MULTIDISCIPLINARNI PRISTUPI U EDUKACIJI I REHABILITACIJI
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The Application of Artificial Intelligence and Assistive Technology in Supporting Children with Developmental Disabilities

Edin Mujkanović[1]

Pre-University Education Institute of Sarajevo Canton

Abstract

Children with developmental disabilities, such as intellectual disabilities, multiple impairments, and autism spectrum disorders, often face challenges in learning, communication, and social integration. Traditional support methods are often insufficient to help them reach their full potential. The development and application of modern technologies, particularly artificial intelligence (AI) and assistive technology (AT), offer new possibilities for improving educational and rehabilitation processes. This paper analyzes how these technologies are used to support children with disabilities through a review of the literature, practical examples, and available technological tools. The role of AI in personalizing learning and recognizing emotional states is emphasized, as well as the application of AT in facilitating daily activities and the importance of AAC for developing communication skills. Challenges in the implementation of these technologies, including the education of professionals, device availability, and ethical aspects, are also discussed. The conclusion highlights that the integrated use of AI and AT significantly contributes to the inclusion and quality of life of children with disabilities, provided it is supported by appropriate education and support systems.

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[1] Corresponding author's email: edin.mujkanovic@irpo.ba

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Introduction

Children with developmental disabilities, including intellectual disabilities, multiple disabilities and autism spectrum disorders (ASD), form an extremely heterogeneous group with complex and multifaceted needs in the educational and social context. Their difficulties often include simultaneous challenges in verbal and non-verbal communication, sensory integration, emotional regulation, planning and organizing activities, as well as executive functions. Precisely because of this, traditional educational models and methodologies - based on a uniform approach and standardized programs - are often not sufficient to ensure quality education and social participation of this population (UNESCO, 2020; WHO & World Bank, 2011).

An individualized approach, which includes the adaptation of teaching contents, methods and environment, has been recommended for decades in the framework of inclusive education, but in practice it remains difficult to achieve without additional professional and technical support. In this context, modern technologies such as artificial intelligence (AI - Artificial Intelligence), assistive technology (AT - Assistive Technology) and augmentative and alternative communication (AAC - Augmentative and Alternative Communication) become key factors that enable innovative solutions for inclusion, learning and rehabilitation. AI enables the creation of dynamic educational platforms that adapt to the individual abilities of the child, analyze progress in real time and automatically suggest changes in approach (Holmes et al., 2019). For example, AI systems that analyze the emotional reactions of children with autism through facial expression, physiological indicators and behavioral patterns are increasingly used to predict and prevent crisis situations (Goodwin et al., 2019). In combination with wearable technologies, such as the Empatica E4 wristbands, it is possible to monitor electrodermal activity, heart rhythm and movement patterns, which enables professionals and parents to intervene in a timely manner (Kylliäinen et al., 2021).

Assistive technologies include a wide range of aids - from simple devices to control the environment, to sophisticated communication and educational tools. Children with multiple disabilities and severe motor impairments benefit from adapted input devices (eg, switches, alternative keyboards, and gesture-controlled systems), which allow them to interact more independently with the world, learning, and the environment (Dell, Newton & Petroff, 2017). In the context of education, AT is used to access digital content, participate in the teaching process and develop functional academic skills.

AAC is an invaluable component for children who do not speak or have significant difficulties in verbal communication. The use of symbolic systems, applications for speech generation and communication boards allows children to express needs, emotions and thoughts, which significantly reduces the risk of social isolation and increases the quality of life (Beukelman & Light, 2020). According to the American Speech-Language-Hearing Association (ASHA), early implementation of AAC significantly contributes to language and literacy development, even in children with complex communication needs.

However, integrating these technologies into everyday work with children with disabilities is not a simple process (Mehdaoui, 2024). Challenges include the need for training teachers and therapists, securing financial resources, technical support, but also ethical issues – such as data privacy and user autonomy (Almufaher et al., 2024; Alquraini & Gut, 2012; Zubair & Salim, 2021). In addition, there is a gap between the availability of technology and its actual use, especially in resource-limited settings and communities (Afzal et al., 2023).

The aim of this paper is to analyze in detail the ways in which artificial intelligence, assistive technology, and augmentative and alternative communication are applied in supporting children with developmental disabilities. Through a review of the latest literature

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and available examples of good practice, it aims to highlight how these technologies can contribute to the personalization of the educational process, the improvement of communication and social skills, and the increase in the overall quality of life. It will also consider the challenges of their implementation and propose guidelines for further development and application within the framework of inclusive educational and rehabilitation models.

