Forum for Education Studies 2023; 1(1): 280.
Original Research Article

Formation of readiness for the use of digital technologies in future qualified computer workers with hearing impairments

Hanna Alieksieieva

Berdyansk State Pedagogical University, Berdyansk, Zaporizhzhia Region 71100, Ukraine; alekseeva.kts@gmail.com

ARTICLE INFO

Received: 27 October 2023
Accepted: 27 November 2023
Available online: 26 December 2023

doi: 10.59400/fes.v1i1.280

ABSTRACT: The conducted research offers a model and system of electronic support for training students of professional educational institutions with special needs to use computer technologies. The proposed model will help prepare future teachers for studying computer disciplines in general. To implement research tasks, we build a model of an object, determine its structure and relationships with other objects and systems, and highlight its features and characteristics. The model reflects the requirements for training students of professional educational institutions in the specialty "primary education", the assessment of the levels of readiness to use it in inclusive education, and diagnostic tools for determining the level of competence in ICT. The proposed model consists of four main blocks, which we will discuss in more detail. Due to the lack of a comprehensive approach to solving the most important social problem—creating equal opportunities for people with disabilities in all spheres of society, including in the field of education—a number of problems have emerged related to ensuring accessibility to the physical, social, economic, and cultural environment. To solve them, we must provide a differentiated individual package of support for the learning process in an integrated environment, taking into account the educational opportunities and needs of a student with special needs. The analysis of the results of the study confirmed the effectiveness of pedagogical conditions for preparing students of professional educational institutions with special needs for the use of CT in the process of studying computer disciplines based on an electronic textbook.

KEYWORDS: digital learning technologies; readiness to use digital learning technologies; people with hearing impairments; inclusive education; professional education; electronic textbook; educational environment

1. Statement of the problem

Digital technologies are becoming an integral part of the modern workplace, especially in areas related to computer sciences, where they contribute to efficiency and innovation. In various industrial sectors, there is a growing dependence on digital tools, including software, computing platforms, and the Internet of Things. This trend necessitates the development of digital technology management skills, particularly among computer science professionals, especially for future computer workers with hearing impairments. Mastering digital technologies is key to ensuring their competitiveness in the labor market, where digital literacy is becoming a necessity. They face unique challenges, such as limited access to

information through auditory channels and the need for adaptation of work tools to their specific needs. Developing inclusive technological solutions and educational programs that consider the characteristics of people with hearing impairments is critically important for integrating this group into the modern technological world[1–3].

Existing research and practices regarding the use of digital technologies by people with hearing impairments often focus on basic aspects of accessibility, overlooking the specific requirements of professional computer fields. Much of the existing solutions focus on general improvements in accessibility, not taking into account the specific needs that arise in complex technical tasks faced by computer professionals with hearing impairments. There is a lack of specialized research addressing the unique challenges these professionals encounter in their work with high-tech equipment and software, creating a significant knowledge gap. There is also a shortage of methodologies and educational programs aimed at developing digital technology skills among people with hearing impairments who are preparing to become computer professionals[4,5].

Our research focuses on developing and validating a model that enhances the readiness of future computer professionals with hearing impairments to effectively use digital technologies. The specific problem lies in the absence of integrated and specialized educational approaches and tools that take into account the unique needs and challenges faced by people with hearing impairments in the field of computer sciences. This includes the development of inclusive educational environments and the adaptation of computer tools to ensure equal access to professional education and opportunities in this field[6,7].

Schoolchildren, high school students, and youth with hearing impairments in Ukraine and worldwide represent the least numerous categories integrated into higher education institutions, colleges, and vocational schools. This unique group of young people with special educational needs, as recognized in a separate clause of the Salamanca Declaration (1994), requires barrier-free communication and interaction for successful integration into the educational process. Addressing their specific educational needs through pedagogical support is a current concern in educational science. The ability of these individuals to adapt to social environments is crucial for their successful inclusion and internal comfort. Educational inclusivity, ensuring equal access to quality education and training in vocational institutions, is a right for all people, including those with hearing impairments[8,9].

Educational aspects of teaching students with special needs in vocational institutions have been studied by researchers such as O. Paschenko, I. Grytsenog, N. Sofiy, R. Vainola, L. Sergeyeva, and others. The social support for children with special needs has been explored by L. Drozdova, A. Kokareva, A. Kolupaeva, and more. The information and technology revolution has significantly boosted socio-pedagogical progress, enhancing the education level and life quality of children and youth with special needs. Innovations in technology and inclusive education models have profoundly influenced pedagogical processes and professional relationships, making them more refined and harmonious. These technologies and models are particularly relevant in modern Ukraine, which is undergoing fundamental changes in inclusive education for students with hearing impairments in vocational institutions, colleges, and universities[10,11].

