

Innovative and Handcrafted Low-Tech Assistive Tools: The Experiences of Kindergarten Educators and Their Role in Early Childhood Development

Aleksandra Jakovchevska¹, Natasha Chichevska Jovanova²

¹ University Ss. Cyril and Methodius - Skopje, Faculty of Philosophy, Institute of Special Education and Rehabilitation, R.N.Macedonia,

² University Ss. Cyril and Methodius - Skopje, Faculty of Philosophy, Institute of Special Education and Rehabilitation, R.N.Macedonia

Abstract

This study aims to explore how kindergarten educators manually develop and use low-tech assistive technology (AT). Low-tech AT refers to simple, inexpensive devices designed to help children who have certain developmental disabilities. The research uses a combined approach of quantitative and qualitative research techniques. Through surveys of educators we collected quantitative data related to hand-designed ATs, while interviews provided qualitative insights into the motivations, challenges and experiences of teachers with these tools, we also analyzed the content of hand-created low-tech ATs through a checklist.

The results show that handmade low-tech ATs significantly impact and benefit children's engagement, development and progress, especially in communication and motor skills. Educators also emphasized the importance of applying these tools in the early intervention process, noting improvements in more developmental aspects of children. The discussion highlights the need for additional resources and training to help educators create and implement effective AT devices, as well as the role of creativity in emphasizing the individual needs of students.

Article history

Received: 22.10.2025.

Accepted: 2.11.2025.

Keywords:

Assistive technology,
Early intervention,
Children with disabilities,
Inclusive education

¹ Corresponding author's email: ajakovchevska@gmail.com

Introduction

Assistive technology is described as "any item, piece of equipment, or product system, that is used to increase, maintain, or improve functional capabilities of a child with a disability" (p. 8) by the Individuals with Disability Education Improvement Act (IDEIA, 2004). A variety of assistive technologies and accessible devices and software with careful planning and guidance can play a significant role in the education of students with disabilities (Duhaney & Duhaney, 2000). *Assistive technology* according to the World Health Organization (WHO), is a generic term that denotes all systems and services related to the use of assistive products and means of performing services (WHO, 2001). In general and under the Assistive Technology Act of 1998, in the US assistive technology is defined as "any object, piece of equipment, or system, whether purchased commercially, modified, or adapted, that is commonly used to augment, maintain, or improve the functional abilities of persons with disabilities" (Bunning et al, 2004, p. 98). For Lewis, R. B. (1993), AT has two main goals: on the one hand, to increase a person's abilities, thereby mitigating the consequences of any disability. And secondly, to provide alternative access to a particular activity to compensate for the disability. The term AT refers to devices or services used to compensate for functional limitations, to facilitate independent living, to enable older people and people with activity limitations to realize their full potential and have an equal place and equal rights in social life. In the field of assistive technology, there is a distinct dichotomy between low-tech aids and high-tech solutions. Low-tech aids, which usually require minimal programming, while high-tech aids use advanced programming.

Assistive technologies are divided into low technologies, which do not use programming, such as magnifiers and pencil holders, and high technologies, which use programming, such as computers (McCulloch, 2004). Authors such as Cook, A., & Hessey, S. (1995) and Bryant, B., & Crews, P. (1998) also classify AT into two groups: low or simple technology and high or complex technology. Low or simple technology is described as equipment that is usually low cost and easy to create or apply, use. These are simpler to use (pencils, calculator magnifiers, paper communication boards, wheelchairs, white sticks, etc.). Complex technology refers to equipment that has electronic technology (computers, electronic communication boards, electric wheelchairs, etc.). In kindergartens, educators often are facing with risk or obstacle during their work. Kindergarten is a place where children spend their preschool years from birth to the age of 5/6 years, a period that is very significant for children's development. At this stage, kindergarten educators within their classroom also have children who have certain developmental problems, in this case they need to be focus on early intervention, to provide adequate support in order to help these children to overcome developmental problems. Research highlights that early intervention programs can lead to significant improvements in cognitive and social-emotional development, which are essential for successful transitions into formal schooling (Tzouriadou et al., 2016). The emphasis on early identification of learning difficulties, such as reading disabilities, is also critical, as it enables timely interventions that can prevent long-term academic challenges (Catts et al., 2016; Catts et al., 2013). To meet the diverse needs of preschool children, educators often rely on their innovation, creativity and resourcefulness and often handcraft low-tech assistive devices. These hand-made aids, such as communication boards or sensory walls, tactile books are develop to meet elements needs of the children with disabilities and are often created and developed with easy-to-use and inexpensive materials. This creative approach allows educators for special individual support that helps children with disabilities to effectively integrate into

