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The Use of Adaptive Learning Technologies in e-Learning for Inclusive Education: A Systematic Review

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Abstract: The ongoing transformation of the education system involves the introduction of adaptive e-learning technologies at all levels, including inclusive education. The purpose of this study is to conduct a systematic review of scientific papers on e-learning, inclusion, and adaptive technologies. For this purpose, the PRISMA research approach was used to search for relevant sources and to initially process them. Main scientific bases: Scopus and Google Scholar. Date range: 2014-2023. The search for materials was carried out in stages: first, all duplicates were eliminated, a screening was performed, and sources were included based on 5 criteria (mainly content, methodology, and scientific novelty). The results show that the topic of using adaptive technologies, despite its potential, has not yet been covered in detail in scientific circles in recent years. The main methods of support and development of adaptive learning are co-teaching,



individualized and differentiated learning. Besides, they should be used comprehensively to ensure a fair and inclusive environment. The conclusions indicate that the implementation of adaptive learning is important for successful inclusion. Among the adaptive learning technologies, various e-learning platforms, adaptive systems, communication tools, and assistive technologies are important. Together, they contribute to effective support for students with special educational needs.

Keywords: inclusive education, technology, electronic technologies, equitable learning environment, tools, overview.

Introduction

The ongoing improvement of the education system involves the use of various technologies that open up new opportunities for education. This is especially relevant for the implementation of effective inclusive education. One of the key aspects contributing to the current transformation of education is the use of adaptive learning technologies in e-learning. Adaptive learning technologies contribute to the formation of different individual learning trajectories for each student (Alamri et al., 2020; Apoki et al., 2022). These technologies also ensure the implementation of a personality-oriented approach, which is relevant for modern innovative education. In general, the principle of student-centered learning is still relevant and is used in the world's leading countries in terms of education quality. It has been proven in modern studies that modern technologies allow taking into account special needs, abilities, and the pace of learning (Nabizadeh et al., 2020; Truong, 2016). In addition, they also make learning more interactive and interesting, which leads to greater motivation among students (Wen et al., 2020). This is especially relevant for ensuring quality inclusive education, which aims to provide equal access to knowledge for all students.

Research Problem

Despite the current interest of scholars in the use of technology, it requires more attention in the study of inclusive education. Also, despite the existing progress in the system of adaptive learning technologies, their implementation in inclusive education remains an insufficiently studied and practically implemented issue. In particular, it should be taken into account that the lack of a systematic approach to the integration of adaptive technologies into e-learning for students with special needs creates various barriers to achieving the goal of inclusive education (which provides access to education for all students). Thus, there is a need to conduct a qualitative analysis of existing research in this area in order to identify the main trends in the implementation of adaptive technologies in the modern education system.



Research Focus

This study will focus on a systematic review of scientific papers on the use of adaptive learning technologies in e-learning to determine their effectiveness for inclusive education. The focus of the current study will also be on the analysis of various approaches, methodologies and tools used to ensure individualization of the learning process, as well as their effectiveness in implementing inclusive education. Special attention will also be paid to identifying factors that contribute to the implementation of these technologies and the development of inclusive education in general.

Research Aim and Research Questions

The purpose of the study is to systematize and analyze existing research on the use of adaptive learning technologies in e-learning for inclusive education. The research questions are as follows:

1. What is the trend of scientific papers on adaptive technologies in modern education over the past 9 years?
2. What are the methods of adaptive learning used for students with special educational needs?
3. What are the tools for implementing adaptive learning technologies in inclusive education?

