American Journal of Psychiatric Rehabilitation Expert Opinion Article

# Enhancing Educational Access: Digital Solutions for Students with Special Needs

**Iryna Zhadlenko[1]*, Olha Morenko[2], Liudmyla Nikolenko[3], Olena Lastochkina[4], Maryna Mykytenko[5]**

[1]*Candidate of Pedagogical Sciences, Associate Professor, Faculty of Special Education and Social and Human Sciences, Khortytsia National Educational Rehabilitation Academy, Zaporizhzhia, Ukraine, Email: ira-29@ukr.net, ORCID: https://orcid.org/0000-0003-2696-6690
[2]Candidate of Pedagogic Sciences, Associate Professor, Department of Pedagogy and Teaching Methods, Faculty of Rehabilitation Pedagogy, Municipal Institution of Higher Education "Khortytsia National Educational Rehabilitation Academy" of Zaporizhzhia Regional Council Zaporizhzhia, Zaporizhzhia, Ukraine, Email: morenko@khnnra.edu.ua, ORCID: https://orcid.org/0000-0002-6774-7753
[3]PhD in Pedagogy, Associate Professor, Department of Pedagogy and Special Education, Faculty of Psychology and Special Education, Oles Honchar Dnipro National University, Dnipro, Ukraine, Email: L.nikolenko1@gmail.com, ORCID: https://orcid.org/0000-0001-8708-3117
[4]Candidate of Pedagogical Sciences, Associate Professor, Speech Therapy Department, Educational and Scientific Institute of Physical Culture, Sumy State Pedagogical University named after A.S. Makarenko, Sumy, Ukraine, Email: lllastochkina@gmail.com, ORCID: https://orcid.org/0000-0003-3251-4746
[5]PhD Student, Department of Pedagogy, Kryvyi Rih State Pedagogical University, Kryvyi Rih, Ukraine, Email: M_mikitenko@ukr.net, ORCID: https://orcid.org/0000-0002-7644-8819

***Corresponding Author:** Iryna Zhadlenko
*Candidate of Pedagogical Sciences, Associate Professor, Faculty of Special Education and Social and Human Sciences, Khortytsia National Educational Rehabilitation Academy, Zaporizhzhia, Ukraine, Email: ira-29@ukr.net, ORCID: https://orcid.org/0000-0003-2696-6690

**Abstract**
The digitalisation of the educational process and the development of technologies ensure compliance with the principles of accessibility and equality of education. The article is devoted to studying the problem of developing inclusive education in the digital age to ensure the accessibility of education for students with special needs. The study used the methods of questionnaires, a pedagogical experiment, a comparison of the learning outcomes of higher education students before and after the introduction of the outlined pedagogical technology, and statistical processing of the results obtained according to Pearson's criterion. An analysis of classical and digital inclusive approaches and technology for implementing inclusive digital education methods was developed. Criteria and sub-criteria for the effectiveness of inclusive teaching methods in the digital educational environment have been developed for self-assessment. In the course of the self-assessment of the effectiveness of the technology for implementing inclusive digital education methods, the need to increase the availability of digital learning materials, the convenience of adaptive learning platform interfaces, the availability of technical support, inclusive-oriented teacher training, and the logistics of the inclusive learning process was identified. The statistical verification of the effectiveness of introducing digital inclusive learning tools for students with special needs showed an increase in the number of higher education students with high learning outcomes. Introducing digital teaching methods opens up new opportunities for creating an inclusive environment. However, there is a need to develop and implement technical, technological and methodological strategies for working in the learning environment for students with special needs.

**Keywords:** inclusive education, digitalisation, ensuring accessibility of education, students with special needs.

**JEL classification: I 20, I 29**

## Introduction

The development of modern pedagogical approaches ensures equal access to education by introducing inclusive approaches. The digitalisation of education contributes to the emergence of conditions when higher education students with special needs have equal access to educational technologies and participate in the educational process by integrating digital inclusive tools into the educational process. The development of information and communication technologies and artificial intelligence makes it possible to bridge the digital divide in training higher education students with different needs. Technologies such as voice assistants, subtitles, and online learning platforms are indispensable for

students with visual, hearing, and mobility impairments.

However, selecting the most effective digital tools and platforms requires the development of methods and pedagogical technologies for their implementation in the educational process. Challenges to ensuring inclusive education in the digital age include the inconsistency of educational platforms with international accessibility standards, the need to improve the skills of teachers working with students with special needs, the need to overcome the problem of social exclusion for students studying using inclusive methods, and the need for logistical support for the educational process for students with special needs. Digital technologies, as a means of providing an inclusive educational environment, allow adapting educational environments to the individual needs of each higher education student. However, there is a need to develop specialised content and use specialised tools for inclusive adaptation.

The study is devoted to analysing inclusive education technologies in the context of digitalisation and their impact on the learning outcomes of students with special needs.

**Literature review**

Many digital learning environments have emerged today that aim to ensure equal access to education (Syriopoulou-Delli et al., 2024), including for students with special needs (Barth & Grütter, 2024). The study by Shivani et al. (2024) presents the results of an analysis of available artificial intelligence technologies and educational tools that can promote inclusive education. The study by Šumak et al. (2024) aims to identify and classify the challenges and benefits of AI-based educational tools in the context of inclusive education. Also, the literature discusses government laws and policies on digital education reform (Lin et al., 2024), identifies new trends and challenges in this area (Yazici & Uzuner, 2024) and proposes solutions to achieve sustainable digital education in society (Muhammad & Li, 2024). The study by Zhao et al. (2024) aimed to explore new directions in education and the effective implementation of digital education in a sustainable society. The increase in the number of students with special needs in higher education, especially in engineering and computer science, makes it challenging to design active learning methods (Altes et al., 2024), such as Flipped Classrooms and Work-Based Learning (Helden et al., 2023).