Methods

For the purposes of this work, a descriptive-analytical methodological approach aimed at the synthesis of available theoretical and practical knowledge on the application of modern technologies in support of children with developmental disabilities was applied. The basis of the research was the systematization and interpretation of professional and scientific literature from several disciplines: special education and rehabilitation, psychology, pedagogy, information and communication technologies, and medical sciences. Emphasis is placed on works dealing with the development and application of artificial intelligence (AI), assistive technology (AT) and augmentative and alternative communication (AAC) in children with intellectual disabilities, multiple disabilities and autism spectrum disorders (ASD).

The literature was collected through international databases such as PubMed, ERIC, ScienceDirect, Scopus, Google Scholar, and through available sources of domestic and regional publications. Works published in the past ten years (2014–2024), written in English, Bosnian, Croatian and Serbian, are included. Special attention is paid to papers describing specific applications of AI, AT and AAC in an educational context, as well as research on their effectiveness, availability and acceptance among users - children, parents and experts.

Technical descriptions of devices and software solutions developed to support children with disabilities were also analyzed, including wearable devices for monitoring physiological indicators (e.g. Empatica E4), educational applications with AI algorithms for personalized learning, AAC platforms (e.g. Proloquo2Go, CoughDrop), as well as assistive tools such as Eye Gaze technology, interactive screens and devices for communication controlled by gestures or gaze.

In addition to the literature analysis, examples of good practice from educational and rehabilitation institutions in Bosnia and Herzegovina, as well as from international sources, were used, in order to see the real applicability and challenges in implementing the mentioned technologies in daily work with children with disabilities. These examples include the experiences of educators-rehabilitators, speech therapists, psychologists, mobile professional teams and families using these technologies.

The data were structured according to thematic units that correspond to the objectives of the work, and the analysis aimed to:

- Identify and describe specific technologies used in working with children with disabilities.
- Understand the ways in which these technologies contribute to children's learning, communication and social integration.
- Identify obstacles and challenges in implementation (e.g. staff training, device price, infrastructure, ethical aspects).
- Formulate recommendations for practice and future research.

Finally, the results are presented qualitatively, through thematic syntheses and illustrative examples, in order to ensure a depth of understanding and practical value of the conclusions for all those working in the field of inclusive education and rehabilitation.

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Results

Based on the literature analysis, available technological solutions and practices in working with children with developmental disabilities, three key domains were identified in which modern technologies have transformative potential: artificial intelligence (AI), assistive technologies (AT) and augmentative and alternative communication (AAC). Each of these areas shows specific benefits, but also challenges in implementation.

Artificial intelligence (AI) today represents one of the most dynamic areas of modern technological development, with enormous application potential in the education and rehabilitation of children with developmental disabilities. As a branch of computing that enables the development of systems capable of imitating elements of human cognition - such as learning, adaptation, pattern recognition and decision-making - AI is increasingly being used with the aim of creating personalized educational experiences, improving social interactions and ensuring continuous support in the daily functioning of children. Its application is not limited to the educational process in the narrower sense, but also includes emotional and psychological development, behavioral regulation and monitoring of the child's general well-being.

One of the most significant directions of development is the use of adaptive educational platforms based on advanced AI algorithms. These systems collect data on the way a child learns, monitor the pace of material mastery and analyze mistakes, and then adjust the content, difficulty level and type of tasks in real time. Platforms like Knewton, Squirrel AI or DreamBox Learning have already shown that this approach enables children with intellectual disabilities to progress in accordance with their individual abilities, because each child moves at his own pace and requires a different level of support. In this way, education becomes more inclusive and free from a uniform approach, providing children with a sense of success and motivation.

In addition to the educational dimension, AI is also used to recognize and interpret emotions and behavior, which is especially important for children on the autism spectrum, who often have difficulties in expressing and understanding the emotions of others. Modern systems based on computer vision, speech analysis and biometric indicators can detect changes in mood, recognize signs of stress or anxiety, and even predict the possibility of escalation of certain behavior. Applications such as Mood Meter or Tobii Gaze AI, as well as systems that analyze facial expressions and voice intonation, enable parents, teachers and therapists to recognize a child's emotional needs in a timely manner. Interestingly, research has shown that predictive AI models can identify signs of aggressive behavior in children with autism up to 60 seconds before the actual escalation, relying on changes in physiological signals. This possibility of prevention and early response opens completely new dimensions in supporting children, reducing stress and increasing safety in the educational and family environment.

