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INFORMATION AND COMMUNICATION TECHNOLOGIES AS A MEANS OF TEACHING NATURAL SCIENCE IN PRIMARY SCHOOLS: PROFESSIONAL TEACHER TRAINING

Marianna Horvat, Mariia Kuzma-Kachur, Nadiia Bryzhak, Tetyana Mochan, & Yuliia Chuchalina

ABSTRACT

The study's relevance lies in addressing the growing need for training primary school teachers to effectively incorporate information technologies in their teaching of natural science. The purpose of the study is to contribute to the improvement of students' training in the theoretical, practical, and methodological aspects of incorporating information technologies in teaching natural science.

The main criteria for the professional development of students are motivational-targeted, cognitive, technological, and reflexive-prognostic.

As a result of the research, a methodological toolkit was developed by the authors, according to which a psychological and pedagogical diagnosis of the indicated readiness of students was carried out ("Scale of readiness of the future teacher of primary classes for educational cooperation (motivational and goal criterion)", "Dictionary of concepts (cognitive criterion)". "Analysis of completed works (technological criterion)", "Self-assessment of completed tasks" (reflexive and prognostic).

In conclusion, the results of the study make it possible to divide primary school teachers into high, sufficient and low levels of readiness with the corresponding characteristics of quality measurements, which opens up prospects for the development of appropriate effective measures to improve the quality of student training for the use of information and communication technologies in theoretical, practical, and methodological aspects.

Keywords: Information and communication technologies, professional training of teachers, motivational and target criterion, cognitive criterion, technological criterion.

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INTRODUCTION

The changes taking place in Ukrainian education encourage researchers to train personnel capable of creating the educational process in such a way that would develop the ability of subjects to act creatively and apply knowledge and experience in practice. As the goals of education evolve, it is essential to adapt training methods and content to cultivate a holistic worldview, independent learning, critical thinking, and proficiency in modern information technologies. Additionally, fostering self-cognition and creative self-fulfillment are vital aspects of education in response to these changing goals. There is a new type of training – electronic. The strategy for the development of the information society in Ukraine defines e-education as a form of education obtained using exclusively information and communication technologies (Lushchynska, 2022).

The introduction of information and communication technologies in primary education is rapidly progressing. The training of teachers in utilizing these tools and methods has a clear impact on the outcomes of primary school education. Ensuring that teachers are equipped with the necessary skills in this regard is crucial for achieving successful educational outcomes. New reforms in education, conditioned by the adopted Law of Ukraine No. 2145-VIII "On Education" (2017), the introduction of a model curriculum under the Concept "New Ukrainian school" (2016), the implementation of the Law of Ukraine No. 74/98-VR "On the National Informatization Program" (1998) put forward new requirements for the quality of education. The educational space of the new Ukrainian school is not limited to ergonomics issues (Grinevich et al., 2021). The organization of the educational space requires extensive use of the latest information technologies, new multimedia teaching tools, and updating of digital educational equipment.

In turn, ergonomics involves the examination of how job demands and the surrounding environment can be aligned with the capabilities of the worker to optimize efficiency, productivity, and work quality. This approach aims to minimize the risk of work-related musculoskeletal disorders, fatigue, and overexertion (Grinevich et al., 2021).

The relevance of this problem for primary schools lies in the introduction of distance learning and the crucial role of propaedeutics in shaping positive attitudes towards different activities during the early stages of education. The use of information and communication technologies in education cultivates a holistic scientific worldview, fosters general cultural and scientific competencies, and enhances students' cognitive, practical, technological, communicative, and social skills (Chupakhina, 2020). Among them – is the possession of modern information technologies as a means of training. Efforts to improve education and enhance resources have not bridged the significant gap between digital society's development and proficiency in digital tools among teachers and higher education institution (HEI) graduates.

The possession of information and communication technologies is the fastest-growing segment of the readiness of future teachers for professional activities and needs constant improvement as the process of updating digital technologies continues. According to statistics compiled by C. Cooke (2023), The number of online learning users is expected to reach 57 million by 2027. According to her survey at the University of the Potomac, it turned out that 70% of students agree that online classes are better than traditional classroom settings. The term e-learning, which is becoming more popular, no longer causes a stormy reaction among teachers or researchers, and e-learning is a system of learning using information and communication technologies. It is worth noting that there is a prospect of legal regulation of the issue of introducing e-education in the modern educational space of various levels. In particular, the Order of the Ministry of Education and Science of Ukraine No. z0702-18 "On Regulations on the National Electronic Educational Platform" (2018) defines the main tasks, functions, structure, and principles of the National Educational Electronic Platform (e-platform).

