues of developing digital literacy of future teachers in the context of digital transformation of teaching aids, management tools, and instruments that ensure interaction between subjects of the educational process. The article discusses a study that aims to confirm the effectiveness of a differentiated approach based on the analysis of students' professional deficiencies of digital literacy, to prepare them for future careers as teachers in a digital environment.

**Methodology.** In this study, the concept of digital literacy for future teachers was explored through theoretical analysis and generalization of existing literature in the face of digital transformation of all levels of education.

The development of digital literacy of future teachers is expected through the use of a differentiated approach to teaching within the framework of the discipline "Digital Technologies in Education", which is mandatory for all students of Vyatka State University studying in the pedagogical direction of training.



The starting point for the research is Vyatka State University. The study covered 111 first-year students of the direction of training 44.03.05 “Pedagogical education (with two training profiles)”, profile “Subject training. Teaching and education technologies”. Of these, 64 % are girls and 36 % are youths. The average age of respondents is 19 years.

The original diagnostics included tasks aimed at identifying the level of development of information (Inf), computer (Comp), communication and media literacy (Media), as well as attitudes towards technological innovations (Innov).

Statistical processing of the results was performed using the Pearson’s (chi-square) criterion.

Knowing the level of development of each of the listed components, it is possible to calculate the digital literacy index as the arithmetic mean between the proportions of correct answers in five areas of measuring digital literacy [16]:

$$\text{Index} = \frac{\text{Inf, \%} + \text{Comp, \%} + \text{Media, \%} + \text{Comm, \%} + \text{Innov, \%}}{5}. \quad (1)$$

**Results and discussion.** It is proposed to develop digital literacy competencies in students majoring in pedagogy within the framework of the discipline “Digital Technologies in Education”, which is included in the curricula of universities in the pedagogical field of training. This subject aims to enhance the abilities of prospective teachers concerning the incorporation of digital technologies in education for resolving professional issues.

The following objectives can be highlighted in the discipline “Digital Technologies in Education”:

- forming an idea of the digitalization of education as the main trend in its development at the present stage;
- familiarizing students – future teachers – with the most effective pedagogical technologies aimed at developing professional and supra-professional competencies;
- familiarization with existing digital educational resources and tools for their development;
- familiarization with the features of organizing and conducting classes using modern educational technologies;
- developing skills in organizing joint educational activities using digital technologies;
- developing skills in organizing students’ project activities in a digital environment;
- forming an idea of the main stages of development of digital educational resources and methodological features of their application in the educational process.

The following content of the discipline “Digital Technologies in Education” has been formed according to the goal and objectives.

#### *Module 1. Digitalization of society and education*

##### *1.1. Key trends in modern education*

##### *1.2. Culture of continuous learning*

1.3. Information search on the Internet. Cloud services

1.4. Artificial intelligence and neural networks, and their application in the educational process

1.5. Fundamentals of information security

*Module 2. Application of digital technologies in education*

2.1. Digital technologies for processing text, tabular and graphic information for educational purposes

2.2. Review of digital tools in pedagogical activity

2.3. Design of the educational process in the context of the active use of information and communication technologies

2.4. Methodological features of digital educational technologies

*Module 3. Development and application of electronic educational resources*

3.1. Stages of development of digital educational resources

3.2. Principles of developing a digital educational environment under new educational outcomes

3.2. Developing your digital educational content

*Module 4. Digital communications in education*

4.1. Online communities of teachers. Electronic portfolio of a teacher

4.2. Ethics of online communication in the educational process

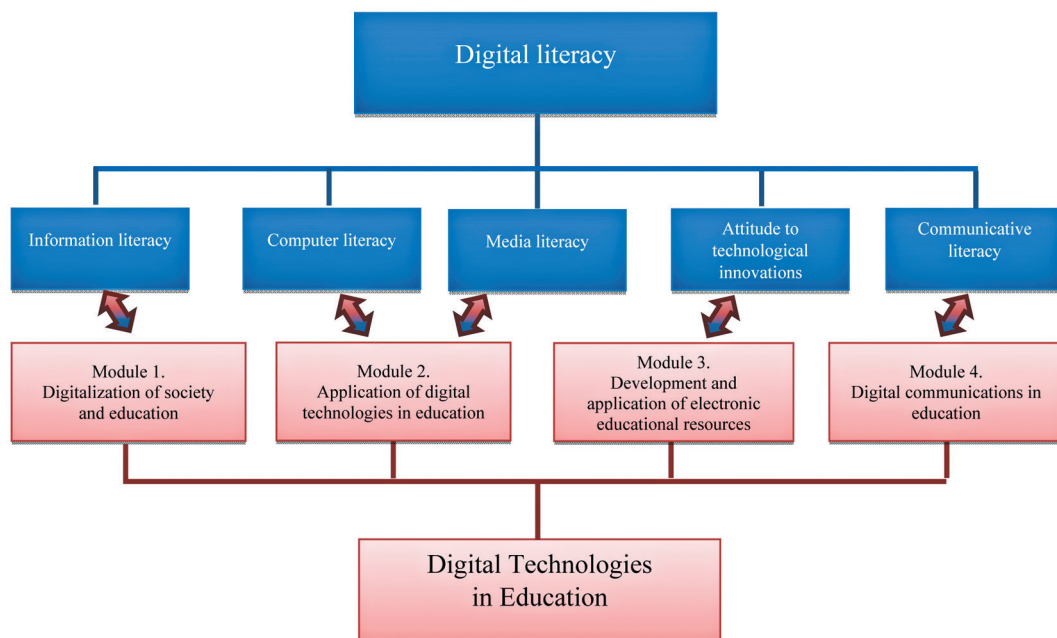
4.3. Strategy for maintaining and promoting the official account of an educational organization in social networks. Creation and design of the content of a public page of an educational organization

