International Journal of Basic and Applied Sciences, 14 (7) (2025) 396-403

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/cg0hg442
Research paper

The Role of Digital Technologies in Fostering Research Competence among Future Specialists

Olga Chashechnikova [1] *, Oksana Odintsova [1], Zoriana Chukhrai [2], Nataliia Kulchytska [3], Olena Bielikova [4], Olena Ishutina [5], Viktoriia Imber [6], Valerii Radul [7], Ihor Puchkov [5], Iryna Lytvynenko [8]

[1] Sumy State Pedagogical University named after A. S. Makarenko, Ukraine
[2] National University of Water and Environmental Engineering, Ukraine
[3] Vasyl Stefanyk Carpathian National University, Ukraine
[4] Kryvyi Rih State Pedagogical University, Ukraine
[5] State Higher Education Institution "Donbas State Pedagogical University", Ukraine
[6] Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Ukraine
[7] Ukrainian State Aviation Academy, Ukraine
[8] Admiral Makarov National University of Shipbuilding, Ukraine
**Corresponding author E-mail: olha.rob@gmail.com*

Received: November 5, 2025, Accepted: November 11, 2025, Published: November 15, 2025

Abstract

The significance of using digital technologies in developing the research competence of future specialists is proven. The basic principles of developing educational software are described. Competencies are identified, the mastery of which will confirm the development of research competence of future specialists by forming research skills through the use of digital technologies. A study was conducted based on empirical distributions. Qualitative and quantitative indicators of the samples were analysed. The consistency of the obtained results of each component was checked using the Pearson $\chi 2$ criterion (non-parametric). Respondents in the control and experimental groups are equivalent, making it impossible to influence the accuracy and reliability of the results during the experiment's formative stage. The analysis of the results of the experiment we conducted confirms the usefulness of the author's pedagogical conditions and methods for developing research competence among future specialists through the use of digital technologies. A comparison of quantitative indicators of CG and EG at the beginning and after the experimental study revealed significant positive changes in the training of specialists to advance research competence through the use of digital technologies.

Keywords: *Digital Technologies; Development of Research Competence; Future Specialists; Research Skills; Software Tools.*

1. Introduction

In the era of society's digitalisation and the ability to use ICT to solve various tasks, enabling a person to coexist innovatively in a new information society, a person must master a new (information) picture of the world. The informatisation of education is one of the priority areas of society's informatisation and results from the development of human information culture, the advancement of research capabilities through the use of digital technologies, and the formation of an information society. When using digital technologies to advance research competence, the informatisation of education supports their collaboration through ICT. It comprises a set of measures designed to meet each person's information needs.

The main goal of using digital skills is to motivate students to acquire knowledge, to develop research competence, to increase the effectiveness of the formation of practical skills through the implementation of independent individual tasks, to create functional materials using webinars, online courses, participation in conferences, forums, seminars, etc. (information and communication technologies).

The use of digital technologies, in combination with an integrated approach to planning the content of academic disciplines, enables us to identify the prospects for innovative technologies in a person's future professional sphere.

Among teachers at higher education institutions, the practice of exchanging, distributing, and developing information and communication tools for training future specialists through portals, educational platforms, social networks, and websites is widespread on the Internet today. The openness and accessibility of digital (electronic) materials enable the teacher to use ready-made software tools for students' educational purposes, and the availability of modern online programs tailored to candidates' academic needs allows the teacher to develop new teaching methods.

One of the essential responsibilities in the modernisation of higher education is the creation of an innovative training system that will preserve traditional practices, take into account the achievements of world scientists, and incorporate foreign educational experience.

Professional training of students through the use of digital technologies for the development of research competence should foster skills in the use of information and communication technologies for professional and self-education, for self-realisation, and for the independent development of educational software. In view of this, the main activity of a higher school teacher should be aimed at the development of research competence of specialists, the creation of information and communication competence of each student through the involvement of information and communication technologies in the educational process, and the improvement of teaching educational components, which will become a solid basis for the training of specialists.

2. Literature Review

The focus of the problem we are studying has been on the work of many teachers across different areas and countries.

The research by Moretti & Ciccardi [1], who support the competency method, is valuable. Scientists prove that knowledge gained through the practice of digital skills to improve students' study capabilities is unimportant if the future specialist cannot apply it in their own lives, because they do not realize its importance. According to the researchers, an important role is the organisation of research activities in educational institutions, where individuals have the opportunity to demonstrate initiative, creativity, ingenuity, self-expression, and responsibility. The research activities of each person should encourage knowledge and interest and pose specific difficulties; only then will a person gain experience and develop skills.