The importance of integrating computer training in the socialization of individuals with hearing impairments is emphasized in the works of D. Dymytrichenko, V. Yermakov, L. Kovalenko, K. Kolchenko, O. Lehkyi, H. Nikulina, I. Poretskyi, P. Talanchuk, L. Shautsukova, H. Tseitlin, and H. Yakunin, among others. In "Fundamentals of Typhlopedagogy: Development, Education, and Training

of Children with Hearing Impairments," V. Yermakov and H. Yakunin state that "in the current era, the range of professions related to coding and information processing is increasingly expanding." They discuss the unique aspects of the programming profession for individuals with hearing impairments. According to these researchers, it's possible to establish an ideal computer workstation for such professionals in any modern organization.

The formation of the readiness of future skilled workers to use digital technologies is a condition for the accessibility of education in accordance with the UN Convention on the rights of persons with disabilities[7]. The use of computer science tools has great potential for implementing inclusion tasks. Their innovative development makes it possible to personalize the interface parameters of the educational space in accordance with individual user requirements. That is why work on creating an educational information environment should take place within the framework of pedagogical control of results[12,13].

Under such conditions, the creation of an inclusive educational environment for teaching computer disciplines to future qualified computer workers, in particular those with hearing impairments, is of primary importance for the implementation of strategic tasks for the development of the education system[14]. Therefore, the model of the methodology for forming readiness to use digital technologies in future qualified computer workers with hearing impairments can be implemented in new inclusive environments created for vocational and technical educational institutions.

The relevance of this problem, the insufficient level of theoretical and practical development of it, and the revealed contradictions led to the choice of the topic of the article: "Formation of readiness for the use of digital technologies in future qualified computer workers with hearing impairments".

2. Analysis of key research and publications

The topic of inclusive education and its role in shaping readiness to use digital technologies is also discussed in numerous scientific sources. Researchers emphasize that inclusion in today's world is not just a trendy concept but a genuine societal need aimed at ensuring equal opportunities for everyone[15,16].

The issue of integrating individuals with special needs into the educational process, especially in the study of computer disciplines, has become increasingly relevant in recent years. Numerous scientific studies published in leading global journals highlight the need for developing methodologies and educational approaches that take into account students' individual characteristics. Research on international and national approaches to the implementation of inclusion in education has identified significant contributions from scholars in shaping the theoretical and methodological foundations of inclusive pedagogy (such as V. Zasenko, D. Deppeler, T. Dmitrieva, and others)[17,18]. Additionally, there were studies focusing on creating harmonious interpersonal communication and a positive psychological environment in inclusive settings[4]. Sources were also identified that discuss methods for the professional preparation of future teachers for activities in the context of inclusive education[13,19].

Questions concerning the preparation of future educators for their professional activities were explored by scholars such as O. Abdulina, A. Belyenka, O. Kucheryavy, L. Kondrashova, K. Krutiy, N. Kuzmina, and others. Particularly valuable for our pedagogical research are studies on the professional preparation of future educators for the application of ICT and modern technologies in the educational process, authored by K. Avramenko, I. Ziaziun, M. Mykhailichenko, O. Pometun, I. Dychkivska, and others[20].

The preparation of future educators for interaction with children in an inclusive educational environment has been studied by scientists such as I. Berezovska, K. Minakova[8], N. Nazarova, I.

Khafizullina, and Y. Shumilivska, among others. The authors emphasize that computer technologies can serve as a bridge to overcome communication barriers, highlighting the pedagogical significance of information technologies in inclusive education. It's highlighted that a specialized teaching approach can help enhance student motivation and engagement, which, in turn, positively affects the quality of education[21].

A literature analysis confirms the relevance and importance of the research issue. The growing attention of researchers to questions of integration and the use of IT in educating individuals with special needs indicates the need for further studies in this area.

3. The purpose of the article

To develop and validate a model for enhancing the readiness of future computer professionals with hearing impairments to effectively utilize digital technologies, ensuring inclusivity and accessibility in professional education by leveraging innovative computer science tools and personalized educational environments.

4. Research methods and techniques

The study was conducted on the basis of methods of designing the educational environment and the corresponding pedagogical experiment. The purpose of the pedagogical experiment was to create the necessary conditions for the formation of readiness for the use of digital technologies in the teaching disciplines of the information block and to ensure continuous computer training in vocational and technical educational institutions.

The pedagogical experiment was carried out to substantiate the developed model of the process of forming the readiness of vocational and technical educational institution students to use ICT in professional activities and diagnose the levels of formation of students' readiness to use ICT in professional activities after the end of the formative experiment in order to identify the effectiveness of the work performed.