They present the experience of higher education institutions during the coronavirus and show how universities assessed the situation (Morsa et al., 2022; Cao et al., 2020), analysed the obstacles (Davis et al., 2021) and proposed solutions (Nie et al., 2021). Hayar et al. (2022) outline how Hassan II University in Morocco assessed the transition from traditional classes to online learning through the i-UH2C platform and how the digital transformation at the university took place and provide recommendations for digital higher education

Current trends in higher education aim to promote inclusive and equitable education, cultural diversity, sustainable growth, social citizenship and education through the cross-cutting integration of technology (Myhovych, 2019). Grindei et al. (2019) present and describe the eSGarden project, funded by Erasmus+ and a strategic partnership in education within the Erasmus KA2 Supporting Innovation Action.

The development of ICT for education is crucial to ensure that the transformation of digital education and its sustainable development meet the goals of national education policies and the Global Sustainable Development Goals (Batsurovska et al., 2024). In terms of education reforms, there are challenges in this context to the use of modern technologies in education and, consequently, quality education, as ICT for education policy development and investment in digital technologies are not ready for the challenges of today (Aung & Kham, 2023)

Experts outline the practice of assessment and accreditation of higher education to harness the potential of digital technologies for the green and digital transformation of higher education (Lob et al., 2024). In this context, the need to introduce a more inclusive notion of impact on education, including sustainability and more humanity, is noted (Chen & Liao, 2020).

It has been noted that the lack of diversity and inequality is particularly evident in the fields of science, technology, engineering and mathematics (STEM) (Dotsenko, 2023; Drogovoz et al., 2022). There has also been research into the current state of teaching and inclusively learning computational thinking and programming. In particular, the work of González-González et al. (2021) addresses this issue and presents an inclusive, collaborative learning approach. Digital learning tools can provide an inclusive, adaptive environment for higher education students, but preparing teachers to work in a digitally inclusive environment is necessary.

**Methods**

The study of the effectiveness of inclusive education in the digital era to ensure the accessibility of education for students with special needs using the methods of questionnaires, comparison of learning outcomes, pedagogical experiment and statistical processing of data obtained during the experiment. The study was conducted based on the Municipal Higher Education Institution "Khortytska National Training and Rehabilitation Academy", Oles Honchar Dnipro National University and Sumy State Pedagogical University named after A. S. Makarenko. The study analysed classical and digital inclusive

approaches and developed a technology for implementing inclusive digital education methods.

The study was conducted in two stages. The effectiveness of employing inclusive teaching methods in the digital educational environment was assessed by two indicators: self-assessment of the effectiveness of using inclusive teaching tools using a questionnaire for teachers and learning outcomes of higher education students with special needs during the academic year 2023–2024.

The first stage was the formation of criteria and sub-criteria for the effectiveness of inclusive teaching methods in the digital learning environment and self-assessment. The self-assessment involved 28 teachers working with students with special needs. The self-assessment questionnaire (Appendix 1) is based on a 10-point scale, where 0 is no result, and 10 is a global result. The scores were converted to a percentage scale.

86 higher education students with special needs were analysed, 43 of whom were in the control group, which studied using classical inclusive teaching aids, and 43 in the experimental group, which used a combination of classical and digital inclusive teaching aids. The students were randomly assigned to the control and experimental groups. The learning outcomes were assessed according to the ECTS scale. To confirm the hypothesis about the effectiveness of learning with the help of digital inclusive educational tools, the Pearson $\chi^{(2)}$ criterion was used to statistically calculate the effectiveness of implementing inclusive learning tools for students with special needs. The pedagogical experiment compared the use of classical and digital inclusive approaches. The second stage of the experiment was the introduction of classical inclusive approaches for the control group and combining classical and digital inclusive approaches for the experimental group, the provision for which is outlined in the next section. We used universal learning design, individual curricula and trajectories, group work and mentoring, active learning methods, and psychosocial support to implement classical inclusive approaches. To implement digital inclusive approaches, specialised software, adaptive learning platforms, VR and AR, online learning formats, inclusive adaptation of digital materials, and interactive and gamified technologies were used.

## Results

Equal access to education, regardless of the physical, social or psychological characteristics of higher education students, ensures compliance with the principle of inclusive education. In the digital age, approaches to education are changing, including inclusive teaching methods. Figure 1 shows classical and digital inclusive approaches that have been used to ensure accessibility of education for students with special needs.

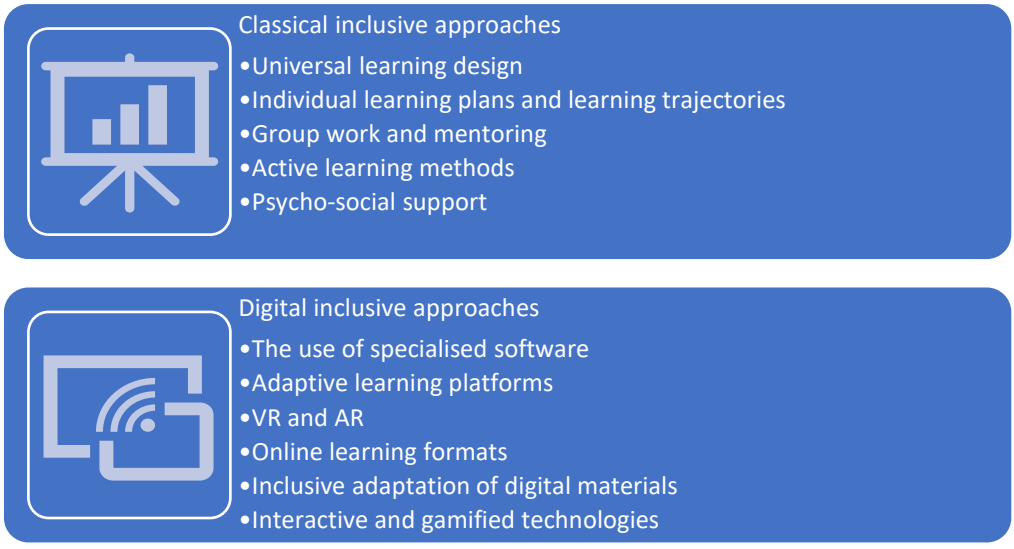


**Figure 1. Classical and digital inclusive approaches implemented in the context of a pedagogical experiment**

Source: compiled by the author

Universal learning design ensures equal access to education through video, audio and text formats that enable the acquisition of competences using various technological tools. Creating individual learning paths and personalised educational plans allows students with visual or hearing impairments to receive learning content and education. Mentoring by other higher education students and the distribution of work in group projects positively impact inclusive education and the moral and psychological atmosphere in the student body. Case studies and interactive discussions are the most