The problem of using information and communication technologies in the preparation of students for the organization of distance learning in document science was covered by M. Korets and D. Chumachenko (2020). They scientifically substantiate the didactic conditions and the necessary technological tools for the implementation of a distance learning system for document science of future Bachelor of Vocational Education.

Researchers M.A. Folomeev et al. (2017) conducted a thorough study on the readiness of Ukrainian free economic zones to implement e-learning. As a result of their study was noted that in Ukrainian universities, 58% sporadically use ICT without fully integrating it into the educational process. Only 13% have embraced comprehensive e-education practices, utilizing electronic and distance learning technologies with institutional regulations.

D. Stockley (2021) emphasizes that the main feature of e-learning is that it involves the use of a computer or electronic devices (for example, a mobile phone) to conduct training and deliver educational materials. M.

Kluban (2019) fully shares the view of K. Belyakov et al. (2018) that any technology in education is information technology because the basis of the technological process of learning includes obtaining and transforming information.

M. Kovalchuk (2017) presented a model of the readiness of future teachers to use multimedia educational systems in primary schools. The structure of the developed model contains five interrelated blocks:

- theoretical (social procurement, purpose, scientific approaches, principles);
- motivational (methods and means of motivation);
- semantic (cycle of psychological and pedagogical disciplines ("Pedagogy", "Didactics", "Fundamentals of pedagogical skills", "History of pedagogy", etc.);
- professional and practical ("Methods of using computer technology in teaching school subjects", "Methods of teaching mathematics in primary school", "Innovative technologies of teaching mathematics", etc.), special seminar "Computer technology in working with children of preschool and primary school-age", research work of students;
- pedagogical practice programmes);
- procedural (forms, methods, and means of implementation of the methodology, which were introduced in stages);
- productive (components, criteria, levels, and results).

The purpose of the study is to experimentally test the system of training future primary school teachers for the use of information technologies in teaching natural science.

MATERIALS AND METHODS

The study employed a comprehensive approach, utilizing both theoretical and empirical methods to investigate the readiness of future primary school teachers in incorporating information and communication technologies in their teaching practices. In terms of theoretical methods, the researchers conducted an extensive analysis and synthesis of Ukrainian and European scientific, pedagogical, and methodological sources. This involved a meticulous examination of relevant literature, research articles, educational theories, and best practices related to the integration of technology in education. Furthermore, the researchers thoroughly reviewed the regulatory documents of Ukraine on primary education and the use of information technologies in the classroom. This theoretical groundwork provided a solid foundation for designing the study and formulating the research objectives.

For the empirical aspect, the researchers developed a methodological toolkit to assess the readiness of future teachers. This toolkit comprised specific instruments aligned with the main criteria for professional development, namely motivational-targeted, cognitive, technological, and reflexive-prognostic aspects. The "Scale of readiness of a future primary school teacher for educational cooperation (motivational and target criterion)" was utilized to evaluate the level of motivation and goal-oriented readiness of the participants. This scale measured the extent to which future teachers were prepared and motivated to collaborate with students in an educational setting.

The "Dictionary of concepts (cognitive criterion)" was employed to assess the cognitive readiness of the participants. This instrument aimed to gauge their understanding of key concepts and principles related to the use of information technologies in teaching natural science. Furthermore, the researchers employed the "Analysis of completed works (technological criterion)" to evaluate the technological readiness of future teachers. This analysis involved examining the quality and proficiency of the participants completed tasks using information and communication technologies.

Additionally, the researchers included a "Self-assessment of completed tasks" instrument to assess the reflexive and prognostic aspects of readiness among the participants. This allowed future teachers to reflect on their performance, identify areas of improvement, and predict their potential for growth in utilizing technology in teaching practices. By employing this combination of theoretical and empirical methods, the study was able to gather comprehensive data on the readiness levels of future primary school teachers. These methods ensured a rigorous and systematic approach to assessing the participants' readiness, providing a solid basis for the subsequent analysis and findings of the study.