This study presents a method for assessing the readiness of future qualified computer workers with hearing impairments to use digital technologies. The methodology is based on a model that promotes the training of students in professional educational institutions, especially those with special needs, for the effective use of computer technologies. This model also aims to prepare future teachers for comprehensive teaching of computer disciplines.

Model development: The initial step involves building a model of the research object, which includes defining its structure and establishing its relationships with other objects and systems. The model is developed in such a way as to encapsulate the essential features and characteristics of the educational process.

Model components: The model consists of four main blocks:

Requirements for training: This block sets out special requirements for training students in professional educational institutions, namely in the specialty "primary education".

Assessment of readiness involves assessing the levels of readiness to use the model in the conditions of inclusive education.

Diagnostic tools: The model contains diagnostic tools for determining the level of formation of students' ICT (information and communication technologies) competence.

Support package: a differentiated individual support package is offered to facilitate the learning process in an integrated environment. This package has been developed taking into account the educational opportunities and needs of students with special needs, in particular with hearing impairments.

Solving societal challenges: the methodology eliminates the lack of a comprehensive approach to creating equal opportunities for people with disabilities, particularly in the field of education. The focus is on ensuring accessibility in physical, social, economic and cultural environments.

Analytical approach. The analysis of the research results confirms the effectiveness of the pedagogical conditions for the training of students of professional educational institutions with special needs. This training is aimed at the use of computer technology (CT) in the study of computer disciplines, in particular with the help of an electronic textbook.

Therefore, this methodology is aimed at improving the skills of future computer professionals with hearing impairments in digital technologies, thereby contributing to their integration and success in professional and educational environments.

5. Research results

Obtaining a high-quality education for children with disabilities is one of the important mechanisms of their socialization, professional self-determination, acquisition of communication skills, and integration into society. Since September 2018, vocational schools have started training disabled people in inclusive conditions and implemented a set of measures to create a barrier-free environment for teaching this category of students in vocational schools.

The leading idea of the study is that the creation of an inclusive educational environment in the context of inclusive education, which is a personalized and continuous process, includes content and organizational components and is aimed at forming readiness to use digital technologies in professional activities. The content component of the methodology for forming readiness to use digital technologies in the inclusive educational environment of vocational educational institutions for future qualified computer profile workers with hearing impairments is represented by a modular program that includes interrelated stages designed on the basis of the outlined trends in the development of inclusion and the identified needs of applicants. The organizational component is represented by a model of the methodology for forming readiness to use digital technologies in future qualified computer workers with hearing impairments in an inclusive environment of vocational educational institutions with dynamic adaptive content[22].

In the process of teaching students with hearing impairments, we encountered the following problems:

a) weak organization of current training;

b) violation of general hand motor skills;

c) violation of the logic of thinking.

To overcome these problems, we have designed and created an inclusive information educational environment that combines elements of interactivity within classical education with distance educational technologies[23,24].

Distance technologies that support inclusive learning are presented in the form of the following resources:

1) The direction will be based not only on the basics of testing for students but also on other vocational schools. The site was created multilingually to provide a wide coverage of students with special needs.
2) Publication of lectures, laboratory assistants' works, presentations, and projects based on laboratory data with the ability to link articles (organize links between materials).
3) System portfolio of the student and teacher for sending works for review to teachers and supervisors.
4) A list of training events with the ability to specify the speakers of this speech. Each speaker and teacher (authors of publications) will have a public page with information about themselves and the ability to contact them. The ability to view the entire list of teachers who publish materials or have a connection with this area of study. Information about all other participants will be closed.
5) Gallery that will report on past events.
6) Publish all possible questionnaires to get detailed information about inclusion[25].

The structure of readiness to use CT in educational activities and the purpose of its formation are the fundamental elements of the model, around which the process of computer training itself is built (**Figure 1**).

By assessing the readiness of students with hearing impairments to use CT in future professional activities, we understand a stable structural and functional system of integrative personality traits that ensures the effective implementation of educational activities based on modern ICTs. The developed information environment (inclusive information and educational environment) includes remote technologies (the Internet) and an intranet portal (specialized software).

The electronic course includes the following activities:

a) working with the http://tool environment twitters.com;
b) creating presentations using the service www.prezi.com;
c) create interactive posters using any social service;
d) development of interactive online maps using any mapping service;
e) working with roadmaps of the educational process;
f) familiarization and work with www technology.wiki.IA;
g) creating albums using the service http://flipsnackedu.com (or similar);
h) create videos;
i) create poster files.