effective and widespread active learning methods in inclusive practice. The support of higher education students and teachers ensures a comfortable learning environment for students with special needs.

Special software, such as screen readers (NVDA, JAWS) or speech recognition software (Dragon NaturallySpeaking), allows for adapting learning materials to meet the needs of students with visual or hearing impairments. Distance learning platforms have settings for certain types of needs of higher education students. The interactive capabilities of inclusive learning environments can be enhanced through virtual or augmented reality to provide access to practice-oriented tasks for students with limited mobility. Digital materials can also be adapted with subtitles or sign language. Therefore, the choice of modern digital inclusive learning formats is a powerful tool to ensure accessibility for students with special needs.

However, the development of inclusive approaches in the digital age requires the introduction of methodological, didactic and technological principles for creating educational content for higher education students with special needs. Figure 2 shows the implementation of the stages of the technology for implementing inclusive digital education methods.

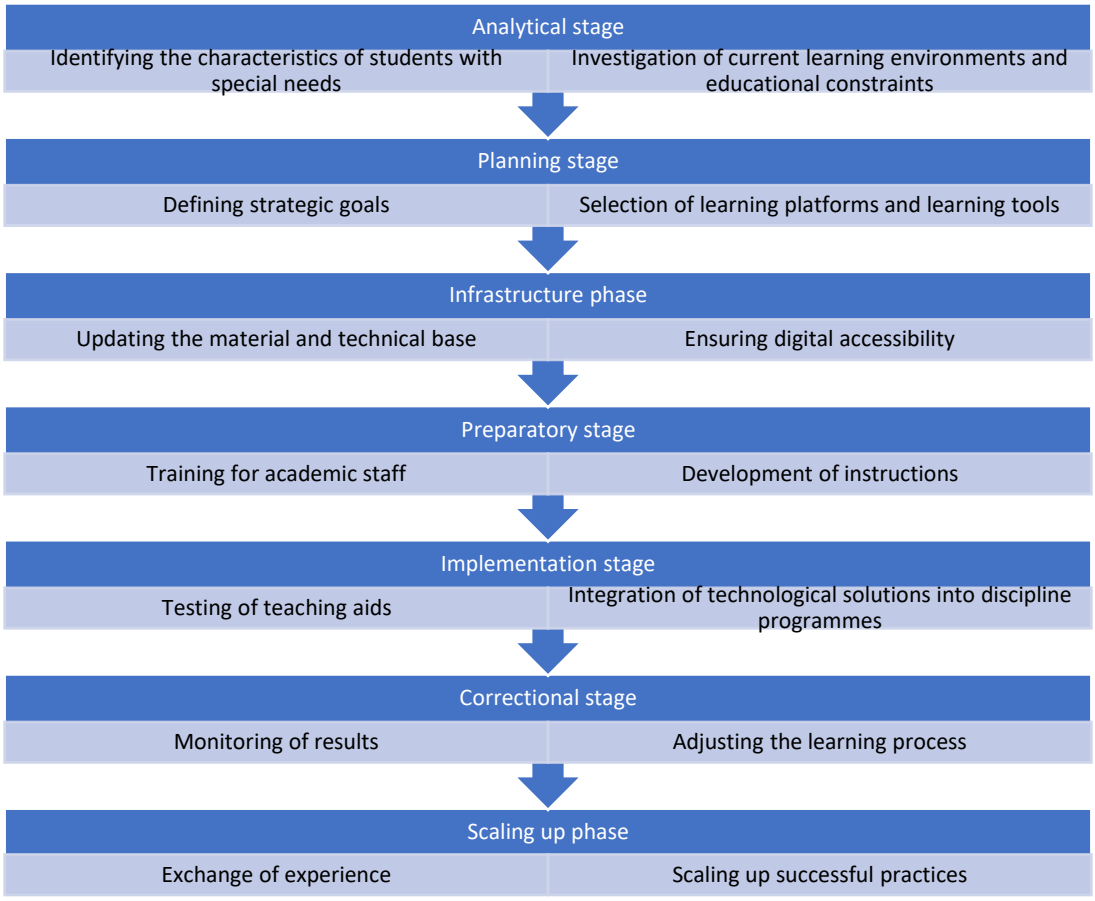


**Figure 2. Technology for implementing inclusive digital education methods.**

Source: compiled by the author

In the context of implementing the technology of introducing inclusive digital methods into the educational process of higher education institutions, it is necessary to identify the characteristics of students with special needs at the initial stages, define strategic goals for the introduction of inclusive teaching methods and outline the range of digital tools that need to be implemented to meet the needs of students. Another important aspect is installing specialised software and configuring educational platforms according to WCAG (Web Content Accessibility Guidelines) standards, as well as conducting educational and methodological seminars and training for teachers and staff. It is necessary to test teaching tools and develop specialised curricula for disciplines using inclusive teaching tools. Based on learning outcomes and feedback from students and teachers, the educational process should be adjusted, and the most successful cases can be scaled up through experience sharing and partnerships.