Another important segment is wearable medical devices based on artificial intelligence, such as Empatica E4, Embrace or Q Sensor. These devices continuously monitor electrodermal activity, heart rate and movement patterns, offering insight into the child's emotional and physiological state in real time. Such technology allows therapists, parents and assistants to react immediately when a child shows signs of being overwhelmed or stressed, thus reducing the number of crisis episodes and providing a safer and more stable environment. Wearable technology not only improves the quality of support, but also contributes to the development of the child's sense of independence, because he can become more aware of his emotional states and learn how to recognize and regulate them.

A particularly interesting field of application of AI technologies in working with children with disabilities is the use of robots and virtual assistants. Humanoid robots such as

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NAO, Kaspar or Milo have already entered educational and rehabilitation centers around the world, where they help children develop social and communication skills. Children often perceive robots as friends and safer interaction partners than adults, because robots offer a predictable and stable environment, devoid of complex social signals that the child sometimes cannot understand. Through play, imitation and guided tasks, robots help develop non-verbal communication, maintain attention and establish contact, and research confirms that children more often initiate interaction with a robot than with an adult. In this way, technology does not replace human contact, but mediates it and prepares the child to more easily build social relationships in a wider social environment.

All these applications of artificial intelligence show that a new field of inclusion is opening before us, in which technology becomes the extended hand of teachers, therapists and parents. AI does not act as a substitute for human support, but as a powerful ally in creating individualized, safe and stimulating environments for children with various disabilities. Personalization of learning, timely recognition of emotional states, monitoring of physiological indicators and development of social skills through interaction with robots represent concrete ways in which artificial intelligence changes the paradigm of education and rehabilitation. Ultimately, it is a technology that has the potential to enable every child to learn, develop and be included in society in a way that best suits their needs and capabilities.

Assistive technologies (AT) occupy a key place in the development of inclusive education and rehabilitation of children with disabilities, as they include a wide range of devices, software and tools designed to improve functional abilities and increase their independence (Chambers, 2019; Hunt, 2021). Their essential purpose is to enable the child to participate more actively and meaningfully in the educational process, facilitate social communication and contribute to a better quality of everyday life. Unlike universal teaching aids, assistive technologies are created to respond to the very specific individual needs of children, which makes them an indispensable resource in working with those who need additional support.

One of the most important aspects of the application of AT relates to the development of communication devices and tools for children who have difficulties in verbal expression. In such cases, specialized devices such as BIGmack, Tech/Speak or GoTalk are used, which allow recording and playback of messages with one touch, thus giving the child the opportunity to communicate basic needs and thoughts. In more advanced cases, more sophisticated eye-tracking systems are used, such as Tobii Dynavox, which enables interaction with the computer exclusively through eye movements. This technology provides children with complex communication difficulties with a unique opportunity to express themselves, which significantly affects their involvement in educational and social activities.

For children with multiple disabilities, assistive technologies offer additional solutions in the form of motor and sensory assistants. These include electronic tables with touch sensors, therapeutic robots like Zora or equipped sensory rooms that combine light effects, vibrations, sounds and various textures. Such multisensory environments help in the process of sensory integration, encourage emotional regulation and contribute to relaxation, which is confirmed by the research of Stephenson & Carter (2014). In this way, children get a structured, but also stimulating environment that encourages development and at the same time reduces the level of stress.

Educational software and applications represent another important category of AT, since they enable the creation of content adapted to the specific needs of children. Programs like Choiceworks, ABCmouse or Endless Reader use visually rich materials, structured tasks and games to facilitate the acquisition of basic cognitive and academic skills. Through the use of educational games, visual layouts and interactive simulations, children develop attention,

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better understand concepts and make progress in learning, and numerous studies confirm their effectiveness in working with children with intellectual disabilities (Dell, Newton & Petroff, 2017).