preschool institutions, but also to build inclusive educational environments and fostering the process of early intervention.

The development of inexpensive, user-friendly hardware, programming environments, and do-it-yourself (DIY) toolkits has accelerated in recent years. As a result, sophisticated technical training or expertise are no longer necessary to design and construct anything utilizing digital technology. This has led to the emergence of the so-called "maker movement" (Hatch, 2014). Recently, the efforts to create original item have also been linked to the expanding Do-It-Yourself, or DIY, trend in the arts, crafts, and other creative fields (Guzetti & Yang, 2010; Knobel & Lankshear, 2010).

Early intervention for children with disabilities is important in the preschool period, especially when it involves low-tech assistive technology. Low-tech assistive technologies are more accessible and cheap, can be easily created using simple materials, can significantly improve learning opportunities for children with disabilities in kindergartens, especially in countries with low economic status. Jadhav et al. emphasize the importance of low-tech assistive technology in supporting children with disabilities in countries with low economic status and those in transition, emphasizing that such tools can facilitate access to education and improve learning outcomes Jadhav et al. (2020). Furthermore, the use of low-tech assistive technologies in kindergartens as early as early childhood can enhance the learning experience by encouraging creativity and critical thinking. Angraeni and Listiana emphasize that modern pedagogical technologies, including low-tech tools, can significantly improve learning outcomes in early childhood education (Angraeni & Listiana, 2023). By incorporating these technologies into early childhood play-based learning, educators can create inclusive, engaging, and interactive environments that support young children's holistic development. However, it is very important that the successful implementation of low-tech assistive technologies requires adequate training and support for educators. Many educators express concerns about their knowledge and abilities to effectively create and then integrate technology into their teaching practices due to lack of training and resources (Ogebo & Aina, 2022).

One of the advantages of handmade low-tech assistive technologies is their value. Lersilp et al. In 2018 suggested that low-tech AT devices are cheap and easy to make and applied in the work with children with disabilities. This ability to craft low-tech AT by hand is important, especially in low-income areas where financial constraints can also limit access to more sophisticated technologies. The authors point out that despite existing regulations and systems for providing assistive technology in certain countries, many types of AT remain underutilized, indicating the need for increased awareness and availability of low-tech options. Swai et al. emphasized that children with physical disabilities should have assistive devices for mobility and communication, which are essential for education, independence and inclusion in society (Swai et al., 2023). Hand-made devices, which are adapted for writing or communication boards, can improve the abilities of these children, but also abilities for all children with developmental problems, to participate in educational activities. Dimitrova-Radojicic et al, (2016) emphasize that the acceptance of children with disabilities is formed in preschool age and these attitudes later significantly influence the success of the inclusive process in the school environment. The positive attitudes of children's peers encouraged in early childhood, in kindergarten, can lead to greater social acceptance and peer support of children with disabilities.

According to Dimitrova-Radojicic et al. (2016), preschool children are generally more willing to engage in play with peers without disabilities, and educators' perceptions of inclusion in kindergartens can influence how effectively children with disabilities are integrated into classroom activities.