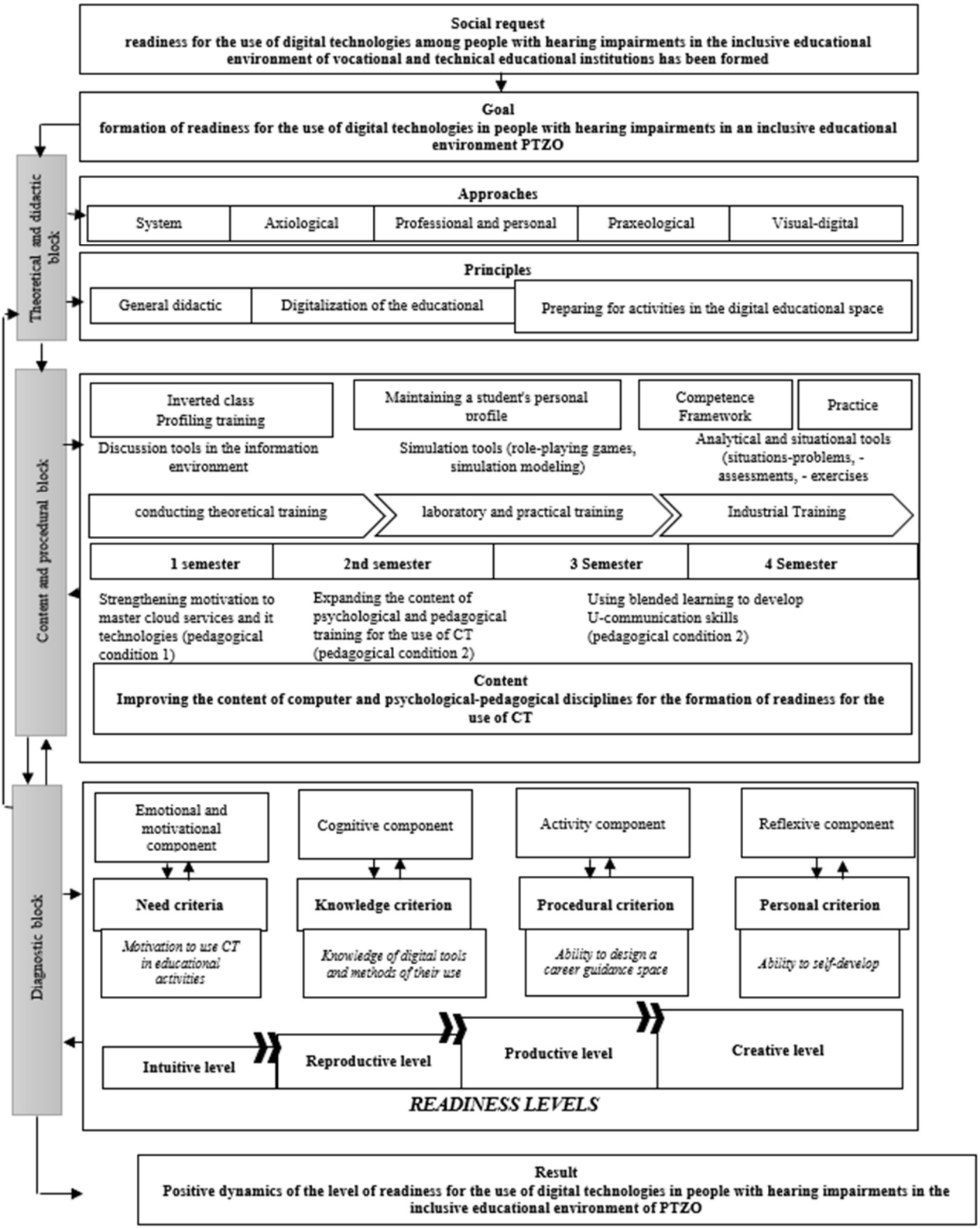

Figure 1. Model of the methodological system for forming readiness for the use of digital technologies in future qualified computer workers with hearing impairments.

With a focus on the testing-based learning process, an intranet portal has been created that contains the following software:

1) Prototyping site:

a) includes the entire technological process for developing prototypes of product models.

2) Automated information system "training utility models", which contains:

a) information and communication network;

b) physical principles of semiconductor operation;

c) associative array "database";

d) physical, logical formatting of the disk;

e) placing programs in the computer's memory;

f) logical elements;

g) number systems, etc.

3) Automated information system "electronic testing", which contains:

a) fund of test tasks in the Moodle SDO system;

b) test training shell;

c) interactive training tests.

4) Video portal:

a) video tutorials on the following information technologies: INSCAPE graphic editor, MS ACCESS DBMS, ABBYY FINEREADER program, WINDOWS OS, and a set of training podcasts.

5) Specialized electronic educational resources:

a) to improve the overall motor skills of the hands, a network training program called "keyboard" has been developed;

b) a specialized database has been developed for the development of logic and thinking among students of vocational schools with disabilities;

c) for successful development of the academic discipline, a set of educational materials called "fundamentals of programming" has been developed.