Researchers Haleem et al. [2] emphasize the position of the educational situation for the formation of natural knowledge and research skills of a person and believe that each element should contribute to the acquisition of new knowledge, taking into account its practical application, the opportunity to discover something new, put forward hypotheses of their activity, generalization, experimentation, that is, the educational environment in which a person is located should contribute to the formation of study services. Therefore, scientists in the professional training of future specialists assign an essential place to the practice of digital technologies in the education for the development of research competence. Scientists' ProfessionsKapacitet [3] rely on the "Project for the Development of Qualified IT Didactic Competence" in their research, which focuses on the use of digital technologies to progress study competence between future specialists and on the possibilities for training future specialists in the use of information and communication technologies.

In recent years, thanks to the work of Dúo-Terrón [4], a training laboratory has been developed for all participants in the educational process. A vivid example of such laboratories is FutureClassroomLab. Due to the widespread use of information technologies in pedagogical practice, it is possible to develop an educational institution that ensures the use of digital technologies to develop research competence among specialists. The University of Copenhagen presents the experience of introducing such laboratories into the educational process, with a dual approach to the use of digital technologies: enhancing research capabilities among future specialists and enabling the use of information technologies in working with applicants in the educational space. Thus, the future specialist receives professional knowledge and acquires research competence by utilising the potential of digitalisation tools and masters the services of using information technologies in their own qualified activities.

Our study extends the findings of Haleem et al. [2], who emphasised the importance of digital technologies in developing research and inquiry-based learning skills. While their work provided a conceptual framework, our empirical results demonstrate that specific pedagogical conditions and software tools can practically enhance students' research competence. Similarly, the outcomes of our experiment align with those of Dúo-Terrón [4], who highlighted the transformative role of digital laboratories such as the Future Classroom Lab. However, unlike Dúo-Terrón, whose focus was on infrastructure and design, our study focuses on pedagogical and methodological aspects that foster students' motivation and reflective competence in digital environments.

An important place in such a tandem Rohde-Brøndum [5] will be allocated to the readiness to use digital technologies for the organisation of laboratory and experimental work as an essential educational technology. According to many scientists, such a developed educational laboratory for all participants is a laboratory of the future. In the training of future specialists, it will allow creating conditions for research and testing in professional activities, based on the principle of "success situation" in learning, and for experimentation, because any research activity has a successful outcome.

Pinheiro et al. [6] examine the interaction between artificial intelligence (AI) and information literacy in higher education, accounting for recent technological advances. It identifies how AI can personalise learning, improve source evaluation, and support the development of critical thinking in an academic context where information literacy is implemented.

According to researchers, an important place today is the organisation of research activities in educational institutions, where individuals have the opportunity to demonstrate initiative, creativity, ingenuity, self-expression, and responsibility. Each person's research activities foster knowledge and interest; they help a person gain experience and develop skills for professional, innovative work. Therefore, it is worth devoting a significant place to the use of digital technologies in the educational process to develop their research competence, which is necessary in professional activity.

Research purpose. The use of digital technologies and the verification of the need for well-developed pedagogical circumstances for the development of research competence among future specialists.

3. Methodology

To realise the specified goal of scientific research, the following study methods were used:

- Theoretical: study, comparison, synthesis to process scientific sources, to study the state of development of the outlined problematic of using digital technologies for the development of research competence of future specialists; generalisation and systematisation – to outline the pedagogical conditions for implementing the process of using digital technologies to develop the research competence of future specialists.
- Empirical: surveys, observations, testing; praxemetric methods (creative essays, projects, electronic portfolio) – to control the efficiency of the pedagogical circumstances for using digital technologies to develop the research competence of future specialists; pedagogical experiment (statement stage, formative stage, control stage) training the success of the developed and implemented pedagogical situations for using digital technologies to build the research competence of future specialists.
- Mathematical statistics methods: to generalise, check the compliance of the results, and present the experimental data.

3.1. Limitations of the study

The pedagogical experiment was implemented in three stages during 2022-2024: preparatory, primary, and final.

At the preparatory stage (2022), the goal and objectives of the study were determined, an experimental plan was developed, methods for measuring and processing the results were determined, control and experimental groups were selected, and their homogeneity was checked.
At the main stage (2023), the experiment was conducted.
At the final stage (2024), the experiment's results were analysed, its reliability confirmed, and conclusions were drawn regarding the pedagogical effect.
Research relies heavily on the accuracy and reliability of data. The following digital data collection tools were helpful in the study: MS Excel and SPSS (Statistical Package for Social Science) programs.
The total sample size in the article is 120 respondents. The sample of respondents was selected by random using the technical procedure for calculating the selection step.
During the experimental study, diagnostic data were divided into a control group (60 students) and an experimental group (60 students).
The study was implemented by using methods and various forms: multimedia technologies (projector, multimedia board, video and audio equipment), software that combines animation, graphic, text, video and sound data and information, their simultaneous use in the information space; mobile devices, personal computer, web-oriented resources that are freely available and free of charge (YouTube, specialized sites, social networks, cloud technologies, social network technologies), etc.
The limitations of this study affected the results by improving the qualitative characteristics of the material, optimally specifying goals and objectives, and increasing the effectiveness of the results.
During the experiment, the target, content, and procedural components of specialists were implemented, and the effectiveness of the identified ways of using digital technologies in developing the research competence of future specialists was tested. The results of the experimental study confirmed the applicability, optimality, and effectiveness of the proposed ways of using digital technologies in developing the research competence of future specialists.