24 students in the first year of study in the specialty "Primary Education" took part in the study voluntarily. Of these, 21 are girls and 3 are boys. All procedures performed in studies involving human participants were by the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

As the analysis of scientific literature showed, the problem of introducing information technologies into the general education institutions and the corresponding training of teachers is covered by teachers and a number of researchers, in particular: N. Balitska (2003), K.I. Belyakov, S.G. Onuprienko and I.M. Shopina (2018), N. Bibik, I. Havrysh, M. Zhaldak, Yu. Zhuk, P. Sokolov and M. Shut (2021), L. Makarenko (2007), N. Yusha (2019) et al.

The widespread use of modern information and communication technologies in education allows for fulfilling the humanitarian potential for studying natural disciplines, associated with the development of a scientific worldview, analytical and creative thinking, public consciousness, and a conscious attitude to the world (Zhaldak et al., 2021). Researchers emphasize the need for a harmonious combination of conventional and computer-oriented teaching technologies. This approach involves enhancing and strengthening past pedagogical achievements by incorporating advancements in computer technology and communication tools. The presented specific components of the foundations of the teacher's information culture are especially valuable for this study:

1. Ability to use modern information and communications technology (ICT) for preparation, support, analysis, adjustment of the educational process, management of the educational process and educational institution.

2. Ability to choose the most rational methods and means of teaching, and consider the individual characteristics of students, their requests, inclinations, and abilities.

3. Ability to effectively combine conventional methodological training systems with the latest information and communication technologies.

RESULTS AND DISCUSSION

Researchers are aware of the necessity to train highly qualified teachers who possess a strong information culture. These teachers should be ready to utilize information technologies in education and actively participate in the digitalization of the educational system. For an incentive to improve professional skills, motivation is a key component. Since the need for any activity is determined by the components of the motivational sphere, the most characteristic activities aimed at meeting a need are the state and features of the development of orientation in a particular activity. The motives of cognitive and labour activity are usually manifested in a specific form, quite clearly understood by a person (Plyushch et al., 2017). The rapid spread of information technologies in the educational space becomes a motivator for studying the methodology of their application.

Information and communication technologies allow raising the quality of lessons in primary and secondary comprehensive schools, in-class (lecture, practical, and laboratory) and independent sessions in higher educational institutions. Mastering the knowledge, skills, and abilities to create and use computer training programs in the educational process is an integral part of the professional training of primary school teachers (Barba-Sánchez et al., 2022).

In Ukraine, there has been a growing focus on measuring the impact of e-learning on student performance, satisfaction, and overall learning outcomes. Evaluations involve methods such as feedback surveys, assessments, learning analytics, and qualitative research. On a global scale, e-learning evaluation has become a crucial area of research and practice. Evaluation frameworks and models have been developed to assess the effectiveness and quality of online learning environments, considering factors like instructional design, technological infrastructure, learner support, engagement, and outcomes. Outcome measures include student achievement, knowledge retention, skills development, learner engagement, and satisfaction.

Continuous improvement is emphasized in e-learning evaluation, with feedback from learners, instructors, and stakeholders being gathered and analyzed to identify areas for enhancement. This feedback informs decisions regarding instructional design, technology integration, and pedagogical approaches. It is important to note that e-learning evaluation practices can vary based on local context, educational policies, and available resources. Ongoing research and advancements in e-learning evaluation contribute to the understanding and improvement of online education both in Ukraine and globally.

When mastering information technologies, the computer is considered mainly as an object of study, without focusing on the fact that it is a powerful learning tool, the use of which helps the teacher solve didactic and methodological problems at a qualitatively higher level. Notably, the information culture, the development of which is the focus of attention of researchers, does not exhaust the problem of readiness of primary school teachers for successful professional activity. Since a component of professional competence is the methodological level of readiness, the ability to effectively use information technologies in teaching all primary school disciplines (Hura,

2018). Therefore, the content of training aimed at developing the communication and information competence of a future primary school teacher should be differentiated by the specific features of the subjects that are taught.