4.4. Using digital communications in the educational process. ‘Smart’ chatbots and neurobrowsers

From one perspective or another, each module of the discipline works to form all five components of digital literacy. However, it can be objectively said that the topics of the first module contribute more to the formation of information literacy, the topics of the second module have a greater impact on the development of computer and media literacy, the third module determines the attitude to technological innovations, and the fourth module is aimed mainly at developing communicative literacy. In this regard, the content of the discipline can be variable: depending on the initial level of digital literacy of students, the emphasis in studying “Digital Technologies in Education” can be shifted towards those topics that develop the weakest aspects of digital literacy of students.

It is proposed to measure the initial level of digital literacy in all students of the pedagogical profile and, taking into account the results obtained, divide all students into four groups. Each group will study all four specified modules of the discipline, but in different volumes. For example, the first group, which has information literacy at the initial level, will study modules in approximately the following proportion: 2:1:1:1; the second group – in the proportion of 1:2:1:1, the third – 1:1:2:1, the fourth – 1:1:1:2. That is, if 108 hours (3 credit units) are allocated for this discipline, of which 48 hours are classroom hours, then 10 hours can be allocated to one part, then 18 hours can be allocated to the priority module. Such an organization of the educational process should lead

not only to an increase in the overall level of the digital literacy index of students, but also to an alignment of the level of development of the five specified structural components (Figure). The experiment was conducted in 2024 at the Pedagogical Institute of Vyatka State University. The experiment involved 111 first-year students majoring in 44.03.05 “Pedagogical Education (with two training profiles)”, profile “Subject training. Teaching and education technologies”.



Formation of digital literacy components of future teachers through development of modules of the discipline “Digital Technologies in Education”

Source: created by Natalya I. Isupova, Tatyana N. Suvorova.

The main objective of the experiment was to test the effectiveness of the proposed approach to teaching within the framework of the discipline “Digital Technologies in Education” for the development of students’ digital literacy.

During the initial diagnostics, students were asked to take tests aimed at identifying the level of formation of information, computer, communication and media literacy, as well as attitudes towards technological innovations. Examples of questions and tasks that determine the corresponding components of digital literacy are presented below.

Group 1 questions (to determine the level of information literacy):

- 1) What is cloud computing? What are its features?
- 2) What information tools (services) help fight fakes on the Internet?
- 3) Specify the difference between the terms: identification, authentication, and authorization.

Group 2 questions (to determine the level of computer literacy):

- 1) In the given text fragment, indicate the errors made when typing the text.
- 2) What is a non-breaking space? When is it used?
- 3) In what cases do you have to use absolute references when calculating spreadsheets?



Group 3 questions (to determine the level of media literacy):

1) Determine which of the presented images is infographics, which is data visualization, and which is just an illustration.

2) What type of graphic editor would you choose if you need to create a high-quality collage for submission to a photo contest?

3) Which of the listed software products allows you to process video formats?

Group 4 questions (to determine the level of communication literacy):

1) What is network etiquette? List the basic rules of network etiquette.

2) What are unwanted messages sent in large quantities by telecommunications called?

3) What is phishing in the field of information technology?

Group 5 questions (to determine attitudes towards technological innovations)

1) Describe your attitude to the statement “I easily and with pleasure master any digital innovations” in terms of “agree” / “disagree” / “rather agree” / “rather disagree”.

2) Specify your actions in a situation when your gadget informs you about the release of an update to an application.

3) If the task set before you is not strictly limited in the format of the result presentation, what tools will you choose to complete it: use a pen and paper to get a faster and more accurate result, or find a suitable online service so that you can process and transmit data in digital form?

The results of the measurements carried out before the start of the experiment are presented in the Table.

Results of the test to assess the formation of competencies related to the use of AI technologies in the organization of the educational process before and after the experiment.

Component of digital literacy	Experimental group, 54 students		Control group, 55 students	
	Before the experiment, %	After the experiment, %	Before the experiment, %	After the experiment, %
Information literacy	45 %	95 %	36 %	60 %
Computer literacy	30 %	89 %	28 %	34 %
Media literacy	36 %	90 %	39 %	42 %
Communicative literacy	68 %	93 %	69 %	72 %
Attitude to technological innovations	59 %	70 %	52 %	44 %
Digital literacy index	48 %	87 %	45 %	50 %

Source: compiled by Natalya I. Isupova, Tatyana N. Suvorova.