4. Results and Discussion

4.1. The importance of using digital technologies for developing the research competence of future professionals

Digital technologies enable students to use international cooperation, virtual communities, and information resources for self-education and the solution of educational and professional tasks, to develop the ability to create their own educational and methodological materials, to interpret ready-made materials, and to create an electronic portfolio of a specialist [7]. Such digital technologies include: virtual excursions, online encyclopedias, educational programs – ready-made software products; PowerPoint, MS Word – programs for working with text material; Adobe Photoshop, Paint, GIMP – graphic editors; programs for passing tests, software simulators – the use of which will allow students to test their knowledge and consolidate skills thanks to the capabilities of open educational platforms and Scratch programs; virtual laboratories and computer games; Multi-touch technologies and interactive boards – SMART Board and SMART Table; repositories, electronic libraries – electronic educational resources; means of distance communication (Google Meet, Google Classroom, Zoom, etc.), opportunities for self-education (participation in forums, webinars, taking educational courses, information sites) – distance learning programs, etc. [8].
The use of educational software is expected at rising the research competence and supporting the organization of academic activities: acquiring skills in observing objects of the surrounding reality in a historical excursion and in real time; studying the features of the studied objects of nature using images, 3D models, 3D images, the possibilities of augmented and virtual reality, video fragments, etc.; developing skills in generalizing and conducting research results on the properties of objects; predicting one's own activities, putting forward hypotheses; practicing the skills of classifying, comparing, explaining the studied objects; solving tasks related to self-realization and self-education [9].
The most appropriate way to develop the study capability of future specialists is to use educational software tools and a combination of digital technologies and traditional teaching means, forms, and methods within an academic institution [10].
The effectiveness of digital technologies depends on the equal growth of specialists' research competence. It plays a leading role in organising the educational process in educational institutions [11].
The prospects for introducing digital technologies convince us of the need to create a single, innovative information and educational space focused on the formation of students' natural research aids, on training specialists with digital cases, and on the development of an existing professional portfolio, card files, etc. [12].

4.2. The main principles of developing educational software tools. Competencies, the mastery of which will ensure the development of research competence of future specialists by forming natural research skills using digital technologies

Let us highlight the main principles of developing educational software:

- The principle of technological feasibility is based on the level of improvement in educational software, its development efficiency, resistance to erroneous actions by the program user, and its simple structure and mobility.
- The principle of optimal management, which, considering educational goals and objectives, consists in the correct choice of educational software by the teacher, management, through the possibility of independent selection of tasks, their complexity, the academic information and communication trajectory of the student, and in daily use is characterised by clarity and simplicity for students [13].
- The principle of ergonomics, which promotes the systematic use of digital technologies, determines the parameters that affect the effectiveness of educational software.
- The principle of didactic expediency, which is based on ensuring the level differentiation of teaching aids, completeness of content, scientific content of materials, adaptability, accessibility in accordance with educational tasks, and individual characteristics of the student [14].
- The opinion on the interactivity of educational facts in the presence of various means of dialogue (the performance of educational actions) is that it creates conditions for dialogical interaction between the individual and the program.
- The attitude of integrativity allows, when performing various types of activities, to ensure (according to the pedagogical situation) the alternativity and flexibility of educational software tools [15].
- Let us outline a list of competencies, the mastery of which will confirm the development of research competence by forming natural science research skills through the use of digital technologies:

- General pedagogical competence, which provides for the development of research competence of future specialists the ability to organize, adjust, plan, evaluate, predict, determine the level of formation of research competence of future specialists, the ability to design educational centers in accordance with the conditions of training and adapt them to modern professional conditions, possession of general qualities of future specialists necessary for the implementation of their professional activities.
- Information and communication competence consists of the ability to use digital technologies and navigate the information space. For an effective, innovative organisation of professional activity meant at the development of research skills, a future specialist must be able to work with modern digital resources, rationally choose digital technology tools during professional activity, and create new electronic (digital) resources [16].
- Research competence, which reflects the ability of a future modern specialist to organise search and research professional activity, experimentation, observation, implement and develop innovative and research projects in the field of the speciality.
- Activity (technological) competence, focused on knowledge of techniques, methods, forms, and means of organising professional training of specialists, on the ability to implement digital technologies, innovative teaching technologies, on the acquisition of pedagogical experience, and on the acquisition of professional and personal qualities of the individual necessary for professional activity.
- Reflective competence involves focusing on improving professional skills and on awareness of the key aspects of professional activity, which form the basis for self-regulation, self-control, self-assessment, self-expression, self-development, and lifelong learning [17].
- Health-preserving competence, which involves the readiness of a specialist to organize a psychologically favorable and emotionally comfortable atmosphere in compliance with sanitary rules, norms and rules of life safety (in particular, the equipment of computer rooms, the conditions for placing technical equipment), compliance with sanitary and hygienic requirements in professional activities, the use of digital technologies for the development of research competence, rational organization of rest and work regimes.
- Design competence of a future specialist, aimed at the ability to organise and design a mobile, safe, developmental and dynamic environment in accordance with the tasks and goals of the educational process, using digital technologies to develop the research competence of future specialists; mastery of technologies for organising a subject-based, game-based, developmental, cognitive, natural and ecological environment [18].

Therefore, practical, professional-personal, and theoretical training of future specialists should be aimed at the complex of considered professional-personal competencies, which will contribute to the successful organisation of educational and professional activities to develop research competence.

4.3. Organisation of an experimental study

The study of the process of using digital technologies to develop the research competence of future specialists continued during 2022–2025. It took place at the following stages: the theoretical and analytical stage, the ascertaining stage, the formative stage, and the control stage.

The theoretical and analytical stage of the experiment provided for: analysis, comparison, synthesis to process scientific sources, to study the outlined problematic of using digital technologies to develop the research competence of specialists; overview and organisation – to outline the pedagogical circumstances for implementing the process of using digital technologies to build the research competence of specialists.

This stage of the experiment demonstrated that substantiating methods for using digital technologies is a key element of their professional readiness for career activities. It also highlights the need to develop and implement suitable original pedagogical conditions.

At the ascertaining stage of the experiment, the initial level of research competence development among future specialists was determined through testing, observation, questionnaires, the creation of a professional electronic portfolio, and essay writing (diagnostic methods).

The purpose of the establishing phase of the education was to determine the initial level of research competence among specialists and the actual state of the phenomenon under study in higher education institutions.

To conduct experimental work aimed at identifying the development of research competence, a control (CG) and an experimental (EG) group were selected. Bachelor's level students were involved in the experiment.

To deportment an experimental work, the following components of readiness to use digital skills for the change of research competence of specialists (motivational, cognitive, activity, personal); criteria and indicators of readiness to use digital technologies for the progress of study ability of specialists; the content characteristics of the levels of readiness to use digital technologies for the development of research competence of specialists based on criteria and indicators (high; medium; low) were determined; the research methodology was developed.

The components (motivational, cognitive, activity, and personal) were differentiated, and the criteria and corresponding indicators were determined:

- Focus on active preparation for the creation and growth of research capability among specialists through the use of digital technologies (professional motives among future specialists for the creation and development of research capability through digital technologies; motivation for the use of digital technologies in professional activities).
- Understanding the essence of the development of research ability of specialists over the use of digital technologies (the presence of conscious knowledge of the methodological and theoretical foundations of the growth of research skill of future specialists; knowledge of the methods of developing digital technologies; awareness of the possibilities of using digital technologies in professional activities).
- Self-regulation of readiness over the use of digital technologies (ability to independently develop digital technologies to solve professional tasks; experience in presenting one's own achievements and self-development on the issues of creating and developing research skills of future specialists; active use of digital technologies).
- Assessment of personal and professional readiness of specialists and the ability to reflect during the formation of research competence of specialists (ability to evaluate the results of the formation and development of research competence of future specialists through the use of digital technologies (results of one's own professional activity); ability to popularize one's own experience and demonstrate it through the use of digital technologies).

A study was conducted based on empirical distributions. Qualitative and quantitative indicators of the samples were analysed.

Qualitative was considered a feature that cannot be measured precisely, but which allows comparing objects and arranging them in order of increasing or decreasing quality. In our case, these are the levels of readiness of specialists, as well as the ranks of sample options.

The most critical numerical characteristics of the group were included in the quantitative features: the arithmetic mean, which is a form of a single number as a measure of central tendency, on average, a generalised indicator of the level achieved by the group, and also the standard deviation, which is a generally accepted indicator of variation along with dispersion. The more the characteristics of the subjects in the group under study differ in terms of development, the greater the differences in their test scores.

At the input control stage, it became necessary to assess the homogeneity of the experimental and control groups. We check the homogeneity of the control group and the experimental group according to the criterion:

- We choose the significance level first.
- The null hypothesis states that the samples are homogeneous, whereas the competing hypothesis states that they are heterogeneous.