Due to the fact that it is difficult for students with special needs to master programming in procedural languages (Pascal, Basic, etc.), the process of learning the basics of programming was conditionally divided into two stages: learning the basics of programming in a Russian-speaking environment, and then learning programming in the environment of PascalABC.net. The proposed development can be installed both on the home computer of a vocational and technical educational institution student and on the college server. The second method of placement expands the teacher's ability to quickly edit the materials in the manual.

a) video portal with sign language elements, sign language translation, and subtitles:

- multimedia sign language dictionary for academic disciplines and specialties;
- integrated databases in the direction of using the DH in the specialty.

All theoretical and technological topics in textbooks on computer disciplines cover a large amount of practical work, various levels of complexity in the task book workshop, and additional workshops for engineering classes and artificial intelligence. The choice of the necessary topic and "setting the level of

difficulty" of studying the topic in the course of work are provided to students under the guidance of a teacher. In a simplified form, the levels of mastering the material represent a sequence: the actual reference task, which is analyzed in detail in the paragraph, supports the theory from the textbook, which is supported by the tasks after the paragraph; practical work on a thematic task in the mode of mastering a new software tool from the workshop; individual project work that has grown in the development of the mastered topic at previous levels, which has a socially significant context.

In the first chapter of the information environment, devoted to approaches to the definition of information, its representation, and measurement, the issues of various encoding methods are developed: with return to zero and without return (self-synchronizing), recovery of an analog signal from a digital one (Kotelnikov-Nyquist theorem), methods for compressing information based on uneven encoding (for example, Huffman encoding), and methods for detecting transmission errors and correcting them (in particular, on the example of Hamming code). Relevant computational problems are solved, and applications are discussed. It should be noted that the questions of number systems studied in the main school are used to implement coding in PTO. It makes sense to repeat the number system, but not to learn it again.

The second chapter, which examines the computer as an information system, describes modern approaches to the implementation of the von Neumann and Harvard architectures in their comparison and practical use. This section introduces the necessary purposes and design of logic circuits to create a complete picture of the element base of computers: registers, types of triggers, and decoders, at a sufficient level for understanding but not excessive. In conclusion, these questions are related to the technology of chip production. The topic of the main software classes is quite fully systematized. In particular, the features and characteristics of popular operating system lines are considered and compared; their composition and operating principles, as well as related application software and trends in their changes, are discussed.

In a separate workshop for engineering classes on this topic, three practical works are provided: drawing up and studying the principle of operation of a two-bit serial adder built on basic and combined logic elements, asynchronous and synchronous Rs triggers. For those who are not interested, you can limit yourself to studying the theoretical chapter and testing the topic.

The section devoted to modeling reveals the essence of the modeling method as the main method of cognition in computer science, as well as the essence and application of a systematic approach. Both of these methods are widely used in various scientific disciplines, both in theoretical research and in solving practical problems. The section provides for the use of a set of materials for a task book workshop to master practical skills, in particular modeling techniques in various environments, including using programming. Special attention is paid to simulation methods. In particular, the types of simulation models and classes of problems for which they are intended are considered. Using the Anylogic environment allows you to not only theoretically consider the features and applications of modeling methods but also to demonstrate their capabilities in solving obvious practical problems that were not even considered in computer science courses before. Practical work in the AnyLogic environment involves solving problems on current topics in all the main approaches to simulation modeling: agent modeling, discrete-personal modeling, and system dynamics models. Each task can be a completed mini-project. Project tasks can be improved, complicated, or transferred to another situation. Completed project work must be submitted (protected) individually.

Since models in the AnyLogic environment are actually programs in the Java language, the relationship between modeling and programming is practically demonstrated when solving problems. AnyLogic provides an opportunity to refine the model with the software tools included in the package.

The chapter on algorithmization and programming focuses on mastering the basics of algorithm theory and programming in the selected environment. Algorithmization is given much more attention than is customary in conventional programs. Algorithms are developed and/or analyzed throughout the in-depth course, i.e., they are present in all technological sections. Because the emphasis is placed on the algorithms that underlie existing information technologies, future developers of such products should learn how everything works from the point of view of mathematical methods and how the implementation environment works as early as possible. The classical textbook deals with the concept of the complexity of algorithms, the problem of algorithmic insolvability, and presents a number of effective solutions for problems that are important for further use, in particular algorithms for quick sorting, hashed search, etc. The algorithms proposed in textbooks are implemented in pseudocode with English vocabulary. This is done to ensure independence from the implementation environment, and the appendix to the textbook contains a table for translating pseudocode constructs into the most common programming languages in school. When learning programming, flowcharts are not used because the complexity of programs does not provide for their graphical interpretation due to the bulkiness of structures. The task book-workshop offers a fairly extensive list of tasks on the topic "programming technology". Using the task book-workshop in the classroom allows you to not allocate separate time to prepare for the state final certification. Students will not experience any difficulties in the exam since the material studied in the advanced course is more complex than the tasks offered in the exam. It should be noted that in the future, tasks related to the preparation of programs will be considered in almost all sections of the IIOs. This allows you to study the relevant sections not only to show the methods used to solve various applied problems in the form of an implemented algorithm but also to provide the teacher with the opportunity to organize practical work on preparing programs that implement elements of existing information technologies. In separate workshops for engineering classes and solving artificial intelligence problems. Programming in two languages is used to implement various practical tasks.