Then, all students were divided into two groups: control and experimental. In the control group, study of the modules of the discipline “Digital Technologies in Education” took place in equal volume (12 academic hours for each of the four modules). Students of the experimental group were divided in turn into four subgroups, according to the obtained testing results: the first subgroup (12 people) included students with a minimum percentage of information literacy. For them, the study was shifted to Module 1 “Digitalization of Society and Education” (18 hours for the first model and 10 hours for the remaining three modules). The

second subgroup (17 people) included students with a low level of computer and media literacy, for them the most voluminous module was Module 2 “Application of Digital Technologies in Education”. The emphasis on the Module 3 “Development and Application of Electronic Educational Resources” was made for students of the third subgroup (16 people) with a low level of component “attitude to technological innovations”. Finally, the fourth subgroup (9 people), which showed a low percentage of communicative literacy, devoted more time to studying Module 4 “Digital Communications in Education”.

At the end of the semester, after completing the study of all modules of the discipline “Digital Technologies in Education”, students again took tests aimed at determining the level of digital literacy in general and all its structural components separately. The experimental data are also presented in Table.

Statistical processing of the experimental results was carried out using the Pearson chi-square criterion. For this, hypotheses were formulated.  $H_0$ : the level of digital literacy of students in the experimental group is statistically equal to the level of digital literacy of students in the control group.  $H_1$ : the level of digital literacy of students in the experimental group is higher than the level of digital literacy of students in the control group.

Next, the online calculator calculated the values of the criterion before ( $\chi^2_{\text{obs1}}$ ) and after ( $\chi^2_{\text{obs2}}$ ) the experiment. For the significance level of  $\alpha = 0.05$ , according to the distribution tables, the critical value  $\chi^2_{\text{crit}}$  is 9.488. The empirical value of the criterion before the experiment ( $\chi^2_{\text{obs1}}$ ) is 1.215, and after the experiment ( $\chi^2_{\text{obs2}}$ ) is 9.570. Thus, since  $\chi^2_{\text{obs1}} < \chi^2_{\text{crit}}$  ( $1.215 < 9.488$ ), and  $\chi^2_{\text{obs2}} > \chi^2_{\text{crit}}$  ( $9.570 > 9.488$ ), the shift towards an increase in the level of digital literacy of students in the experimental group can be considered non-random.

A quantitative review of the data shows that initially the digital literacy index of the control and experimental groups was almost the same: 45 % and 48 %, respectively, and the disparity between the various aspects of digital literacy was limited to a maximum of 9 %. After the experiment, an escalation in all indicators can be observed within both the experimental and control groups. However, in the experimental group, the growth of those components of digital literacy that initially had a low percentage is especially noticeable. For example, the level of media literacy increased from 36 % to 93 %, while the same indicator in the control group increased by only 3 %. This is explained by the fact that students in the experimental group with a low level of media literacy were assigned to the second subgroup, in which more hours were allocated precisely to the module aimed at developing skills in working with digital content of different types. Thus, these students improved exactly the component of digital literacy that they had fallen short of at the beginning of the experiment. This organization of training led to the fact that at the end of the experiment, the overall digital literacy index of students in the experimental group increased significantly (by 39 %), while the increase in the digital literacy index of students in the control group was only 5 %.

The results of the experiment allow us to conclude that the proposed differentiated approach to teaching students within the framework of the discipline “Digital Technologies in Education” allows us to:

- identify the initial level of digital literacy of students, identify deficiencies in the formation of its components;
- differentiate the content of the discipline by sections, during the study of which certain components of digital literacy are formed (information, computer, communication, media literacy or attitude to technological innovations);
- form an idea of digital educational resources;
- develop the skills of working with ready-made digital tools, as well as the ability to develop their digital educational content;
- form the readiness of students to use digital technologies in their future professional activities due to a more uniform and effective formation of all five components of their digital literacy.

**Conclusion.** The research defines the idea of digital literacy and discusses approaches to the methods for developing future teachers' digital literacy and their ability to incorporate digital tools in education.

The conclusion is substantiated that digital literacy consists of five main components (information, computer, communication, media literacy, and attitude to technological innovations), each of which can be formed purposefully, on certain theoretical and practical material.

To improve the level of digital literacy of students, a differentiated approach to teaching is used, based on dividing students into groups depending on the level of development of each component of digital literacy. Studying all the issues included in the content of this discipline, each group will devote most of the time to a module aimed at developing the most weakly expressed components of digital literacy in its representatives. The experiment shows that this approach can significantly increase the digital literacy index of students as a whole while increasing the level of development of all five of its components. However, the greatest dynamics of development is manifested precisely in the 'sagging' components of digital literacy. The conducted research shows that the proposed differentiated approach to teaching not only corresponds to the priority goals of modern higher pedagogical education, but is also an effective tool for developing the digital literacy of future teachers and their readiness to use the capabilities of the digital educational environment in pedagogical activities.

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