The evaluation criteria and sub-criteria, which are presented in Table 1, were developed for self-

assessment of the effectiveness of inclusive teaching methods in the digital educational environment.
The criteria include accessibility of digital learning materials, user-friendly interfaces of adaptive learning platforms, availability of technical support, inclusive teacher training, and logistical support for the inclusive learning process.

**Table 1. Criteria and sub-criteria for self-assessment of the effectiveness of inclusive teaching methods in the digital educational**

| Criterion | Sub-criterion |
|---|---|
| Accessibility of digital learning materials | Development of digital learning materials in alternative formats to screen reading |
| | Development or implementation of audio or video materials with sign language interpretation or subtitles |
| User-friendly interfaces of adaptive learning platforms | Use of learning environments that meet inclusive learning standards |
| | A variety of adaptive options for the digital environment interface |
| Availability of technical support | The quick response of the technical support service to the requests of higher education students |
| | Percentage of requests from students with special needs resolved |
| Inclusive teacher training | Advanced training for teachers in the use and development of inclusive digital learning environments |
| | Development of inclusive educational publications available in digital format |
| Logistical support for the inclusive education process | Percentage of devices with adaptive software and hardware per higher education student with special needs |
| | Percentage of classrooms equipped with digital inclusion equipment |

Source: developed by the author

According to the teachers' questionnaire, the effectiveness of the technology for implementing inclusive digital education methods was tested. Figure 3 shows the results of the above-mentioned assessment according to the developed criteria, which was based on Appendix 1 on a 10-point scale.

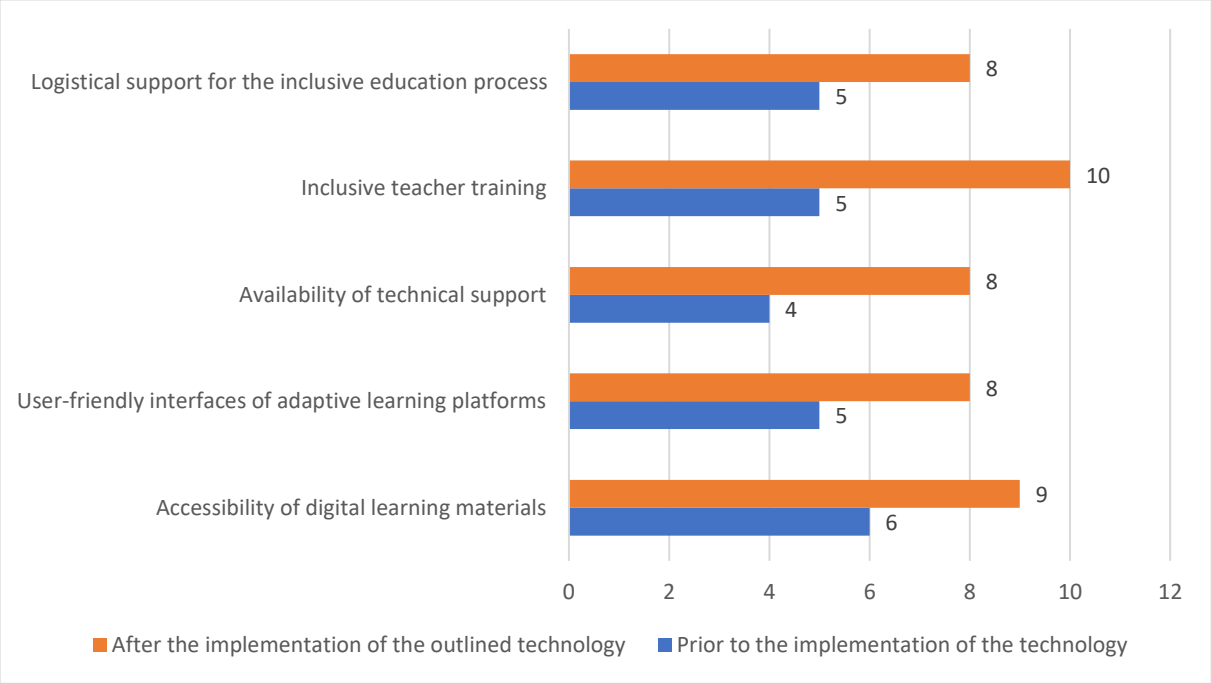


**Figure 3. Verification of the effectiveness of the technology for implementing inclusive digital education methods according to self-assessment**

Source: compiled by the author

During the pedagogical experiment, classical and digital inclusive teaching approaches were applied to the control and experimental groups of higher education students, respectively. At the

implementation stage, teaching aid pilot testing and the integration of technological solutions into discipline programmes were carried out, after which the inclusive teaching approaches outlined in Figure 1 were applied to higher education students.

The second stage of the pedagogical experiment was to test the learning outcomes of higher education students with special needs before and after the introduction of inclusive digital learning tools. Tables 2 and 3 present a statistical calculation of the effectiveness of implementing inclusive learning tools for students with special needs based on Pearson's $\chi^2$ criterion. Learning outcomes were assessed according to the ECTS scale. The degree of freedom for this sample is v=5, the critical values of $\chi^2$ at v=5 ($\rho(0.05) \geq 11.02$; $\rho(0.01) \geq 15.081$). Higher education students in the control group studied using classical inclusive teaching aids, and higher education students in the experimental group used a combination of classical and digital inclusive teaching aids. The universal design of learning was implemented by customising the MOODLE platform to meet the needs of students with special needs. Individual learning paths for students with inclusive needs were implemented by integrating ReadSpeaker courses. Group work and mentoring were provided through the Zoom service and were supplemented by interactive learning tools from the Kahoot service. The TalkSpace service was used for psychological support.

Dragon NaturallySpeaking platforms for voice control and NVDA screen reader software were used to implement digitally inclusive approaches. VR and AR technologies were used to immerse students with limited mobility in the learning environment fully. When creating the educational content, subtitles were created with the CaptionSync software, and voice duplication of information using the Read&Write service was also applied.