The application of methods and algorithms for obtaining new technological means in computer science is presented in the chapter "Information technologies for processing various information". It reveals both the theoretical and technological components of existing modern software products for working with information in their interrelation. To understand how modern information technology tools work, a sufficient number of tasks are used, and practical work is offered with the possibility of bringing them to educational and research projects. To strengthen some of the thematic modules of the textbook, additional workshops have been created in the UMK environment.

The section "Text Information Processing Technologies" covers material on two broad topics: preparation of printed publications by automated means and text analysis in natural language. In the preparation of printed publications, it is proposed to systematize the studied theory and practice with the opportunity to perform an interdisciplinary project where these skills will be needed for its design. The motivation for studying the second topic is the widespread use of the regular expression mechanism as part of text editors and processors, specialized tools for working with regular expressions, and software libraries that implement regular expressions in development environments, scripting languages, etc.

In the theory of the question, the syntax of regular expressions is considered, using the example of searching for a proper name. To check the correctness of composite expressions, the Expresso regular expression preparation and testing program is used. Next, typical problems with using regular expressions

are solved. You can use other online environments for practice. For those who are passionate about programming, practical work involves using regular expressions in preparing programs. The material in these works can be used selectively, taking into account the training and interests of students. The material allows you to start project work.

The study of the topic ends with theoretical material on what frequency text analysis is and what text generators are. The value of this material lies in the fact that it reveals the essence of the analyst's work in any field and how information technologies affect the effectiveness of this work. Content analysis and automatic classification are discussed in detail. A fairly high level of generalization of the material about scientific analysis is proposed, which forms the ability to identify general patterns in the processes taking place.

The section "graphics processing technologies" systematizes the previously acquired knowledge (raster and vector graphics, color models) and relies on the programming skills acquired in the framework of studying programming. To solve problems, we use graphical tools built into the. NET library package. The library itself is installed with the environment PascalABC.NET. To use it, an image object is created in the program code.

When studying algorithms and methods of machine graphics, the transformation of coordinates and shapes is considered, as is the construction of a segment using the example of the Brezenham algorithm. Next, we consider bitmap image processing and methods for compressing image files for storing them. Practical work begins with color transformation, then filters are applied, and the mathematical foundations of these processes are revealed.

The second part is devoted to three-dimensional modeling and also begins with a small theoretical material on creating photorealistic images and important areas of computer graphics application. Then comes the practical development of techniques for creating three-dimensional images in Google Sketchup. A separate workshop for engineering classes on this topic provides practical work for mastering the Autodesk Fusion 360 engineering graphics package.

The section "Information systems" discusses popular classes of modern information systems for various purposes. Theoretical material on IP is based on the conceptual framework studied in the main school (application program, database, table, form). Request, Report, etc.), which is specified and supplemented in the PTO.

First, we consider the diversity of IPs and their classification. It describes the types of information systems, the components and structure of IP, and the life cycle. Next, we consider data storage tools, basic database objects, data processing, query construction, report generation, etc. When performing practical work, we consider the big task of designing a database for a small company. The environment and the described approach allow us to set many practical project tasks not only for computer science but also for a lot of other subjects, both natural science and the humanities.

The chapter "Sound, Video, and Multimedia" begins with theoretical questions of sound processing, presents many new terms, and generalizes the material. Next, we offer practical development of the basics of sound engineering using the Nuendo program. The following are considered in stages: tracking—the process of editing recorded audio files using standard senquestor tools; mixing—creating a single sound track of good quality; and mastering—the final stage of working with a mixed audio track to eliminate sound defects.

Chapter 4, "Intelligent algorithms and artificial intelligence", is significantly new. Despite the popularity of this topic and the expanding use of intelligent software products at present, the issues of artificial intelligence (AI) in the content of the computer science course are covered rather poorly (only as expert systems) and mainly exclusively from the point of view of their availability and application in the near future. There are no practical works on this topic in textbooks, which does not allow students to form the necessary competencies for applying modern tools based on intelligent systems. There are more and more of them in our lives and professional activities. Just a few years ago, there was a sharp jump in the development of technologies related to artificial intelligence and data science. The number of open projects and research projects increased, which only widened the gap between the theory outlined in textbooks and the practice of using AI. The development of high-tech projects has led to an increase in the number of open frameworks, libraries, and other tools that can be used not only by programmers but also by non-professionals. The appearance of such tools with simple commands, often understandable without reading documentation, allows them to be used when considering complex topics at school, both at the advanced and basic level of computer science studies.