The concept of DIY-AT implies the creation and adaptation of assistive technologies by educators or organizations to support persons with disabilities (Manero et al., 2019). This phenomenon is especially relevant with the progress in 3D printing technology, which allows easy adaptation to the needs of the user and the development of a product with low costs. Such innovative and creative creations have had a great impact on a global level, especially for families, institutions or countries with limited financial resources (Goldstein & Naglieri, 2011). Despite the benefits, there are also several challenges in implementing DIY-AT for children with disabilities. Hook et al. (2014) identify various problems faced by educators including lack of technical skills, limited access to materials and insufficient knowledge about the design and construction of assistive devices. The effectiveness of DIY-AT can be significantly improved through mutual cooperation of relevant institutions and exchange of good practices. Research shows that when institutions collaborate, they can share resources, knowledge, and skills that contribute to better outcomes for children with disabilities (Judge et al., 2015). For example, cross-institutional collaborations focusing on DIY-AT trainings/seminars/workshops can provide support, enabling educators to overcome technical challenges and build appropriate skills to create assistive devices.

Methodology

Procedure

This study uses a mixed-methodology approach, combining both quantitative and qualitative research techniques to explore how kindergarten educators craft and use low-tech assistive technology for children with disabilities. The concept of mixed methods research has been evolving, gaining traction in fields such as health sciences, education, and social research. Fetters, Curry, and Creswell (2013) emphasized the importance of integration in mixed methods designs, outlining principles that guide researchers in achieving a seamless amalgamation of qualitative and quantitative data. Their work underscores that effective integration can enhance the validity and richness of research findings in complex health-related topics (Fetters et al., 2013). The application of mixed methods is not limited to health and social media studies but extends into areas such as education and environmental research. Mohajan (2018) emphasized the importance of qualitative methodologies in social sciences, suggesting that integrating these approaches with quantitative data can lead to more holistic insights. The study was designed to assess the types of handmade low-tech ATs in use, the experiences of educators, and the impact of these tools on child development.

Participants

Participants in this study were educators (educators and professional collaborators: special educators, speech therapists, pedagogues, psychologists) from several kindergartens in North Macedonia. A total of 90 educators participated in the study in an online survey, selected through purposive sampling to ensure that they had experience in manually creating low-tech AT. In addition, semi-structured surveys were conducted with 10 educators.

Quantitative data collection

Quantitative data were collected through an online survey conducted among kindergarten educators. The survey was designed to capture detailed information about the types of handmade low-tech ATs being used, the frequency of their use, and the areas of child development they target (eg, communication, motor skills, sensory development). The survey contained both closed and open-ended questions to allow clear quantitative analysis.

Qualitative data collection

To gain deeper insights into the motivations, challenges and experiences of educators with manual development and use of low-tech ATs, semi-structured interviews were conducted with a subgroup of 10 participants. Interview questions focused on the motivation of educators for developing specific AT tools, a description of the creative process, materials used, observed benefits for child development, and challenges faced in implementing these tools. This qualitative approach allowed us to explore personal experiences in depth.

Content analysis

In addition to surveys and interviews, a content analysis of manually created low-tech ATs was also performed. In the online survey, the educators uploaded pictures/samples of the handmade low-tech ATs, and in the interview they gave detailed descriptions of the devices they created. They were evaluated using a pre-defined checklist, which assesses device category, device function, materials used, device complexity, degree of creativity and innovation of the educator, general effectiveness (according to visual assessment), visual appeal and convenience for children as well as the security level of the device.

Data analysis

Data from the quantitative survey were analyzed using descriptive statistics to summarize the frequency and types of low-tech ATs used, as well as the development areas they target. Statistical analysis software (SPSS, Excel) was used to calculate percentages, means, and correlations between AT use and observed developmental improvements in children.

Qualitative data from the semi-structured interview were transcribed and analyzed using thematic analysis. Themes were identified based on recurring patterns in educators' responses, focusing on their motivations for using low-tech AT, challenges they faced, and perceived benefits for children. Key themes were categorized accordingly.