**Table 2. Calculating the effectiveness of implementing inclusive teaching aids for students with special needs before the experiment**

| Learning outcome | EG, % | $EF_{EG}$, number of students | CG, % | $EF_{CG}$, number of students | $(EF_{EG} - EF_{CG})^2$ | $(EF_{EG} - EF_{(CG)})^2 / EF_{CG}$ |
|---|---|---|---|---|---|---|
| A | 4,65% | 2 | 6,98% | 3 | 1 | 0,33 |
| B | 11,63% | 5 | 16,28% | 7 | 4 | 0,57 |
| C | 20,93% | 9 | 23,26% | 10 | 1 | 0,10 |
| D | 25,58% | 11 | 20,93% | 9 | 4 | 0,44 |
| E | 30,23% | 13 | 27,91% | 12 | 1 | 0,08 |
| FX | 6,98% | 3 | 4,65% | 2 | 1 | 0,50 |
| Total | 100,00% | 43 | 100,00% | 43 | | 2,03 |

Notes: $EF_{(CG, EG)}$, number of students - empirical frequency of grades for higher education students with special needs in the control and experimental groups (CG and EG, respectively); CG - control group; EG - experimental group; A, B, C, D, E, FX - grades according to the ECTS scale

Source: compiled by the author

**Table 3. Calculation of the effectiveness of the implementation of inclusive teaching aids for students with special needs after the experiment**

| Learning outcome | EG, % | $EF_{EG}$, number of students | CG, % | $EF_{CG}$, number of students | $(EF_{EG} - EF_{CG})^2$ | $(EF_{EG} - EF_{(CG)})^2 / EF_{CG}$ |
|---|---|---|---|---|---|---|
| A | 20,93% | 9 | 9,30% | 4 | 25 | 6,25 |
| B | 34,88% | 15 | 16,28% | 7 | 64 | 9,14 |
| C | 27,91% | 12 | 30,23% | 13 | 1 | 0,08 |
| D | 9,30% | 4 | 23,26% | 10 | 36 | 3,60 |
| E | 4,65% | 2 | 16,28% | 7 | 25 | 3,57 |
| FX | 2,33% | 1 | 4,65% | 2 | 1 | 0,50 |
| Total | 100,00% | 43 | 100,00% | 43 | | 23,14 |

Notes: $EF_{(CG, EG)}$, number of students - empirical frequency of receiving grades for students with special needs of the control and experimental groups (CG and EG, respectively); CG - control group; EG - experimental group; A, B, C, D, E, FX - grades according to the ECTS scale

Source: compiled by the author

Comparing Tables 2 and 3, we can conclude that before the experiment $\chi^2 = 2.03$, which is less than the critical value, and after the experiment $\chi^2 = 23.14$, which is greater than the critical value, therefore, the introduction of digital inclusive learning tools has a

positive effect on the educational outcomes of higher education students with special needs.

Figures 4 and 5 compare the learning outcomes of higher education students with special needs in the control and experimental groups according to the ECTS scale levels before and after the experiment.

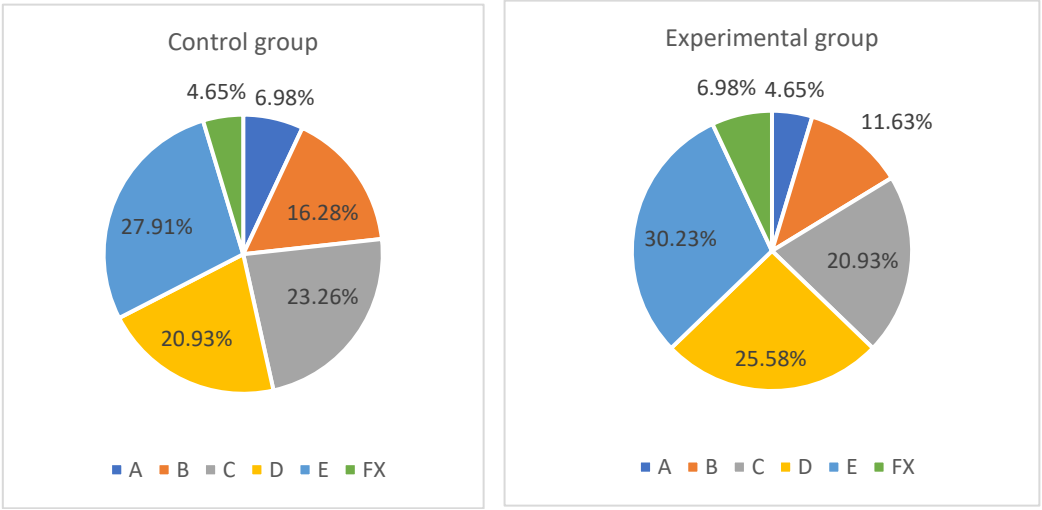


**Figure 4. Distribution of learning outcomes of students with special needs by levels in the control and experimental groups before the experiment**