Mobile applications for organizing time and activities have a special value, because they directly contribute to the development of independence in children. Applications such as First Then Visual Schedule, Avaz Timer or MyRoutine provide structured support in planning daily tasks and transitions between different activities. Their use reduces the feeling of insecurity and anxiety that often cause changes in routine in children, and at the same time strengthens the feeling of control and predictability. Empirical research confirms that this form of support contributes to increasing children's independence and reducing stressful situations (Knight et al., 2019). In addition, the use of such tools is positively regarded by parents who believe their use enhance children's educational outcomes and promote inclusion (Jakovchevska & Chichevska Jovanova, 2024).

All these dimensions clearly show that assistive technologies are not just technical additions to the educational process, but key instruments of inclusion and empowerment of children with disabilities. From communication devices that enable the first step in expression, through sensory-motor aids that open up space for the development of new abilities, all the way to applications that facilitate the organization of everyday life - AT shapes the way towards greater independence, better social integration and a better educational experience. By integrating these technologies into educational and rehabilitation programs, society sends a clear message that it is ready to recognize and respond to the different needs of children, giving them the opportunity to learn, communicate and grow in accordance with their potential.

Augmentative and alternative communication (AAC) represents one of the most important areas of assistive support for children who cannot adequately use speech in everyday communication. These technologies include a wide range of solutions, from simple, low-tech tools such as image boards, to sophisticated, high-tech applications and systems based on motion recognition and speech generation. Their common goal is to enable the child to express his needs, participate in the educational process and develop social relationships, which significantly improves the quality of life and reduces the feeling of isolation.

The traditional and often first form of AAC technologies are pictorial communication boards and symbol books. This approach, also known as PECS (Picture Exchange Communication System), allows children to use pictures or pictograms to express basic needs, answer questions or initiate interactions. The PECS system is used worldwide, and numerous studies have confirmed its effectiveness in developing communication skills and reducing frustration in children with autism spectrum disorders (Bondy & Frost, 2001; Beukelman & Light, 2020). In this way, children get a structured, visually supported tool that serves as a bridge towards the development of more complex forms of communication.

Along with these low-tech approaches, mobile application development has revolutionized AAC support. Apps like Proloquo2Go, CoughDrop, JABtalk or Speak for Yourself allow users to select symbols, words or phrases on the screen, which are then converted into speech in real time. This kind of technology opens up the possibility for children to express more complex thoughts and participate in educational and social contexts without intermediaries. As Light and McNaughton (2014) point out, these tools significantly contribute to participation and inclusion, because they enable the child to actively communicate and participate in decision-making, which was often not possible before.

In addition to applications for speech generation, AAC also includes technologies based on motion and gesture recognition. Systems like GazeSpeak and SignAloud have been developed to track eye movements, gestures and signs, enabling communication for children with severe motor limitations. Although such technologies are still in development and

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undergoing testing and adaptation phases, research shows that they have enormous potential in working with children with multiple disabilities, opening up new possibilities for expression and social interaction (Zubair & Salim, 2021).

A special place within AAC is occupied by tools intended for children on the autism spectrum. Their purpose is not only to enable basic communication, but also to support emotional expression, recognition of social context and the development of skills necessary for successful management in social situations. Applications such as AutiPlan and Social Stories Creator are designed to help children anticipate social events and learn appropriate responses through structured "social stories". This approach, which was elaborated in detail by Gray (2010), significantly contributes to reducing anxiety, strengthening self-confidence and developing social competences in children with autism.

All of the above dimensions clearly show that AAC technologies are not just technical tools, but a powerful instrument of inclusion, communication freedom and empowerment of children. From the simplest picture boards to advanced applications and gesture recognition systems, AAC provides children with the opportunity to be active participants in the educational process and society as a whole. Ultimately, it is about technologies that allow children to express themselves in a way that matches their abilities

Discussion

The implementation of artificial intelligence (AI), assistive technology (AT) and augmentative and alternative communication (AAC) in working with children with disabilities represents one of the most promising directions for the development of inclusive education and rehabilitation. The results of previous research and examples of good practice clearly indicate that these technologies can significantly improve the quality of life of children with developmental disabilities, especially when they are aligned with their individual educational and communication needs (Beukelman & Light, 2020; Holmes et al., 2019).

The greatest value of these technologies is reflected in the personalization of access - AI enables individually adapted educational content, AT supports the development of functional skills, while AAC enables expression and communication in children who do not have developed speech. This personalization has a direct impact on increasing children's self-confidence, independence and participation in educational and social activities, as confirmed by the results of studies conducted in the USA, Sweden and Japan (Scassellati et al., 2018; Knight et al., 2019).