Literature Review

The problem of applying adaptive learning in the current conditions of technological development has attracted the attention of scientists who have analyzed various aspects of this phenomenon. Aulakh et al. (2023) analyzed the experience of using digital technologies in the context of the COVID-19 pandemic, pointing out the importance of adaptability when analyzing large amounts of data. Betlej and Danileviča (2022) traced the possibilities of modern educational technologies for use among people with mild intellectual disabilities. A similar topic was addressed by El-Sabagh (2021), who emphasized the importance of understanding students' specific learning styles - in fact, the need to form individual learning trajectories in each case. Peng et al. (2019) supported the formation of a smart learning environment that will allow to realize all the benefits of using digital learning platforms. The issue of personalization of learning was investigated by Hocine and Sehaba (2023), who systematically reviewed personalized online digital education systems for people with cognitive disabilities. Hussein and Al-Chalabi (2020) pointed out the possibility of using special pedagogical agents that can support students in the implementation of adaptive learning. In the post-pandemic context, a lot of attention has been paid to the further development of digital technologies: researchers are emphasizing the importance of personalization in education. Such vectors also demonstrate the movement of



modern pedagogical thought, which is designed to take into account the characteristics of students at all stages of education.

Mechanisms for the development of digital online environments have also become a separate area of research. Beem et al. (2023) traced the peculiarities of the application of the design method on the African example, which also had a particular impact on inclusive education. De Medio et al. (2020) explored the possibilities of the Moodle platform for creating courses for inclusive education. Hubalovsky et al. (2019) demonstrated the effectiveness of adaptive online learning aimed at acquiring the necessary competencies in the future on the example of a secondary school. Labonté and Smith (2022) also analyzed the experience of using adaptive digital learning in secondary school - in their opinion, a comparative study based on empirical indicators showed the benefits of digital learning, including in inclusive education. In contrast, Horne et al. (2019) pointed out some of the challenges that exist in the use of digital environments in education. Although the conclusions of this article were made a little earlier, the relevance of most of the comments still exists, that is, the problems noted by scientists have not lost their importance. Some elements to address the shortcomings were proposed by Persico et al. (2014): the researchers considered adapting the technology acceptance model to identify specific factors that do not contribute to the evolution of new technologies in inclusive education. Pratama (2021) identified important hypotheses about the use of the technology acceptance model (using Google Classroom as an example). The proposed remarks are valuable for further perspective in the research work. In general, the research focuses on ways and models to overcome the challenges of incorporating digital technologies into inclusive education.

At the same time, Marín et al. (2020) summarized some results in the study of digitalization of education, considering digital technologies as important components in the formation of independent thinking among students. Also, Eljak et al. (2023) systematically reviewed the possibilities of cloud computing technologies for the use of e-learning platforms. Such studies are generalized, but do not provide complete answers to questions related to the need for changes in digital technologies in connection with their use in inclusive education. This opens up opportunities for further research, taking into account existing scientific views. In particular, the systematization of the main tools to support adaptive learning in the e-learning environment is poorly understood. This study will attempt to do so.

Materials and Methods

This systematic review was conducted using various scientific materials, including articles, chapters from monographs, books, etc. A qualitative research approach was used to process all the materials found.

Sample and Participants

The sample of sources was based on the inclusion of various scholarly materials, including chapters from collective monographs, scholarly articles, and books. However, articles of less than 4 pages and materials from scientific conferences were not taken into account. The sample also



included references from peer-reviewed journals and papers written by reputable scholars. This was done in order to include high-quality research papers in the study and to analyze them further.

Instruments and Procedures

The main tool for the research was the PRISMA approach, which involved searching for the most relevant scientific literature and processing it step by step. In particular, the authors of the article were initially aware of 11 papers that were included in the study because their topics were relevant to the research. After that, keywords such as adaptive technologies, inclusion, modern education, inclusive education, innovations were entered into the selected search databases, including Scopus and Google Scholar. After that, 2276 results were found. First, all duplicates were eliminated (589). Based on the analysis of abstracts and titles, all articles that were not relevant to the topic of the article were rejected and referred to other scientific sources. This resulted in 938 sources. After that, all irrelevant articles that were not related to education or technology were excluded (-259). This yielded 679 results. The criteria for including literature were based on the content of the work and the methods of the study. A total of 5 inclusion criteria were obtained:

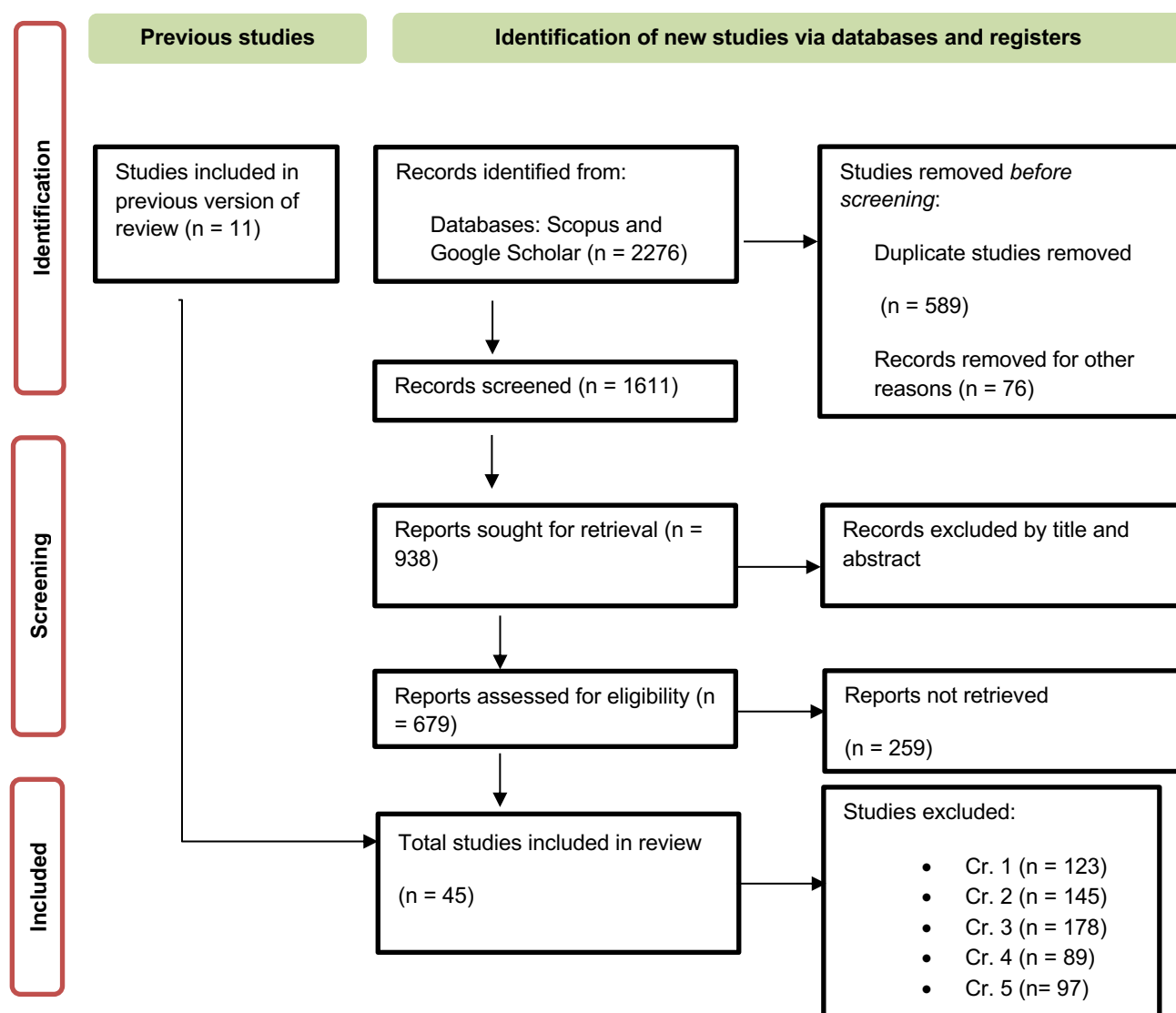
1. The paper describes 1 or more adaptive technologies
2. The study describes different mechanisms for their implementation
3. The study characterizes the features of their use to ensure an inclusive environment
4. The study contains a methodology or mentions the specifics of the study
5. The study has scientific novelty and practical significance

Based on these criteria, 45 scientific sources were selected (See Figure 1).



Figure 1

Using the PRISMA approach for data collection



Source: Author's development.

Data Analysis

The method of coding was used to analyze the data. In particular, such concepts as the type of technology and its importance for inclusive education were entered into pre-formed tables based on Microsoft Word. The information from the authors was entered into these tables in order to trace the main trends in the use of adaptive technologies. At the same time, the study also used a comparison method. This was done in order to compare the data obtained with the data presented in other works. The synthesis was used to combine the results and summarize the main trends.

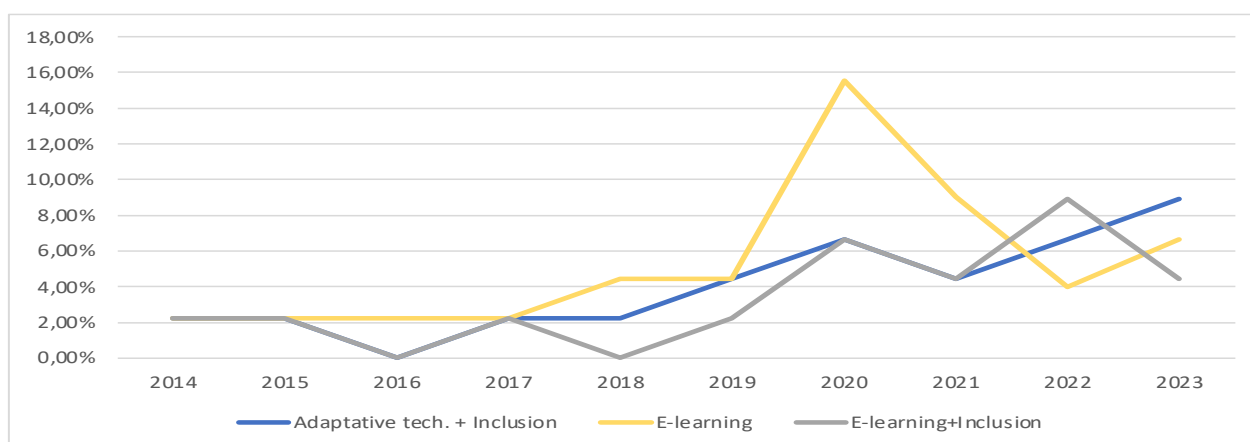


Results

There are more than one billion people with disabilities in the world. UNESCO research shows that despite significant progress in the fight against discrimination, there are still many areas in which opportunities for people with disabilities are less than for the general population (Cinquin et al., 2019). This is also true for the education system, where the representation of people with disabilities falls significantly from primary school to higher education, resulting in lower qualifications. For those who suffer from cognitive or intellectual disabilities, this is even more important, as they may be active members of an educational system that may contain people who are not ready for inclusion (Björnsdóttir, 2019; Cinquin et al., 2019). Therefore, the implementation of an inclusive environment requires teachers to have mandatory skills, in particular, skills in the use of adaptive and assistive technologies. Over the past 9 years, there has been a noticeable interest of scientists in the problems of ensuring inclusion in the e-learning environment. In general, in 2014-2017, this problem was not so popular among academics. However, since 2019, researchers have become more interested in the use of electronic technologies to ensure inclusion (see Figure 2).

Figure 2

Diagram of the Appearance of Scientific Papers in 2014-2023



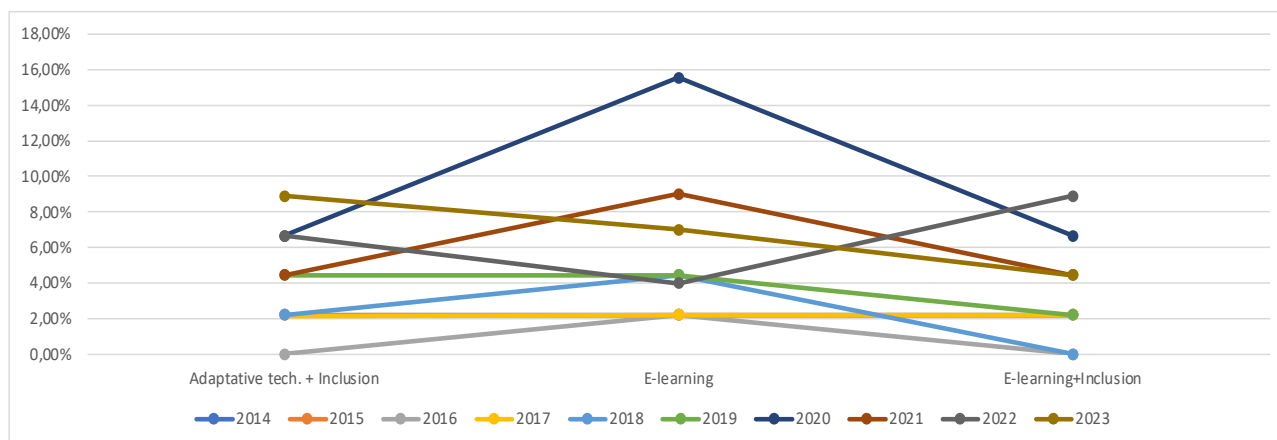
Source: Author's development.

In 2020, the topic of e-learning implementation became especially popular among academics. This can be explained by the active transition to distance learning during the Covid pandemic.¹⁹ However, after that, as of 2023, this topic has not been as actively discussed in academia. The issue of using adaptive technologies to promote inclusion was not as popular in the authors' works as e-learning (see Figure 3).



Figure 3

Diagram of Scientific Papers in 2014-2023 (According to Topics and Years)



Source: Author's development.

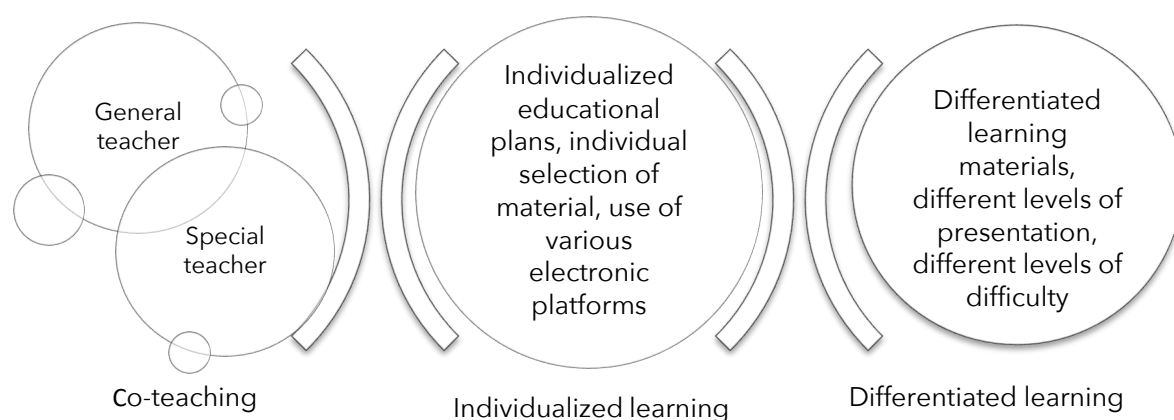
Implementation of adaptive learning technologies for students with special educational needs involves the use of various methods and tools in the e-learning system. They can be adapted to the individual needs of students. An important technique that promotes inclusion in the e-learning environment is the introduction of individualized learning. In particular, this involves the introduction and use of various platforms and applications that can adapt learning materials to make learning convenient for each student (Bradac & Walek, 2017). These platforms also make it possible to customize learning resources according to the needs of each student and take into account their strengths and possible weaknesses. Individualized curricula also play an important role in this methodology (Kakosimos, 2015). The latter should be developed specifically for each student, taking into account their unique needs and goals. They should be based on learning objectives, strategies, and assessment methods.

Another important technique is the introduction of differentiated instruction, which requires teachers to use different methods of presenting material (including video, audio, text) and different forms of assessment. This will help meet the needs of different students. Implementing differentiated instruction also involves transforming the content, process, or learning environment to meet the needs of students, especially those with special education needs. Differentiated learning also involves the use of different learning materials and different levels of difficulty. In addition, the availability of different forms of information presentation should also be taken into account (Kem, 2022). However, perhaps the most important method is cooperative learning. It is implemented when there are two teachers in the classroom. This involves the organization of teaching in a classroom by two teachers, usually a general teacher and a special educator. They work in the same classroom to provide individualized support to students with special needs. Figure 4 demonstrates the structure of adaptive techniques used to support an inclusive environment in a modern classroom. In particular, co-teaching takes the 1st place in this system, followed by the formation of an individualized learning environment and the use of a differentiated approach.



Figure 4

The Structure of Using Methods to Support Inclusion in the e-Learning Environment



Source: Author's development.

The use of various learning management systems (LMS) platforms is an important tool for supporting an inclusive e-learning environment. In particular, applications such as Moodle, Canvas, or Google Classroom play an important role and can provide various features to facilitate individualization of the learning process. They help to customize tasks for special needs, create adaptive tests, and provide quick feedback (Kolekar et al., 2018). Adaptive learning systems are also important for ensuring quality inclusion in the educational environment. In particular, such tools (Knewton, DreamBox, Smart Sparrow) are aimed at quickly analyzing answers and automatically adjusting further tasks according to their level of knowledge or, possibly, needs. Interactive learning support tools also contribute to inclusion, as they allow for the creation of various interactive learning materials (Kem, 2022). At the same time, it is important that teachers know how to adapt them to different levels of difficulty. Communication is particularly important for maintaining an effective learning environment. In particular, research has shown that tools that allow for virtual communication, virtual classrooms, electronic discussions, or individual consultations are essential for creating an inclusive educational space. In the e-learning system, when there is no proper level of social communication, this step is mandatory for the effective organization of the learning environment.

Assistive learning technologies are almost essential for maintaining an effective inclusive e-learning environment. The Read & Write app helps support students with reading, writing, and learning disabilities. Its features include text-to-speech, dictionaries and translators for better understanding of the text. The Kurzweil 3000 provides support for students with dyslexia or reading difficulties. It also allows you to convert text to speech using a high-quality voice synthesizer. The application system also includes tools for highlighting and annotating text and managing learning materials (Mavroudi et al., 2017). Dragon Naturally Speaking features speech recognition, which allows users to dictate text and control the computer by voice. At the same time, there are special assistive learning technologies for students with visual or hearing



impairments. In particular, screen readers (JAWS, NVDA, Voice Over) quickly convert text into speech. For students with hearing problems, there are special applications that help amplify sound and provide subtitles or sign language translation. In the system of proper inclusive education, it is also important to pay attention to programs that promote the development of social and communication skills. In particular, Social Express and Emotion Regulation Apps allow students with autism and other disorders to develop social skills and emotional intelligence. Thus, the use of these tools in eLearning can effectively ensure accessibility of education for all students. Table 1 provides a detailed description of these tools and the results of their use.

Table 1

Summary table of tools that facilitate adaptive e-learning

Title	Main tools	Results	Authors
Electronic learning platforms	Moodle, Canvas Google Classroom, Zoom, Microsoft Teams, Google Meet	Individualization of the learning process Customization of tasks Creating adaptive tests Providing feedback.	Kolekar et al. (2018); Marone and Heinsfeld (2023); Khamparia and Pandey (2019)
Adaptive learning systems	Knewton, DreamBox, Smart Sparrow, etc.	Quick analysis of responses Support for an individual approach Customization of tasks according to skills and abilities	Mavroudi et al. (2017); Kem (2022); Timothy et al. (2020); Eljak et al. (2023); Essa et al. (2023); Colchester et al. (2017)
Interactive learning applications	Quizlet, Kahoot!, Nearpod, Canva, H5P, Adobe Captivate, Articulate 360	Maintaining interest in learning Development of motivation	Behl et al. (2022)
Technologies that facilitate electronic communication	Google Classroom, Zoom, Microsoft Teams, Google Meet, Read&Write, Kurzweil 3000, Dragon NaturallySpeaking, Viber, Messenger, Telegram	Support for communication Interaction between teachers and students Communication support for people with special needs	Marone and Heinsfeld (2023); Kolekar et al. (2018); Kem (2022); Eljak et al. (2023)
Assistive technologies (for better reading, vision, speech)	For hearing problems: Ava, Roger Pen, Pocketalker For realizing sign language: Purple VRS, Sorenson VRS	They help to voice the text. These platforms also promote speech development because they contain different	Hubalovsky et al. (2019); Moriña (2019)



	For students with reading, writing, and speech problems: Read&Write, Kurzweil 3000, Dragon NaturallySpeaking	communication interfaces. These apps include special subtitles or a keyboard	
Assistive technologies (Programs for the development of social and communication skills)	Social Express, Emotion Regulation Apps, etc.	Help students with autism and other disorders develop social skills and emotional intelligence	Betlej and Danileviča (2022); Megahed and Mohammed (2020)

Source: Author's development.

Therefore, to ensure effective inclusion, it is necessary to combine different adaptive learning methods and tools. Such diversity will help improve the motivation of students, make learning more interactive and accessible to all students.

Discussion

Identifying opportunities for using digital technologies in inclusive education, given student-centered learning in the modern world, has become a relevant subject for scientific discussion. The proposed study systematizes and examines individual studies on such issues as the use of adaptive learning technologies in e-learning in the environment of inclusive education. It was intended to trace the existing scientific hypotheses on such issues as trends in the emergence of scientific papers, analysis of existing adaptive learning methods used in the teaching of persons with special educational needs, and identification of effective tools for the implementation of adaptive learning technologies in inclusive education.

The proposed results indicate that the problem of using digital technologies in inclusive education is relevant in the modern scientific environment. The analyzed works indicate general trends in the importance of a student-centered approach, adaptation of educational methods to the specific needs of students. This confirms the results of Özyurt and Özyurt (2015), according to which the current state of scientific development of the topic is a continuation of the older trends in the development of scientific thought. Studies have also noted that the emphasis on the importance of inclusive education indicates the manifestation of humanistic trends in education, which is facilitated by active digitalization (Bjekić et al., 2014; Ingavélez-Guerra et al., 2021). Such assessments, which dominate today, are an important consequence of the combination of technology development and worldview paradigms.

When considering the second question, it was determined that the introduction of adaptive learning technologies for students with special educational needs involves the use of various methods and tools in the e-learning system. First of all, the current trend is the introduction of inclusion in the e-learning environment, which contributes to the individualization of the educational process: it is the introduction of various digital platforms that can transform learning materials to make learning convenient for each student. These results confirm the findings of



other researchers on the importance of individualizing learning (Cinquin et al., 2019; Kardan et al., 2015). Starks and Reich (2022) also advocated the possibility of using modern technologies in inclusive education, but with an emphasis on the special conditions for their use. The proposed results confirm this view, as digital technologies should be developed specifically for each student, taking into account their unique needs and goals. Another relevant methodology is the use of differentiated learning, which is based on the specifics of the material presentation (video, audio, text, etc.). Similar views are also held by Ezzaim et al. (2023), who, however, point to the possibility of using artificial intelligence in this methodology. Without denying this result, it is worth noting that AI technologies are developing quite dynamically, and therefore final conclusions about their usefulness will still need to be considered.

The proposed results indicate that the use of various e-learning platforms (LMS) is an important tool for supporting an inclusive e-environment. First of all, we are talking about the capabilities of Moodle, Canvas, or Google Classroom, which can be useful for further individualization of the learning process. The proposed results confirm the views of Ünlüsoy et al. (2021) that cutting-edge tools related to virtual communication, virtual reality, etc. are of great importance for creating an inclusive educational space. The proposed study also refers to the need to establish social communication, which is also emphasized by other scholars (Gandolfi et al., 2021; Moriña, 2019). The importance of these factors is undeniable and has a direct impact on the development of inclusive education today. However, other researchers have also emphasized the importance of using machine learning to support adaptive models (Hillel et al., 2021; Warin & Stojkov, 2021). However, the authors of this study believe that such approaches will not at all contribute to the development of a truly inclusive environment.

The proposed methodology has limitations. First of all, it is necessary to take into account the fact that the research literature on the use of digital technologies in inclusive education is quite numerous and its development will still require additional efforts. First of all, we are talking about focusing on English-language studies that offer an up-to-date overview of the state of the problem. This, on the one hand, opens up opportunities for taking into account the most relevant scientific opinions and hypotheses, but at the same time somewhat limits the search possibilities. Some non-English-language articles written in other academic environments could have been overlooked in the results presented here. Undoubtedly, such a layer of material may contain relevant thoughts that still require scientific analysis. On the other hand, the works analyzed in this study have their own base of scientific references, which was also studied.

Conclusions and Implications

Consequently, the research revealed a growing interest in inclusion. In particular, during the last decade, scientists have increasingly paid attention to ensuring inclusion in the electronic learning environment. This is especially noticeable since 2019, when an active study of the introduction of electronic technologies to support students with special educational needs began.



The study found that the implementation of adaptive learning is critical for successful inclusion. The inclusion of individualized learning, a differentiated approach, and collaborative learning allows you to take into account the unique needs of each student and create favorable conditions for learning. Individualized learning plans, based on the specific needs and goals of students, are the foundation for effective learning. This allows you to create a more targeted and productive learning environment.

Modern e-learning platforms, adaptive systems, communication tools and assistive technologies play an important role among adaptive learning technologies. Together, they provide effective support for students with special educational needs, including reading, writing and communication difficulties. Thus, the integration of adaptive technologies in e-learning is an important condition for ensuring accessible education for all students.

Suggestions for Future Research

Further perspectives of research on the use of adaptive learning technologies in e-learning in the field of inclusive education will require consideration of several aspects. First of all, we are talking about the next digital evolution, which will determine the vectors of development of learning technologies. As demonstrated in the study, the current state of integration of e-learning platforms in the educational process is based on the use of a certain set of platforms. At the same time, this list may grow in the future, so the integration of new technologies into inclusive education may acquire other features. The possibilities of artificial intelligence deserve special attention, which will make it possible to form individualized educational learning trajectories, which will significantly increase the effectiveness of inclusive education. The second aspect that will require further research attention is the interaction between teachers and modern technologies. however, it is said how teachers use already available digital tools and what are the future prospects of such development. The third aspect is the possibility of individualization of learning, which is partly provided by the combination of the previous two elements. In the case when teaching skill and technological aspects are combined, we are talking about the importance of forming a suitable educational environment, which in the conditions of inclusive education will make it possible to realize the full potential of combining the use of digital tools and features of teaching skill. Taking such aspects into account is an important direction for further research in the specified issue.

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Conflict of Interest

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