Content analysis was conducted using a checklist, and the results were collected to draw conclusions about the most common types of handmade low-tech ATs, what materials they are made of, their application and effectiveness for different development areas. All respondents were informed that the research was anonymous, and all participants voluntarily accepted to be the respondents in this study. The subjects were aware that their participation was voluntary and that they could withdraw from the study at any time without any consequences.

Results

Quantitative Analysis

Quantitative data from the online survey were analyzed using descriptive and inferential statistical methods to investigate the effectiveness of handmade low-tech assistive technology or handmade assistive technologies among kindergarten teachers in North Macedonia.

Descriptive statistics showed that most of the participants had experience in creating handmade assistive technologies, and many of the respondents reported that they had noticed positive changes in children with disabilities after using these hand-made products. The average perceived effectiveness of handmade HT was high, with a mean score of 5 on a scale of 1 to 5. This indicates that these tools have a positive impact on child development.

Chi-square tests were conducted to assess associations between variables. A statistically significant association was observed between educators who created handmade assistive technology and those who reported noticing developmental changes in children ($\chi^2(1, N=90) =$

14.95, $p < 0.001$). This suggests that the creation and use of such technology may be significantly associated with observed improvements in child development. However, no significant association was found between participation in workshops or seminars on assistive technology and educators' motivation to create handmade AT ($\chi^2(1, N=90) = 0.003, p = 0.958$), indicating that formal training did not strongly influence the motivation to create assistive technology in this sample.

To investigate whether perceptions of assistive technology effectiveness differed based on training participation or work experience, we conducted independent samples t-tests, which found no statistically significant difference between the effectiveness ratings given by educators who attended workshops and those who did not ($t(43) = -1.08, p = 0.290$). Pairwise comparisons were also made based on work experience (less than 5 years, 5-10 years, and more than 10 years) and revealed no significant differences in perceived assistive technology effectiveness between groups. These findings suggest that the educator's personal motivation and experiential learning alone may play a more significant role in the development of assistive technology than formal experience or training alone.

Quantitative results indicate that educators view handmade low-tech assistive technology as a valuable tool for supporting early childhood education for children with disabilities. The findings highlight the need for further support and training, but also indicate that individual creativity and initiative are key drivers for the successful use of such tools and their implementation in everyday work.

Table 1. *Quantitative Analysis Summary*

Variable	Statistic / Result
Created Handmade AT	68 out of 90
Observed Developmental Change	64 out of 90
Attended Workshop	14 out of 90
Effectiveness Rating (Mean)	3.98
Chi-square: Created AT vs Observed Change	$\chi^2 = 14.95, p < 0.001$
Chi-square: Workshop Attendance vs Created AT	$\chi^2 = 0.003, p = 0.958$
T-test: Workshop Attendance vs Effectiveness	$t = -1.08, p = 0.290$
T-test: Work Experience vs Effectiveness	All comparisons non-significant

Content Analysis of Handmade Assistive Technologies

For this part of the research, we applied structured content analysis, using a pre-developed screening instrument developed for the assessment of handmade low-tech assistive devices made by kindergarten teachers. This instrument included both categories and evaluation, allowing for a systematic classification of the types, functions, materials and quality level of each handmade AT.

Each handmade AT was scored and categorized according to pre-defined criteria, allowing for a structured comparison and summary of trends across all available handmade ATs that teachers uploaded to the online questionnaire.

A total of 30 handmade ATs were analyzed. The most common materials used for these ATs were: Cardboard/paper (22), adhesive tape (15), fabric (14), foam/plastic (12).

The most common reasons for making these technologies: Sensory support (10), cognitive/learning support (7), fine motor skills support (6).

From the above, the results indicate that sensory and cognitive support were the most common goals for handmade ATs. The most commonly used materials were cardboard, adhesive tape and fabric, reflecting their acceptability and accessibility.

Most of the devices were simple or moderately complex, making them practical for everyday use in kindergartens. Despite their simplicity, they proved to be very effective and visually appealing to children.