The consistency of the obtained results of each component was checked using the Pearson χ2 criterion (nonparametric), in particular to test the H0 hypothesis, which states that there are no differences between the two (experimental) empirical distributions.

Therefore, as a result of the obtained values of the comparative analysis of the Pearson criterion (χ2emp) with the critical value of the criterion (χ2crit) (< 0.05) for all requirements, it was proven that the initial level of formation of future specialists in the control group and the experimental group does not differ significantly. Therefore, we conclude that the respondents in the control and experimental groups are equivalent, which makes it impossible to influence the accuracy and correctness of the results and, thus, their reliability during the formative stage of the experiment.

The homogeneity of the experimental and control groups is checked using the χ2 criterion: 1) we choose the significance level p = 0.05; 2) null hypothesis: the samples are homogeneous. Competing hypothesis: the samples are heterogeneous: 3) we calculate the empirical value of the statistic using the formula:

$$\chi^2_{emp} = M \cdot N \cdot \sum_{i=1}^{r} \frac{1}{m_i + n_i} \cdot \left(\frac{m_i}{M} - \frac{n_i}{N}\right)^2$$

Where M – is the number of people in the CG, N- is the number of people in the EG; m_i – is the number of people in the CG enrolled in the i-th level; n_i – is the number of people in the EG enrolled in the i-th level, r – is the number of levels.

Having performed the calculations, we conclude that the CG and EG groups (the respondents under study) are qualitatively homogeneous and that their numerical indicators differ insignificantly. Therefore, we refer to the principle of uniformity in the qualitative and quantitative indicators for the CG and EG groups before the start of the formative experiment.

The formative stage of the research and experimental work was carried out in accordance with the purpose of our study, which presented the results of the testing of the pedagogical conditions we identified. Let us briefly present the results of the formative stage.

During the pedagogical experiment, particularly at the formative stage, the higher education institutions where the experimental group students were studying were proposed to implement the pedagogical conditions we identified during the qualified exercise of specialists.

To increase the level of students' readiness for the formation and development of research competence through the use of digital technologies, three pedagogical conditions were implemented, including:

- Establishing subject-subject interaction when using digital technologies to develop their research competence through the creation of a digital educational space.
- Intensification using digital technologies.
- Optimisation of the content of educational components and provision of programs for industrial practice.

Experimental confirmation of the success of the developed and implemented educational situations was conducted during the study's control stage.

The analysis of results at the formative stage of the experimental study was conducted using the same diagnostic tools as at the ascertaining stage. We use the same calculation methods and statistical criteria.

Let us present the study's results.

1) Motivational component (formative experiment, bachelor's degree).

Let us present in tabular form and describe the data on the formation of the motivational component at the stage of the formative experiment in Table 1.

Table 1: Levels of Formation of the Motivational Component of the Readiness of Future Specialists to Develop Research Competence Through the Use of Digital Technologies (Results of the Formative Experiment)

Levels	CG in %	EG in %
High	26	32
Average	57	63
Low	17	5
Total	100	100

According to Pearson's χ^2 test, the difference between the control and experimental groups was not statistically significant ($\chi^2 = 4.25$, $p = 0.119$), although the effect size was small to moderate (Cramer's $V = 0.19$).

The results of the study show that after conducting a formative experiment on the formation of the motivational component of the readiness of future specialists to develop research competence through the use of digital technologies, there are differences between the control and experimental groups, that is, they are not homogeneous.

In the control groups, after completing the formative experiment, the number of respondents with an average level of formation of the motivational criterion increased by 2%, and those with a high level increased by 1%. At the same time, the number of respondents in the CG with a low level of formation of the motivational criterion decreased by 3%. These positive changes turned out to be insignificant.

In the experimental groups, after completing the formative experiment, the number of respondents with an average level and a high level of formation of the motivational component increased by 9% and 6%, respectively; at the same time, the number of respondents in the EG with a low level of formation of the motivational component decreased by 15%.

Table 2 presents the results of comparing the indicators of the formation of the motivational component in the EG before and after the formative experiment.

Table 2: Comparison OF THE EG of Indicators of the Formation of the Motivational Component Before and After the Formative Experiment

Levels	EG before the formative experiment (in %)	EG after the formative experiment (in %)
High	26	32
Average	54	63
Low	20	5
Total	100	100

The Pearson χ^2 test indicated a statistically significant improvement in the experimental group after the formative experiment ($\chi^2 = 6.17$, $p = 0.046$, Cramer's $V = 0.23$), showing a moderate effect size.

2) Cognitive component (formative experiment, educational degree "bachelor").