Undoubtedly, each subject has its content. Therefore, the teacher must know the typology of electronic resources for teaching in each discipline, the typology of electronic tasks, the features of assessing the quality of educational electronic materials, quality assessment criteria, etc. Analysis of the state of providing academic disciplines with computer training programs shows that new services (especially during the implementation of the New Ukrainian School Concept) are constantly appearing on the services market, designed for the development of logical, critical, and figurative thinking of younger students (Poledňová et al., 2022). The most popular mini games among primary school children are: " Snizhok. Pryhody vedmezhaty", "Taiemnytsia Bermudskoho trykutnyka", "Operatsiia Zhuk", "Iabluchnyi pyrih", "Modnyi butik 2", "Niamstery", "Koshmarni ditky", "Turtyks", "Honky", etc. Their application in the educational process requires awareness of primary and secondary aspects of computer didactics by primary school teachers. For example, the game "Snizhok. Pryhody vedmezhaty" is designed to promote the development of logical, critical, and imaginative thinking in younger schoolchildren. Through engaging gameplay and interactive storytelling, the game stimulates logical thinking by presenting puzzles, challenges, and problem-solving tasks. Players are encouraged to analyze situations, make connections, and apply reasoning skills to overcome obstacles and progress in the game. Critical thinking is fostered as children are required to evaluate different options, weigh consequences, and make informed decisions within the game's narrative. This helps them develop the ability to think critically, assess situations from multiple perspectives, and consider the implications of their choices.

The implementation of the New Ukrainian School, supported by Intel technologies, emphasizes the need to enhance the skills of primary school teachers in utilizing modern information technologies for teaching. Additionally, it requires highly trained professionals in higher education who can contribute to the new e-learning environment. These professionals should be capable of developing innovative models within the "1 student – 1 computer" framework and creating their computer training programs. Training primary school teachers to effectively use information technologies in teaching specific subjects, such as natural science, requires special attention. It is important to develop a scientific and methodological system that integrates information technologies into these lessons, allowing students to acquire natural science competencies.

It is well known that high-quality professional training of future primary school teachers is possible if it functions as an integral, dynamic, open system that has the appropriate purpose, functions, content, forms, and methods of implementation at each educational qualification level (Bachelor, Master). In developing the readiness of pedagogical faculty students to introduce information technologies, three stages can be distinguished:

- the first stage – is basic training at the bachelor's degree level (1st and 2nd year students master the basics of computer use and a deep understanding of natural objects and phenomena). At this stage, it is important to master computer literacy and accumulate personal experience in using information technology tools, namely: knowledge of the basic concepts of computer science and computer technology, computer user skills, and application software;
- the second stage – 3rd and 4th-year students learn the theoretical and methodological principles of using information technology training and implement them during internships. At this stage, students learn to use information technologies for visualizing educational material and enhancing learning through computer games;
- the third stage is basic training for the master's degree (students master the methods and means of solving scientific problems and automating research in performing master's theses and mastering the discipline "Technology of teaching educational fields "Natural Science ", "Social Science".

Considering the features of training primary school teachers, it is advisable to identify criteria for their readiness to use information technologies in teaching natural science: motivational and target, cognitive, technological, reflexive and prognostic and levels: high, sufficient, and low. The study involved 24 first-year students majoring in "Primary Education" at Mukachevo State University to determine the initial level of readiness of a future primary school teacher to use information technologies in teaching natural science. The results of the study are shown in Table 1.

Table 1 **Results of the study on the readiness of 1st-year students in the field of "Primary Education" to the use of information technology in teaching natural science (%)**

Criteria | Levels	Motivational and target	Cognitive	Technological	Reflexive and prognostic
High	6 (25%)	3 (12.5%)	3 (12.5%)	12 (50%)
Sufficient	14 (58.33%)	11 (45.83%)	11 (45.83%)	9 (37.5%)
Low	4 (16.67%)	10 (41.67%)	10 (41.67%)	3 (12.5%)

The results of diagnostics of first-year students (2017 year of admission) indicate the prevalence of a sufficient level of readiness of the future teacher to use information technologies in teaching natural science. A fairly high percentage of the low level allows concluding that in the first year, a great part of students is not ready to use information technologies in teaching natural science. The lowest results were found according to cognitive (45.83% sufficient and 10 (41.67%) low) and technological (45.83% sufficient and 10 (41.67%) low) criteria. This trend is natural since 1st-year students do not yet have special knowledge and skills regarding the use of information technologies in teaching natural science.