It must be noted here that personal creativity seems to be a significant driver in this process of handmade ATs - almost a third of the devices showed a high level of innovation, even without the educators receiving formal training in handmade assistive technology.

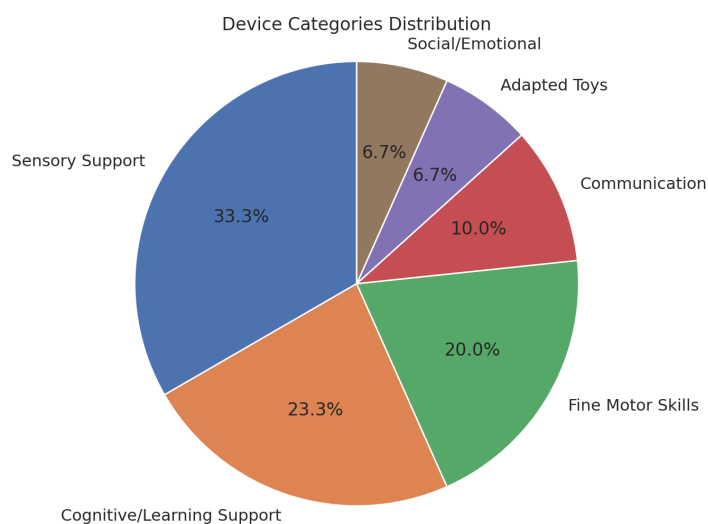


Figure 1. *Distribution of Handmade Low-Tech Assistive Technology by Device Category*

Qualitative data analysis

A total of 20 kindergarten teachers were interviewed in a semi-structured interview format, followed by thematic analysis. The analysis was conducted in 6 phases, according to the framework of Brown and Clark (2006): introduction, coding, theme generation, theme review, theme definition and naming, and report writing. The aim of this qualitative analysis was to identify in more detail how teachers perceive the role of handmade AT in supporting early development, inclusion, and their own professional development and creativity.

Table 2. *Thematic Summary of Interview Topics*

Topic	Description	Educator Quote
Recognizing the Individual Needs of Educators	Educators often identify the need for AT through direct observation of developmental challenges in children, such as sensory barriers or fine motor problems.	“I noticed that the child was bothered by noise, so I decided to create a sensory board to calm him down, I made the board with different textures.” – Educator 3
Emotions in Children and Fulfillment when Using AT	Many educators described feeling satisfaction, pride and establishing a deeper emotional connection with children as a result of the impact of handmade AT.	“When the child smiled and focused on the task for the first time, I felt fulfilled and proud as an educator.” – Educator 7
Observed Developmental Benefits in the Child	Participants reported improved attention, communication and fine motor skills in children who regularly used the handmade AT.	“With the communication board I made, the child started pointing to pictures to express his basic needs - this was a huge improvement for the child.” – Educator 12
Creativity and Professional Development	Educators considered the process of designing AT to be an important creative experience that influenced their overall approach to work.	“I started to think outside the box - not only in making AT, but also in the way I plan activities with children.” – Educator 5
Role in Early Intervention	AT devices were considered key tools for early stimulation and intervention, especially when introduced at critical developmental stages, in the preschool period.	“The earlier we introduce these tools, the better results we can achieve - we see that children respond faster to the stimuli they receive by using these creations.” – Educator 14
Contribution to Inclusive Education	Most educators emphasized the importance of handmade AT, believing that it fosters inclusion by enabling the participation of children with disabilities in group learning activities.	“These tools help me to include every child in group activities” – Educator 17

Discussion

This study discusses the importance and highlights the role of handmade assistive technologies in kindergartens, highlighting the role that these technologies play in improving education, especially in early childhood for children with disabilities. The results obtained confirm that most kindergarten teachers in North Macedonia not only create such tools on a daily basis, but also consider them to be very effective in stimulating child development, especially in the areas of communication, fine motor skills and sensory development. The observed correlation between the creation of handmade AT and the observation of developmental improvements in children ($\chi^2 = 14.95$, $p < 0.001$) supports previous research indicating the importance of initiative and innovation of educators in inclusive education (Anggraeni & Listiana, 2023; Jadhav et al., 2020). These findings have resulted in a growing body of literature and research emphasizing the value of do-it-yourself approaches in education, particularly in the use of assistive devices to personalize learning experiences (Knobel & Lankshear, 2010; Hatch, 2014).