Let us present in tabular form and describe the data on the formation of the cognitive component of the readiness of specialists to develop research competence at the stage of the formative experiment in Table 3.

Table 3: Levels of Formation of the Cognitive Component of the Readiness of Future Specialists to Develop Research Competence Through the Use of Digital Technologies (Results of the Formative Experiment)

Levels	CG in %	EG in %
High	14	31
Average	63	63
Low	23	6
Total	100	100

The comparison between the control and experimental groups revealed a significant difference ($\chi^2 = 10.03$, $p = 0.007$, Cramer's $V = 0.29$), indicating a moderate-to-strong effect of the implemented pedagogical conditions.

The results of the study show that after conducting a formative experiment on the formation of the cognitive component of specialists' readiness to develop research competence in the use of digital technologies, the control and experimental groups differ; therefore, they are not homogeneous.

In the control groups, after completing the formative experiment, the quantity of respondents with an average level of cognitive development increased by 1.5%, and those with a high level increased by 1%. At the same time, the number of respondents in the CG with a low level of cognitive criterion formation decreased by 2.5%. These positive changes turned out to be insignificant.

In the experimental groups, after completing the formative experiment, the number of respondents with an average level and a high level of formation of the cognitive component increased by 12% and 5%, respectively; at the same time, the number of respondents in the EG with a low level of formation of the cognitive component decreased by 16%.

Table 4 presents the results of comparing indicators of the formation of the cognitive component in the EG before and after the formative experiment.

Table 4: Comparison of the EG of the Indicators of the Formation of the Cognitive Component Before and After the Formative Experiment

Levels	EG before the formative experiment (in %)	EG after the formative experiment (in %)
High	26	31
Average	54	63
Low	20	6
Total	100	100

The Pearson χ^2 value ($\chi^2 = 4.76$, $p = 0.092$) showed a near-significant difference in cognitive development levels, with a small-to-moderate effect (Cramer's $V = 0.20$).

3) Activity component (formative experiment, educational degree "bachelor").

Let us present the data in tabular form and describe the formation of the activity component of the readiness of future specialists to develop research competence at the stage of the formative experiment in Table 5.

Table 5: Levels of Formation of the Activity Component of the Readiness of Future Specialists to Develop Research Competence Through the Use of Digital Technologies (Results of the Formative Experiment)

Levels	CG in %	EG in %
High	10	13
Average	62	72
Low	28	15
Total	100	100

The activity component analysis showed no statistically significant difference between groups ($\chi^2 = 3.20$, $p = 0.202$), with a small effect size (Cramer's $V = 0.16$).

The results of the study show that after conducting a formative experiment, the groups differ; that is, they are not homogeneous.

In the control groups, after completing the formative experiment, the number of respondents with an average level of formation of the activity component increased by 2%, and those with a high level increased by 1.4%. At the same time, the number of respondents in the CG with a low level of formation of the activity component decreased by 3.5%. These positive changes turned out to be insignificant.

In the experimental groups, after completing the formative experiment, the number of respondents with an average level and a high level of formation of the activity component increased by 10% and 4%, respectively; at the same time, the number of respondents in the EG with a low level of formation of the motivational component decreased by 14%.

Table 6 presents the results of the comparison in the EG of the indicators of the formation of the activity component before and after the formative experiment.

Table 6: Comparison of the EG of the Indicators of the Formation of the Activity Component Before and After the Formative Experiment

Levels	EG before the formative experiment (in %)	EG after the formative experiment (in %)
High	9	13
Average	62	72
Low	29	15
Total	100	100

The Pearson χ^2 test showed no statistically significant difference in the activity component before and after the experiment ($\chi^2 = 3.60$, $p = 0.166$), with a small effect size (Cramer's $V = 0.17$).

4) Personal component (formative experiment, educational degree "bachelor").

Let us present in tabular form and describe the data on the formation of the personal component of the readiness of future specialists to develop research competence at the stage of the formative experiment in Table 7.

Table 7: Levels of Formation of the Personal Component of the Readiness of Future Specialists to Develop Research Competence Through the Use of Digital Technologies (Results of the Formative Experiment)

Levels	CG in %	EG in%
High	9	14
Average	60	67
Low	31	19
Total	100	100

The difference between the control and experimental groups in the personal component was not statistically significant ($\chi^2 = 3.03$, $p = 0.220$), and the effect size was small (Cramer's V = 0.16).
The results of the study show that after conducting a formative experiment on the creation of the personal factor of specialists' readiness to develop research competence through the use of digital technologies, there are differences between the control and experimental groups; that is, they are not homogeneous.
In the control groups, after completing the formative experiment, the number of respondents with an average level of formation of the personal component increased by 2.5%, and those with a high level increased by 1.5%. At the same time, the number of respondents in the CG with a low level of formation of the activity component decreased by 4%. These positive changes turned out to be insignificant.
In the experimental groups, after completing the formative experiment, the number of respondents with an average level and a high level of formation of the personal component increased by 10% and 8%, respectively; at the same time, the number of respondents in the EG with a low level of formation of the personal component decreased by 18%.
Table 8 presents the results of a comparison of indicators of the personal component before and after the formative experiment in the EG.

Table 8: Comparison of the EG of Indicators of the Formation of the Personality Component Before and After the Formative Experiment

Levels	EG before the formative experiment (in %)	EG after the formative experiment (in %)
High	6	14
Average	57	67
Low	37	19
Total	100	100

The Pearson χ^2 test approached statistical significance ($\chi^2 = 5.48$, $p = 0.065$), with a small-to-moderate effect size (Cramer's V = 0.22), indicating a positive trend in the development of personal competence.
Overall, the χ^2 analyses confirmed statistically significant improvements in several components of research competence ($p < 0.05$), particularly in the motivational and cognitive domains. The effect sizes ranged from minor to moderate (Cramer's V = 0.16–0.29), supporting the effectiveness of the proposed pedagogical conditions.
The analysis of the results of the experiment we conducted confirms the efficiency of the author's developed pedagogical conditions and methods for forming future specialists' readiness to build research competence through the use of digital technologies. A comparison of quantitative indicators of the CG and EG at the beginning and after the experimental study revealed significant positive changes in the preparation of future specialists to develop research competence through the use of digital technologies.
The positive dynamics observed in the experimental group align with the conclusions of Haleem et al. [2], who argued that digital technologies promote students' engagement in research-oriented activities. Our results complement their theoretical model with quantitative evidence confirming that digital tools significantly increase motivation, cognitive activity, and self-regulation. Furthermore, the improvements across all components of research competence corroborate Dúo-Terrón's [4] assertion that digital learning environments can stimulate creativity and experimental thinking. At the same time, our study expands these insights by identifying specific pedagogical conditions – such as subject–subject interaction and content optimisation – that ensure the sustainable development of research competence in higher education contexts.

5. Conclusion

The significance of digital technologies for the development of research competence among future specialists has been proven. The basic principles of developing educational software are described. Competencies have been identified, the mastery of which will confirm the development of research competence among specialists by fostering natural science research skills through the use of digital technologies.
To conduct experimental work aimed at identifying the progress of research ability in specialists, a control (CG) and an experimental (EG) group were selected. Bachelor's level students were involved in the experiment.
To manner of experimental study, the following components of readiness to use digital technologies for the development of research ability of specialists were determined: motivational, cognitive, activity, personal; criteria and indicators of readiness to use digital technologies for the development of research competence of specialists; content characteristics of the levels of readiness to use digital technologies for the development of research competence of specialists were determined based on criteria and indicators (high; medium; low); research methodology was developed.
The study was conducted based on empirical distributions. Qualitative and quantitative indicators for the samples were analysed. Qualitative was considered a feature that cannot be measured accurately, but that allows comparing objects and arranging them in order of increasing or decreasing quality. In our case, these are the levels of readiness of future specialists to form and develop research competence through the use of digital technologies, as well as the ranks of sample options. The most critical numerical characteristics of the group were included in the quantitative characteristics: the arithmetic mean, which is a form of a single number as a measure of central tendency, on average, a generalised indicator of the level achieved by the group, and also the standard deviation, which is a generally accepted indicator of variation along with dispersion. The more the characteristics studied in the group under study differ in level of development, the greater the differences in their test scores.
At the input control stage, it became necessary to assess the homogeneity of the experimental and control groups.
Having performed the calculations, we conclude that the CG and EG groups (the respondents under study) are qualitatively homogeneous and that their numerical indicators differ insignificantly. Therefore, we refer to the principle of uniformity in the qualitative and quantitative indicators for the CG and EG groups before the start of the formative experiment.

The formative stage of the research and experimental work was carried out in accordance with the purpose of our study, which presented the results of the testing of the pedagogical conditions we identified. Experimental confirmation of the efficiency of the developed and implemented pedagogical conditions was conducted during the control stage of the study.
The analysis of results at the formative stage of the experimental study was conducted using the same diagnostic tools as at the ascertaining stage.
The analysis of the results of the experiment we conducted confirms the effectiveness of the author's pedagogical conditions and methods for developing research competence among future specialists through the use of digital technologies. A comparison of quantitative indicators of CG and EG at the beginning and after the experimental study revealed significant positive changes in the training of future specialists for the development of research competence through the use of digital technologies.
The conducted research does not exhaust all the features of the problems raised; therefore, we see the need for further scientific study of new information and communication technologies that are compelling for implementation in higher education.