Traditional textbooks briefly mention the area of information technology referred to as "artificial intelligence", but do not describe the tasks of this area, existing ways to solve them, or specific tools and technologies. The availability of a sufficient number of hours and the level of training allow students to get an idea of some of the means of this field, their opportunities and limitations, and more accurately describe the global tasks that specialists have been solving for decades. No less significant is the fact that this area allows you to show the line between automated (albeit time-consuming) processes and non-automated ones and show the results obtained when solving such problems.

On this topic, a separate workshop on solving artificial intelligence problems is planned, revealing several areas: neural networks, machine learning, expert systems, and algorithms for finding patterns and rules.

To get an idea of the content of practical works, we offer the content of a workshop on artificial intelligence for students of vocational schools.

Content of the workshop on artificial intelligence for schoolchildren introduction:

1) What is artificial intelligence?
2) A little history
3) Tests for "humanity"
4) Big data and working with it

a) Terms: Data science and data mining
b) Data science consumers
c) Data science: Stages of analysis
d) Data, information, knowledge
e) Data mining models

5) Classification of intelligent algorithms
6) Preparing for practice

a) Organization of the working environment

7) Classification

a) Case study "zoological catalog"

8) Regression

a) Case study "who is the best athlete and why?"

9) Clustering

a) Case study "new to the class"

b) Case study "German loans"

10) Associative rules

a) Implementing the algorithm manually

b) Case "shop of my friends"

c) Case study "medical center"

d) Shelter case

e) Case study "Data scientist: The beginning"

11) Cart-building a crucial tree

12) Expert systems

a) Mini-expert system

b) Expert system for computer fault diagnostics

13) Neural networks

All practical tasks are performed using the Anaconda distribution in Python using the SciKit-Learn, Tensor Flow and Keras libraries, the Apriori module, and the PyKnow package. This is done to better reach the target audience with different academic training and motivation.

Within the framework of the proposed software courses, students' project research work is successfully implemented since the content of the courses mainly involves performing practical work that can "grow" into projects. The subject of projects is determined jointly by the teacher and students. The necessary theoretical material is present in the relevant chapters of advanced-level computer science textbooks, and practical work is taken from the task book-workshop.

6. Results and discussions

To test the proposed model at different stages of the study, students, working teachers, and leading teachers of departments of pedagogical universities were involved in the experiment. The total number of participants is 593, including 564 students, 16 students with hearing impairments, 10 teachers, and 19 vocational and technical educational institution teachers.

The knowledge criterion for checking the cognitive component provided for the study of the indicator "knowledge of digital tools and techniques". To determine it, we used testing of "digital programs" on the platform "Diya" (**Figure 2**).