The ability of educators to identify children's individual needs and respond appropriately and creatively by crafting simple, accessible, and functional tools confirms previous work by Lersilp, Putinoi, and Okahashi (2018), who have noted through their research that low-tech technology is practical and necessary in many communities where formal devices are not available. The most common materials used by educators and highlighted in their responses to this study are: cardboard, fabric, and tape; these materials reflect the availability of DIY solutions and further demonstrate how creative and resourceful educators can overcome financial and institutional constraints (Manero et al., 2019; McCulloch, 2004).

Interestingly, the lack of correlation between workshop attendance and technology effectiveness suggests that intrinsic motivation and creativity, rather than formal training, may be the driving force behind the successful integration of low-tech technology into early childhood classrooms. This is consistent with the findings of Hook et al. (2014), who highlight that many educators face challenges in accessing training and materials, yet ultimately find ways to innovate and develop through their own experiences.

The qualitative interviews in the study provide valuable insight into how these tools support emotional connection between educators and children, enhance inclusion, and promote individualized learning – echoing the arguments made by Dimitrova-Radojičić et al. (2016) for the importance of early acceptance of children with disabilities. This socio-emotional dimension of the use of handmade AT also aligns with the broader goals of early intervention, as described by Tsouriadou et al. (2015), which advocate for timely, contextualized support in preschool settings. Finally, this study supports calls for institutional support to provide educators with more resources and training (Ogegbo and Aina, 2022), while also recognizing the goodwill, motivation, and creativity of educators and their efforts to create inclusive environments for children with disabilities from an early age.

Conclusion

This study provides a description of the impact of handmade low-tech assistive technologies in kindergartens during early childhood, especially in supporting children with developmental disabilities. Through the use of triangulation, the research showed that educators not only actively design and use such tools, but also consider them to be very effective in encouraging communication, sensory development, motor skills and inclusion in general in preschool

institutions. The results emphasize that the success of the use of handmade products does not depend only on formal training, but arises solely from the creativity of educators, their motivation and a deep understanding of the individual needs of children. Content and thematic analyses further highlighted how these tools promote the emotional connection of the educator with the child, professional development and an inclusive environment in kindergartens. Handmade low-tech assistive technology is proving to be an accessible, cost-effective and inclusive solution in resource-poor educational contexts, confirming its relevance to global early intervention strategies and inclusive education goals.

Recommendations

1. Supporting the creativity and autonomy of educators: Policymakers and school administrations should encourage, foster and recognise the innovation of educators at the local level by providing time, space, materials and autonomy to design and implement low-tech assistive solutions.
2. Implementing assistive technology in teacher education curricula: Universities and training institutions should integrate content related to different types of assistive technology into early childhood education programmes, promoting both theoretical knowledge and practical.
3. Create networks and platforms for educators: Form regional or national networks and/or platforms where educators can share successful examples of handmade assistive technology, learn from examples of good practice, and receive guidance from specialists in inclusive education and assistive technology.
4. Invest in resources and materials: Although handmade assistive technology often uses recycled or low-cost materials, educators still need ongoing access to basic materials for making. Ministries, institutions, and various donors should provide material support, especially in rural or low-income settings.
5. Promote research and documentation: Continued academic research is needed to assess the long-term outcomes of the use of low-tech assistive technology. Future studies should include longitudinal follow-up and broader demographic sampling to validate and scale these promising practices.
6. Recognizing assistive technology as a right in early intervention: National policies should formally include assistive technology as part of early intervention strategies, ensuring that all children with disabilities have access to tools that support their developmental potential from the earliest years.

Conflict of interest

None.

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