A comparison of the results shows the relationship between cognitive, technological, reflexive and prognostic criteria of the future teacher's readiness to use information technologies in teaching natural science. To confirm the hypothesis that there is a correlation between these criteria, a correlation analysis was performed. The dependencies between all criteria were also checked using K. Pearson's formula:

$$r\,xy = \Sigma(X1-X)\cdot(Y1-Y) / n\,\sigma\,X\,y\,y, \quad (1)$$

where (x1-x) is the deviation of each x1 value relative to the arithmetic mean x; (y1-y) is the deviation of each y1 value relative to the arithmetic mean y; n is the number of pairs compared; σ x σ y – the average square deviations.

$$\sigma\,x = \sqrt{\Sigma(x1-x)^2/ (n-1)};\ \sigma\,y = \sqrt{\Sigma(y1-y)^2/ (n-1)}. \quad (2)$$

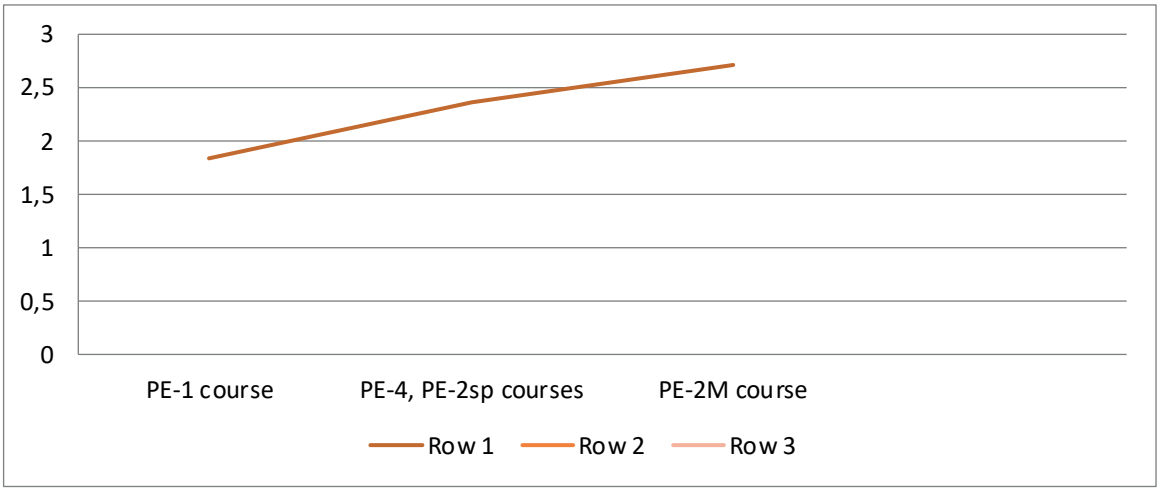
Calculations of correlation coefficients were conducted on indicators of the 2nd year of PE-1m and the relationship was identified between:

- cognitive and technological criteria (r1 XY=0.79>R tab=0.52);
- cognitive and reflexive-prognostic criteria (r 2 xy=0.66>r tab=0.51);
- technological and reflexive-prognostic criteria (R3 xy=0.74>R tab=0.52);
- motivational-target and cognitive criteria (r 4 xy=0.84>r tab=0.56).

Thus, a direct interdependence between all these pairs of criteria of the readiness of future primary school teachers to use information technologies in teaching natural science at the $p<0.02$ significance level is confirmed.

Quantitative and qualitative analysis of the study results on the readiness of future primary school teachers to use information technologies in teaching natural science showed the level of readiness in each course. Given that 1 point is a low level, 2 is a sufficient level, and 3 is a high level, respectively, the arithmetic mean for the 1st year is 1.83 for the PE-4, PE-2sp is 2.36, and 2.71 for PE-2M. The dynamics of average indicators of future teachers' readiness to use information technologies in teaching natural science at different stages of training are presented using a graph (Fig. 1).

Fig. 1. Dynamics of average indicators of future teachers' readiness to use information technologies in teaching natural science at various stages of training



The study revealed clear dynamics in the readiness of future teachers to use information technologies in teaching natural science at different stages of their training. Additionally, it is noteworthy that students demonstrated a special interest in the utilization of mind maps, both for subject-related and professional applications. Mind maps offer an interactive method for visually organizing knowledge, fostering the development of the professional image of pedagogy experts in higher education. They facilitate goal setting, self-reflection, identification of strengths and weaknesses, and the formulation of a plan for ongoing professional improvement. The use of mind maps is appropriate for organizing the independent work of Masters, and allows organizing their classroom and extracurricular work in a new way (Korkishko et al., 2020).

Moreover, the findings of N.V. Morse, V.P. Wember, M.A. Gladun (2019) on the application of 3D mapping of digital competence of students and teachers are of interest. The latest information technologies in the field of education are already widely used in Ukraine, so the Ministry of Education and Science together with EdEra has prepared an updated programme for grades 1-4. Moreover, for teachers to not be afraid to implement a new programme, the site (Edera L3C, 2022) offers tips and methodological recommendations that are freely available. The issue of the quality and process of improving teacher training for the use of information and communication technologies in primary schools remains open.

N. Yusha (2019), upon investigating the specific features of the development and spread of e-education in educational institutions, recommends restructuring the educational process into a discussion and cognitive one on educational topics based on ICT. This type of educational process would allow students to learn how to develop their opinion on the topic of the lesson, express this opinion publicly, and argue in favor of it.

Implementing information and communication technologies in science teaching faces challenges such as limited infrastructure, lack of teacher training, resistance to change, and cost considerations. To overcome these obstacles, strategies can be employed, including providing professional development for teachers, improving infrastructure, integrating ICT into the curriculum, addressing resistance through communication and evidence-based practice, and fostering collaboration and partnerships. By addressing these challenges, ICT can be effectively integrated into science teaching, enhancing learning experiences for students.

The question of whether acquiring knowledge online is worse than acquiring it in classrooms is subjective and depends on various factors. Both online learning and traditional classroom learning have their advantages and limitations. Online learning offers flexibility and accessibility, allowing individuals to access educational content from anywhere and learn at their own pace. However, classroom learning provides face-to-face interaction, immediate feedback, and the opportunity for real-time discussions and collaboration. Different individuals have varying learning styles, and some may thrive in a classroom setting while others prefer the independent nature of online learning (Akram et al., 2022). Additionally, online learning often provides diverse digital resources, while classroom learning may have limitations in terms of resource availability.

Classroom learning allows for personalized attention and immediate support from teachers, while online learning may incorporate support mechanisms like online tutoring. However, online learning may lack the immediacy of face-to-face interaction. Ultimately, the effectiveness of both online and classroom learning depends on factors such as the quality of instruction, learner motivation, technological infrastructure, and instructional design.

The choice between online and classroom learning should be based on individual preferences, learning goals, and the specific context of the educational experience. Blended learning approaches that combine elements of both can provide a balanced and effective learning environment.

The approach described above for evaluating the readiness of future teachers to utilize information and communication technologies in primary schools can serve as a foundation applicable to various disciplines. However, it is important to acknowledge that specific modifications may be required when implementing this approach in different scientific fields. The specialized knowledge and skills, self-assessment abilities, and use of multimedia emphasized in the approach can be adapted to suit the unique requirements and characteristics of specific disciplines.

For example, in disciplines such as mathematics or language arts, the specific technological tools and resources used may differ from those used in natural science. The assessment methods and criteria for measuring readiness and effectiveness may also need to be adjusted to align with the particular goals and outcomes of each discipline. Additionally, further studies can explore the impact of digital technologies on students' assimilation of educational material and the development of educational multimedia products in specific scientific fields. This research can provide insights into discipline-specific challenges and opportunities for incorporating information technologies effectively.

CONCLUSIONS

In conclusion, the readiness of future teachers to effectively utilize information and communication technologies in primary schools encompasses a range of specialized knowledge and skills, a consistent and motivated desire to engage in this activity, the ability to self-assess and enhance their own training, and the proficient use of multimedia in multi-subject and multifunctional propaedeutic pedagogical activities within the context of early inclusion of younger students in digital educational environments.

The findings from the formative stage of the experiment demonstrated positive progress in the development of future teachers' readiness to employ multimedia educational systems in primary schools, along with all its associated components. These results are further supported by statistical analysis, strengthening the validity and reliability of the study's outcomes.

Studying this topic is relevant and significant as it addresses the need to train primary school teachers to effectively incorporate information technologies in teaching natural science. By providing a methodological toolkit and assessing readiness levels, the study offers valuable insights and opportunities for improving the quality of student training in theoretical, practical, and methodological aspects. Promising areas of further studies are the impact of digital technologies on the assimilation of educational material by students, and the development of educational multimedia products in the field of natural science. This research has the potential to positively impact teaching practices and ultimately enhance the learning experiences of primary school students.

Future research on training primary school teachers to incorporate information technologies in teaching natural science should address limitations such as small sample sizes, limited measurement tools, short-term focus, contextual restrictions, variations in implementation fidelity, and reliance on self-assessment. By utilizing larger and more diverse samples, incorporating objective assessment tools, exploring long-term effects, considering various educational settings, assessing program fidelity, and supplementing self-assessment, future studies can provide more comprehensive and reliable findings.

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