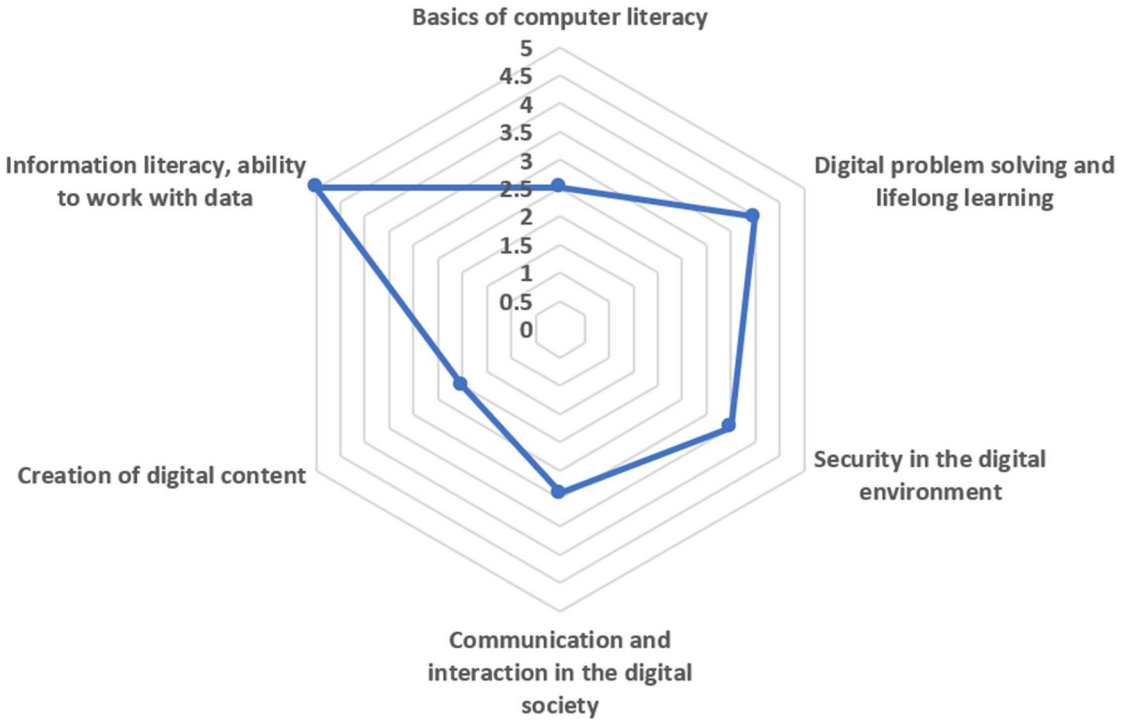

Figure 2. Knowledge of digital instruments and psychodiagnostic techniques.

As you can see, the positive dynamics of averages after the experiment are observed in all groups, but in the experimental groups more intensively. In particular:

- EG1 showed the best average dynamics (64%) for the indicator "motivation to use CT in the process of studying computer disciplines", which is explained by the introduction of the first pedagogical condition;
- EG2 showed the maximum increase in the average for the indicators "knowledge of digital tools and techniques" (70%) and "readiness for self-development" (60%), which is explained by the positive influence of the second pedagogical condition on the formation of cognitive and reflexive components of readiness to use CT in the process of studying computer disciplines;
- EG3 showed the best dynamics for the indicators "ability to self-develop" (72%), and "ability to design an educational space by means of CT" (50%), which is explained by the positive influence of the third pedagogical condition on the formation of activity and reflexive components of readiness to use CT in the process of studying computer disciplines.

So, the analysis of the results of the pedagogical experiment confirmed the effectiveness of pedagogical conditions for preparing students of vocational schools with special needs to use CT in the process of studying computer disciplines.

7. Practical implications

The findings from our study, particularly the observed positive dynamics in experimental groups (EG1, EG2, EG3), have several practical implications for the training and development of future computer professionals with hearing impairments. These implications are especially relevant for vocational schools and educational institutions aiming to integrate effective digital technology (CT) use into their curricula.

Enhanced Motivation Strategies. The significant improvement in motivation to use CT in EG1

suggests the effectiveness of the first pedagogical condition. This implies that similar strategies could be widely adopted to boost student motivation across similar educational settings. Educational programs should focus on enhancing motivation through targeted pedagogical methods, ensuring a more engaging and effective learning experience for students with hearing impairments.

Curriculum Development for Digital Tool Proficiency. EG2's marked increase in knowledge of digital tools and readiness for self-development highlights the need for curricula that prioritize digital literacy and self-driven learning. Educational institutions should integrate comprehensive training on digital tools and techniques, fostering a culture of continuous learning and adaptation.

Fostering Self-Development and Educational Design Skills. The notable improvement in EG3's ability to self-develop and design educational spaces using CT points towards the importance of teaching students not just to use technology but to creatively implement it in educational contexts. This underscores the need for programs that encourage innovative thinking and the practical application of technology in designing inclusive educational environments.

Implementing Tailored Pedagogical Conditions. The overall positive influence of the tailored pedagogical conditions on the experimental groups suggests that similar approaches should be implemented more broadly. This could involve developing specialized training modules and support systems that cater to the unique learning styles and needs of students with hearing impairments.

Policy and Resource Allocation. On a policy level, these findings advocate for the allocation of resources towards the development of specialized training programs and support systems. This includes investing in technology, training educators, and developing materials that are accessible and effective for students with hearing impairments.

In conclusion, our study's results emphasize the need for a holistic and inclusive approach to education for future computer professionals with hearing impairments. By adopting these practical implications, educational institutions can significantly enhance the readiness and competence of these students to use digital technologies, ultimately contributing to their successful integration into the professional world.

8. Conclusions

The planned educational results as a basis for the previously proposed competence structure can be achieved only in the process of students mastering modern educational technologies in the educational environment of the school. The use of an analog of a printed textbook in the form of an electronic textbook significantly expands interactive opportunities, significantly increases the visualization of educational material, provides operational control of the results of educational activities and their correction, provides access to new sources of educational information, and provides students with the means to solve practical and project problems that form research, design skills, and the creative nature of educational activities.

The experiment showed that the use of an electronic textbook encourages students with hearing impairments to participate in new types of educational and mental activities and to use their intellectual potential in the development of multimedia projects related to areas of future professional activity.

Conflict of interest

The author declares no conflict of interest.

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