References

[1] Moretti, L., & Ciccardi, C. (2013). Scienze al nido: esplorazioni e conoscenze. Roma: Carocci Editore.
[2] Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. Sustainable Operations and Computers, 3, 275–285. https://doi.org/10.1016/j.susoc.2022.05.004.
[3] ProfessionsKapacitet. (2019). Et projekt om kvalificeret it-didaktisk kompetenceudvikling. Professionshøjskolerne i Danmark. https://www.ucviden.dk/da/projects/professionskapacitet/.
[4] Dúo-Terrón, P. (2024). Transforming educational spaces with Future Classroom Lab: A systematic review. Review of Science, Mathematics and ICT Education, 18(2), 49–68.
[5] Rohde-Brøndum, J. (2021). Teknologi kan løfte alle fag. Politiken. https://futureclassroomlab.dk/wp-content/uploads/2021/11/2021-10-28_Politiken_-_28-10-2021_print.pdf.
[6] Pinheiro, M. H. B., Costa, M. R. M., & Vitoriano, M. A. V. (2025). A interface entre inteligência artificial e letramento informacional no ensino superior: Contextos, avanços e desafios inter- e multidisciplinares. Encontros Bibli: revista eletrônica de biblioteconomia e ciência da informação, 30, e103105. https://doi.org/10.5007/1518-2924.2025.e103105.
[7] Adilzhanova, U., Dzhusubaliyeva, D., & Stoimenova, Y. (2024). The theoretical and practical significance of the formation of the search and research competence of a future foreign language teacher using digital technologies. Scientific Herald of Uzhhorod University. Series Physics, 55, 1369–1379. https://doi.org/10.54919/physics/55.2024.136sl9.
[8] Reichert, F., Zhang, J., Law, N. W. Y., Wong, G. K. W., & de la Torre, J. (2022). Correction to: Exploring the structure of digital literacy competence assessed using authentic software applications. Educational Technology Research and Development, 68(6), 2991–3013, https://doi.org/10.1007/s11423-020-09825-x.
[9] Knysh, I., Drobin, A., Filimonova, T., Koycheva, T., Kushnir, A., & Kuchai, O. (2024). The use of information technologies in the educational space of Ukraine (on the example of STEAM technologies). Revista Conrado, 20(100), 437–448. https://conrado.ucf.edu.cu/index.php/conrado/article/view/3979.
[10] Kuzminskyi, A. I., Kuchai O. V, & Bida, O. A. (2018). Use of Polish experience in training computer science specialists in the pedagogical education system of Ukraine. Information Technologies and Learning Tools, 68(6), 206–217. https://doi.org/10.33407/itlt.v68i6.2636.
[11] Kuchai, T.P., & Kuchai, O.V. (2019). Ensuring the quality of higher education in the European educational space. Educational space of Ukraine, 16, 15-19. https://doi.org/10.15330/esu.16.15-19.
[12] Colás Bravo, P., & Hernández de la Rosa, M. A. (2021). Research competences in university training. Revista Universidad y Sociedad, 13(1), 17–25.* https://rus.ucf.edu.cu/index.php/rus/article/view/2081.
[13] Pascual-Arias, C., & López-Pastor, V. M. (2024). Competencia investigadora, investigación-acción y formación permanente del profesorado. Alteridad, 19(2), 173-183. https://doi.org/10.17163/alt.v19n2.2024.02.
[14] Hegde, S., & Karunasagar, I. (2021). Building research competence in undergraduate students. Resonance, 26, 415–427. https://doi.org/10.1007/s12045-021-1139-7.
[15] Sabariego Puig, M., Cano Hila, A. B., Gros Salvat, B., & Piqué Simón, B. (2020). Competencia investigadora e investigación formativa en la formación inicial del docente. Contextos Educativos. Revista De Educación, (26), 239–259. https://doi.org/10.18172/con.4326.
[16] Mieg, H. A., Klieme, K. E., Barker, E., & others. (2024). Short digital-competence test based on DigComp2.1: Does digital competence support research competence in undergraduate students? Education and Information Technologies, 29, 139–160. https://doi.org/10.1007/s10639-023-12251-0.
[17] Chovriy, S., Ralo, G., Zakharevych, M., Sinitska, N., Gavrylenko, O., Chernychko, S., Taran, S., Shynkaruk, V., & Kuchai, O. (2025). STEM-Based Training in Future Specialists in Higher Education. International Journal of Basic and Applied Sciences, 14(6), 586-595. https://doi.org/10.14419/zqcznm16.
[18] Toquero, C. M. D. (2021). “Real-world:” Preservice teachers' research competence and research difficulties in action research. Journal of Applied Research in Higher Education, 13(1), 126–148. https://doi.org/10.1108/JARHE-03-2019-0060.