However, despite these advantages, the implementation of AI, AT and AAC technologies carries a number of challenges that cannot be ignored. First, there is a pronounced lack of systemic support at the level of educational institutions, which is reflected in limited funds for the purchase of equipment, insufficient technical infrastructure and the absence of strategic guidelines for the use of these technologies in regular teaching. In many educational institutions, especially in less developed regions, the use of these technologies is limited or completely absent, although the needs of children with disabilities clearly require it (UNESCO, 2020). Another important challenge relates to the education and training of staff. Teachers, rehabilitation educators, speech therapists, teaching assistants and other professionals often do not have sufficient knowledge or practical skills to use AI and AT solutions. The same applies to parents, who should play a key role in the use of AAC tools in everyday situations. The education of all stakeholders must be systematic, continuous and practically oriented, with technical and advisory support provided (Dell, Newton & Petroff, 2017; Alquraini & Gut, 2012).

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The issue of financial sustainability also emerges as one of the key ones. Most advanced devices, such as eye-tracking systems, wearable sensors or communication tablets with speech modules, are still extremely expensive and inaccessible to many families and schools. Although there are free and open versions of software solutions (e.g. CoughDrop, JABtalk), they often require technical support and additional equipment. Therefore, it is necessary to ensure institutional subsidies, donation programs and partnership projects with technology companies.

No less important is the issue of ethical implications. Technologies that collect biometric data (e.g. wearable sensors) must be used with strict privacy protection, parental/guardian consent and taking into account the child's autonomy. The question arises: to what extent is it acceptable to "monitor" a child in order to prevent a crisis situation, without violating their dignity and sense of safety? These dilemmas require a clear ethical framework and guidelines, as well as an interdisciplinary dialogue between experts in law, technology, education and rehabilitation (Zubair & Salim, 2021).

It has also been noted that current AI systems in education are still limited in terms of context and emotional sophistication. Most existing models are based on the recognition of surface patterns (e.g. tone of voice, heart rate), but do not integrate more complex dimensions of communication, such as irony, subtle social signals or cultural differences in the expression of emotions. This points to the need for further development of so-called "empathic AI", which could provide more subtle and humane support (Holmes et al., 2019).

Future research should focus on developing more accessible and culturally sensitive AI models, evaluating the long-term effects of implementing these technologies on children's educational achievement, mental health and social inclusion, and developing universal design for learning that integrates AI, AT and AAC. It is particularly important that research includes the voices of children and parents, to ensure the participation of end-users in the development of technologies that directly affect them. In conclusion, although AI, AT and AAC technologies bring new dimensions of support for children with disabilities, their true potential can only be realized through a holistic approach that includes cross-sectoral collaboration, ethical sensitivity, adequate funding and ongoing education of all involved.

Conclusion

Modern technologies – including artificial intelligence (AI), assistive technologies (AT), and augmentative and alternative communication (AAC) – are increasingly recognized as key tools in creating a more inclusive and equitable educational environment for children with disabilities, especially those with intellectual disabilities, multiple disabilities, and autism spectrum disorders. Their proper and integrated application can significantly contribute to empowering children's potential, facilitating their everyday communication, improving social skills, and increasing their level of independence and community involvement.

AI enables personalized learning and recognition of students' emotional needs, AT paves the way for greater functionality and independence, while AAC provides children without developed speech with a "voice" and a means to express feelings, desires, and needs. All of these technologies, when carefully selected and adapted to the child's individual capabilities, can serve as a bridge between the child and his or her environment, directly strengthening a sense of belonging, security, and competence.

However, the real effectiveness of these technologies depends not only on their technical sophistication, but also on the readiness of the system – educational, health and social – to recognize, accept and actively support them. It is necessary to ensure continuous education of experts and parents, stable financial support, available and accessible equipment and clearly defined ethical and legal frameworks for the application of technology in work with children.

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Special attention should also be paid to empowering children as active users and participants, whose voice must be present in the planning, implementation and evaluation processes. In conclusion, AI, AT and AAC are not miracle solutions, but they represent powerful tools when used in the service of a person and when integrated into a wider support system. Their value will not be measured only by technical specifications, but by the human relationships they will enable – between the child, the family, experts and the community. In this sense, investing in these technologies also means investing in a society that leaves no one behind.

Conflict of interest

None.

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