Source: compiled by the author

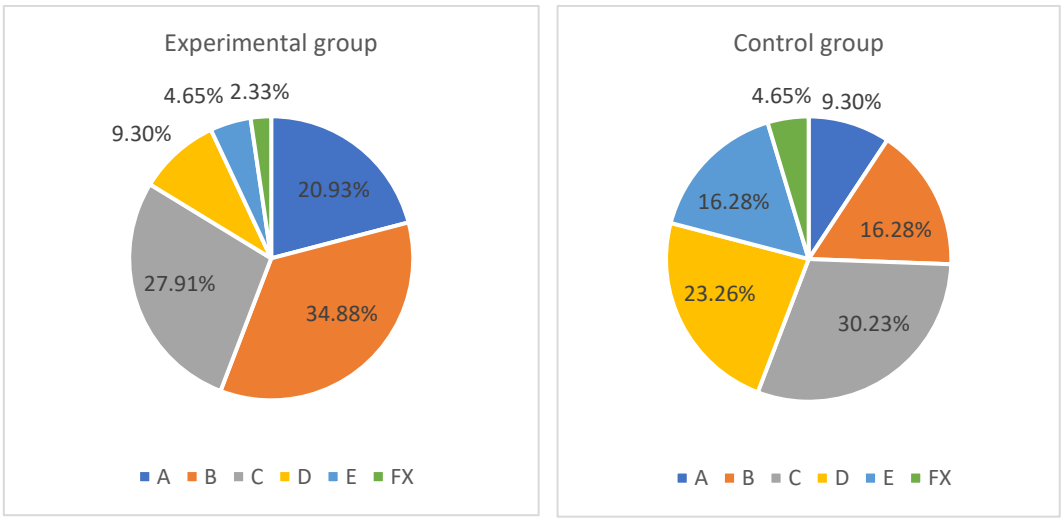


**Figure 5. Distribution of learning outcomes of students with special needs by levels in the control and experimental groups after the experiment**

Source: compiled by the author

Comparing the data in Figures 4 and 5, we can conclude that the learning outcomes of the control and experimental groups did not differ significantly before the experiment. After the introduction of digital inclusive learning tools in the experimental group, the number of higher education students with A-level increased by 11%, the number of students with B-level increased by 18%, and the indicators of C-level decreased by 3%. The indicators of D and FX levels decreased by 14% and 2%, respectively. Thus, using digital inclusive learning tools to train higher education students with special needs is effective.

**Discussion**

Inclusive education in the digital age opens up equal opportunities for students with special needs but also poses many challenges for academic staff. Among them are the support of inclusive digital technologies, financial and professional development, and teachers' digital skills in designing inclusive environments. According to the Digital Action Plan (2021-2027) developed by the European Union, integrating digital technologies and education is a general trend in the digital era. It also indicates the direction of development and priority actions for the digital transformation of education and provides

policy guidance on the digital transformation of vocational education and training. Based on the interpretation of the plan proposed by the European Union, it is pointed out that high-quality and inclusive education is urgently needed (Yanli & Danni, 2021). Therefore, higher education in the digital age must continuously improve digital capabilities and promote digital transformation to meet the rapidly changing structure of the economy and the changing demand for skills in the labour market.

Higher education institutions should ensure the selection and implementation of the most effective practices for designing digital inclusive environments. The findings show that innovative education facilitates learning, promotes digital competence, fosters professional growth and collaboration, and ensures inclusive education. Innovative educational tools and methodologies have been found to improve educational outcomes by providing personalised learning experiences and adaptive learning environments, thus supporting the development of higher-level thinking skills and digital literacy. However, the implementation of innovative education faces several challenges that need to be addressed, including the need for high-quality teacher training, lack of professional development opportunities, technological infrastructure issues, resistance to change, privacy and security concerns, and the need to align pedagogical practice with technological tools (Pal Singh, 2024).

An important aspect is to balance the provision of digital content and the practical aspects of learning in higher education. Practical solutions in this context are often quite innovative, especially in STEM fields. For example, Yim et al. (2024) explore the potential of virtual robotics to promote inclusive education and improve STEM learning. In the context of inclusive education, students from different backgrounds can have equal access to STEM learning and collaboration, leading to more significant opportunities for success in their future careers.

The current educational system often fails to meet the unique needs of students with disabilities. An important challenge is to create an inclusive, barrier-free environment where people with disabilities can enjoy equal opportunities and rights and to empower them by supporting their full participation in society through specialised resources, adaptive technologies, and mentoring. Elavarasi et al. (2024) outline a project that proposes innovative efforts to address the barriers faced by people with disabilities in education and employment. The requirements of the modern working and educational environment, embodied in industry and education 4.0 paradigms, have led to a special focus on reducing the digital and educational gap among students. A differentiated pathway for learning experiences created through a decision tree and various multichannel educational resources has been outlined. Adaptive learning has become a relevant strategy for increasing student engagement as it promotes better engagement, equity, and learning outcomes

Ftáčnik et al. (2020) outline proposals for the digital transformation of education in Slovakia based on European documents, namely The Digital Education Action Plan, the European Skills Agenda, the Digital Competence Framework for Citizens (DigComp), the Digital Competence Framework for Educators (DigCompEdu), the European Framework for Personal, Social and Key Competences “Learning to Learn” (LifeComp) and other policy and conceptual materials. The digital transformation of education should actively build a pathway for developing digital skills and competences of key education stakeholders and support the professional development of teachers, enabling them to use digital technologies wisely to improve the quality of education.

Our empirical research has shown that the use of inclusive digital learning tools positively impacts the outcomes of higher education students with special needs. Dragon NaturallySpeaking for students with impaired motor skills and JAWS for students with visual impairments provides easy customisation to individual student needs and equal access to learning resources. Adaptive online learning platforms support polyformatting and monitor learning outcomes and other characteristics of educational trajectories. Immersive learning based on AR and VR allows for practice-oriented learning for higher education students with mobility restrictions. Using subtitles and audio accompaniment and choosing these settings when using online platforms make learning content accessible to higher education students with different disabilities. Digital inclusive learning tools make the learning environment accessible and increase the level of engagement of higher education students. Thus, our study has become one of the successful examples of a differentiated path to learning for students with special needs, a variety of multichannel educational resources, and adaptive learning described by various authors.

**Conclusion**

Adapting the educational process to the needs of higher education students with special needs is an important prerequisite for ensuring an accessible, equal and inclusive educational process. The study analyses classical and digital inclusive approaches, based on which technology for implementing inclusive digital education methods has been developed.

The following classical inclusive approaches were used in the pedagogical experiment: universal learning design, individual curricula and learning

trajectories, group work and mentoring, active education methods, and psychosocial support. Digital inclusive approaches in the study included the use of specialised software, adaptive learning platforms, VR and AR, online learning formats, inclusive adaptation of digital materials, and interactive and gamified technologies.

The study was conducted in two stages: self-assessment was carried out by means of a teacher questionnaire. For this purpose, criteria and sub-criteria for self-assessment of the effectiveness of inclusive teaching methods in the digital educational environment were developed. During the pedagogical experiment, classical and digital inclusive teaching approaches were used for students with special needs. The control group of higher education students used classical inclusive teaching approaches, and the experimental group used a combination of classical and innovative ones.

The second stage was to study the effectiveness of the implementation of inclusive teaching aids for students with special needs by comparing learning outcomes before and after the use of technology for the implementation of inclusive digital education methods. To meet the needs of higher education students in the context of implementing digital approaches, the Dragon NaturallySpeaking platform for voice control and NVDA screen reader software was used. VR and AR technologies were used for practice-oriented learning for students with limited mobility. CaptionSync was used to duplicate the educational content with subtitles, and voice duplication of information was done using the Read&Write service.

The results obtained according to Pearson's criterion were statistically calculated. The learning outcomes of higher education students with special needs in the control and experimental groups were compared according to the levels of the ECTS scale before and after the experiment. The positive impact of the use of digital inclusive learning tools on students' educational outcomes was determined. Ensuring an integrated approach and using innovative digital inclusive learning tools is the key to ensuring equality and accessibility of education.

## References

1. Altes, T., Willemse, T., Goei, S. L., & Ehren, M. (2024). Higher education teachers' understandings of and challenges for inclusion and inclusive learning environments: A systematic literature review. *Educational Research Review, 43*, 100605. https://doi.org/10.1016/j.edurev.2024.100605
2. Aung, H. L., & Kham, N. S. M. (2023). A conceptual framework for ICT policy development in Myanmar education sector. *2023 IEEE Conference on Computer Applications (ICCA*), Yangon, Myanmar, 417-422. https://doi.org/10.1109/ICCA51723.2023.10181934
3. Barth, C., & Grütter, J. (2024). Inclusive classroom norms and children's expectations of inclusion of peers with learning difficulties in their social world. *Journal of School Psychology, 104*. https://doi.org/10.1016/j.jsp.2024.101312
4. Batsurovska, I., Dotsenko, N., Gorbenko, O., Haleeva, A., & Kurepin, V. (2024). Online control of educational results of the unit "Electricity" in the conditions of blended learning. *Journal of Physics: Conference Series, 2871*, 012013. https://doi.org/10.1088/1742-6596/2871/1/012013
5. Cao, H.-L., et al. (2020). Robot-assisted joint attention: A comparative study between children with autism spectrum disorder and typically developing children in interaction with NAO. *IEEE Access, 8*, 223325-223334. https://doi.org/10.1109/ACCESS.2020.3044483
6. Chen, K.-S., & Liao, H.-T. (2020). Mapping the field of educational assessment and professional accreditation in higher education: Bibliographic coupling and co-citation analyses for green and digital transformation. *2020 Management Science Informatisation and Economic Innovation Development Conference (MSIEID*), Guangzhou, China, 281-284. https://doi.org/10.1109/MSIEID52046.2020.00058
7. Davis, M., Watts, G., & López, E. (2021). A systematic review of firsthand experiences and supports for students with autism spectrum disorder in higher education. *Research in Autism Spectrum Disorders, 84*, 101769. https://doi.org/10.1016/j.rasd.2021.101769
8. Dotsenko, N. (2023). Interactive posters as a learning tool for practical tasks in the context of electrical engineering education. *2023 IEEE 5th International Conference on Modern Electrical and Energy System (MEES)*, Kremenchuk, Ukraine, 1-5. https://doi.org/10.1109/MEES61502.2023.10402463
9. Drogovoz, S. M., Seredyns'ka, N. M., Shtroblya, A. L., Luk'yanchyuk, V. D., Lutsenko, R. V., Krutskykh, T. V., Panfilova, A. L., Derymedvid', L. V. & Shtroblya, M. V. (2022). Circadian rhythms: Physiological and pathophysiological aspects. *Neurophysiology, 54*, 175-181. https://doi.org/10.1007/s11062-024-09949-3
10. Elavarasi, S. A., Suryavikram, K., Nandha, S. C., Poojashri, A. L., Krishnakanth, S., Mohammed Hussain, M., Srinath, D. K. (2024). Enhancing the education ecosystem for specially abled students. *2024 International Conference on Computing and Data Science (ICCDS*), Chennai, India, 1-5. https://doi.org/10.1109/ICCDS60734.2024.10560440

11. Ftáčnik, M., Šveda, D., & Kireš, M. (2020). Digital transformation of education in Slovakia within the context of European documents. *2020 18th International Conference on Emerging eLearning Technologies and Applications (ICETA*), Košice, Slovenia, 113-118. https://doi.org/10.1109/ICETA51985.2020.9379154
12. González-González, C. S., Caballero-Gil, P., García-Holgado, A., García-Peñalvo, F. G. (2021). COEDU-IN Project: An inclusive co-educational project for teaching computational thinking and digital skills at early ages. *2021 International Symposium on Computers in Education (SIIE)*, Malaga, Spain, 1-4. https://doi.org/10.1109/SIIE53363.2021.9583648
13. Grindei, L., Blanc, S., & Benlloch-Dualde, J. V. (2019). eSGarden-Implementing a school-university collaboration project for inclusive and equitable education through technology. *2019 29th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE)*, Ruse, Bulgaria, 1-4. https://doi.org/10.1109/EAEEIE46886.2019.9000448
14. Hayar, A., Khalil, M., Kheddioui, E., Aadil, M., Diab, G., & Hattabi, M. (2022). Inclusive digital transformation in higher education during COVID-19 pandemic: i-UH2C use case. *2022 IEEE International Smart Cities Conference (ISC2*), Pafos, Cyprus, 1-6. https://doi.org/10.1109/ISC255366.2022.9922339
15. Helden, G. V., Van Der Werf, V., Saunders-Smits, G. N., & Specht, M. M. (2023). The use of digital peer assessment in higher education-An umbrella review of literature. *IEEE Access, 11*, 22948-22960. https://doi.org/10.1109/ACCESS.2023.3252914
16. Lin, X.-F., Luo, G., Luo, S., Liu, J., Chan, K. K., Chen, H., Zhou, W., & Li, Z. (2024). Promoting pre-service teachers' learning performance and perceptions of inclusive education: An augmented reality-based training through learning by design approach. *Teaching and Teacher Education, 148*. https://doi.org/10.1016/j.tate.2024.104661
17. Lob, K., Sawka, D. M., Gaitanis, J. N., et al. (2024). Genetic diagnostic yield in autism spectrum disorder (ASD) and epilepsy phenotypes in children with genetically defined ASD. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-024-06512-1
18. Morsa, M., Andrade, V., Alcaraz, C., Tribonnière, X., Rattaz, C., & Baghdadli, A. (2022). A scoping review of education and training interventions in autism spectrum disorder. *Patient Education and Counselling, 105*. https://doi.org/10.1016/j.pec.2022.05.012
19. Muhammad, K., & Li, Z. (2024). Analysis of education reform in Indonesia based on qualitative methods for a digital sustainable society. *2024 International Conference on Culture-Oriented Science & Technology (CoST)*, Beijing, China, 291-294. https://doi.org/10.1109/CoST64302.2024.00064
20. Myhovych, I. (2019). International mobility as a means of ensuring inclusive global higher education space. *Advanced Education, 6*(12), 80-86. https://doi.org/10.20535/2410-8286.137813
21. Nie, G., et al. (2021). An immersive computer-mediated caregiver-child interaction system for young children with autism spectrum disorder. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 29*, 884-893. https://doi.org/10.1109/TNSRE.2021.3077480
22. Pal Singh, S. (2024). *Smart Education: Transforming the future of learning*. Grin Verlag.
23. Shivani, Gupta, M., & Gupta, S. B. (2024). A systematic analysis of AI-empowered educational tools developed in India for disabled people. *Information Technologies and Learning Tools, 100*(2), 199-216. https://doi.org/10.33407/itlt.v100i2.5501
24. Šumak, B., López-de-Ipiña, D., Dziabenko, O., Duarte Correia, D., Serrano de Carvalho, L. M., Lopes, S., Şimşek, I., Can, S., Ivanuša Kline, D. & Pušnik, M. (2024). AI-based education tools for enabling inclusive education: Challenges and benefits. *2024 47th MIPRO ICT and Electronics Convention (MIPRO*), Opatija, Croatia, 472-477. https://doi.org/10.1109/MIPRO60963.2024.10569714
25. Syriopoulou-Delli, C., Sarri, K., Papaefstathiou, E., Filiou, A., & Gkiolnta, E. (2024). Educational programmes supporting higher education individuals with autism spectrum disorders: A systematic review. *Trends in Higher Education, 3*(3), 710-724. https://doi.org/10.3390/higheredu3030040
26. Yanli, X., & Danni, L. (2021). Prospect of vocational education under the background of digital age: Analysis of the European Union's "Digital Education Action Plan (2021-2027)." *2021 International Conference on Internet, Education and Information Technology (IEIT)*, Suzhou, China, 164-167. https://doi.org/10.1109/IEIT53597.2021.00042
27. Yazici, M., & Uzuner, F. (2024). School-based inclusive mentoring within the scope of an experiential learning model (IEM) for teacher education. *Teaching and Teacher Education*. https://doi.org/10.1016/j.tate.2024.104799

28. Yim, T.-S., Woo, K. T., & Chin, L. T. (2024). Promoting inclusive education through virtual underwater robotics experience: Enhancing STEM learning and collaboration with real-world applications. *2024 IEEE Global Engineering Education Conference (EDUCON*), Kos Island, Greece, 1-5. https://doi.org/10.1109/EDUCON60312.2024.10578740

29. Zhao, M., You, Y., Gao, X., Li, L., Li, J., & Cao, M. (2024). The effects of a web-based 24-hour movement behaviour lifestyle education programme on mental health and psychological well-being in parents of children with autism spectrum disorder: A randomised controlled trial. *Complementary Therapies in Clinical Practice, 56*, 101865. https://doi.org/10.1016/j.ctcp.2024.101865

**Appendix 1**

**Self-assessment questionnaire for ensuring accessibility of education in the digital age for students with special needs**

*C1. Accessibility of digital learning*

Rate from 0 to 10 the availability of learning materials in formats compatible with screen readers

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Please rate from 0 to 10 the availability of audio and video learning materials with subtitles or sign language interpretation.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

*C2. User-friendly interfaces of adaptive learning platforms*

Please rate from 0 to 10 the compliance of the platforms you use with accessibility standards

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Rate the availability of adaptive interface settings from 0 to 10

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

*C3. Availability of technical support*

Rate the response time of the technical support service for students with special needs from 0 to 10.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Estimate 0 to 10 per cent of resolved requests based on support calls.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

*C4. Inclusive teacher training*

Estimate the percentage of teachers who have been trained in the use of digital technologies for inclusive learning from 0 to 10 per cent.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Rate 0 to 10 per cent of available inclusion guides and training materials in digital format

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

*C5. Material and technical support for inclusive education*

Estimate 0 to 10 per cent of accessible devices per student with special needs.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Estimate 0 to 10 per cent of classrooms equipped with the necessary equipment for digital inclusion.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |