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Digital Applications as Assistive Technology for Students with Disabilities

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ABSTRACT

This research aims to develop and design the application of assistive technology to transform the lives of individuals with disabilities, providing them with the skills and tools they need to overcome barriers that previously prevented them from fully participating in society. This research focuses on developing digital applications as a technological support for media lecturers to use in learning for students with disabilities. The research method used in this research is Design Based Research, which consists of three main stages, namely needs assessment, design process, technology used, and making interactive prototypes. Current developments in assistive technology and disability research indicate a growing interest in using assistive technology to promote inclusive practices in the pursuit of knowledge. There is a focus on creating diverse and culturally adaptive learning environments that suit diverse needs and experiences and increasing awareness of society's challenges and prejudices when using assistive technology. Adopting digital apps as assistive technology is not only a huge step toward making educational settings more inclusive and accessible for students with disabilities but also provides a variety of capabilities to meet the different requirements of students, such as configurable displays, interactive and multisensory learning possibilities, and interaction with other assistive technology.

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1. INTRODUCTION

The development of assistive technology (AT) has altered the lives of individuals with disabilities, providing them with the skills and tools they need to overcome the barriers that previously stopped them from participating fully in society (Fernández-Batanero *et al*., 2022; Soetan *et al.*, 2021; Alimi *et al*., 2021; Olumorin *et al*., 2022; Onojah *et al*., 2022; Olatunji & Babalola, 2022). Different theories in the literature regarding AT refer to various devices, software, and services that assist persons with disabilities with their daily activities, education, and employment (Karki *et al*., 2023). This technology has the potential to significantly enhance the quality of life for persons with disabilities, providing them with greater independence, autonomy, and inclusion (Moon *et al*., 2019). The significance of AT in meeting the needs of people with disabilities cannot be understated (Edusei & Mji, 2019). The AT for disability has been extensively studied. There are two types of AT devices: low-tech and high-tech (Kirboyun, 2020). Markers for the prediction of AT have been widely investigated (Yanagawa *et al*., 2023). Magnifying glasses, canes, and communication boards are examples of low-technology devices, whereas high-technology devices include complex software and hardware like voice synthesizers, brain-computer interfaces, and augmented reality systems. A substantially similar point has just been granted, which defined it as any item or system that improves the functional skills of people with impairments, including device selection and usage services. It has progressed from specialized goods to enabling technologies that address a wide range of requirements and cultures (Zallio & Ohashi, 2022).

AT is critical in educating persons with intellectual disabilities because it enhances academic achievement and fosters inclusion (McNicholl *et al*., 2021). It enables teachers to customize instruction, accommodate individual needs, and effectively interact with students with disabilities (Woodcock *et al*., 2022). AT allows students to acquire knowledge, grow, and engage in educational activities, making them more engaging and efficient (Rizk & Hillier, 2022). Furthermore, AT can provide compensatory choices, harness strengths, and foster independence in both daily life and education. AT enhances the functional capabilities of persons with disabilities. AT is based on mainstream technologies like mobile devices and is crucial for disability inclusion, now more affordable and integrated into mainstream technology. The research-validated AT therapies address speech, language, and communication issues, as well as the use of communication systems known as augmentative and alternative communication devices. This collection of scientific facts is powerful and clear, providing individuals with a method of communication, the sooner the better, improves a wide variety of outcomes in terms of self-determination, and scholastic accomplishments.

As educational institutions increasingly prioritize inclusive practices, the development and implementation of digital whiteboards represent a significant stride toward ensuring that students with disabilities have equitable access to education (Nzuza, 2023; Peruzzo & Allan, 2024). This introduction outlines the importance of digital whiteboards as assistive technology, setting the stage for a deeper exploration of their role in improving educational outcomes for students with disabilities. The novelty of this study underlined the importance of AT as an application in raising awareness of diversity, which may lead to increased understanding and empathy. Most studies in the field of an application as an AT have only focused on comprehension of the intended life improvements that AT supports, as well as the importance of having an expanded viewpoint on AT application that goes above practical requirements. It underlined the value of designed research in developing an accessible scientific basis and driving changes in policy in the field of AT application. Therefore, this paper focused on the development of an application for AT for students with disability.

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2. LITERATURE REVIEW

2.1. Assistive Technology

The integration of technology into educational settings has revolutionized the way teaching and learning occur, particularly for students with disabilities and impairments (Rizk & Hillier, 2022). AT refers to products, devices, equipment, or software designed to maintain or improve an individual's functioning and independence, promoting their well-being. These products can include items like spectacles, hearing aids, wheelchairs, communication boards, and therapeutic footwear. The goal of AT is to enhance the quality of life for individuals with disabilities by increasing their inclusion and participation in society (Boot *et al*., 2017). Meanwhile, AT encompasses a range of devices, interventions, and environmental modifications that enable individuals with disabilities to enhance their functional abilities and participate more fully in various aspects of life. It includes both hardware devices and software applications tailored to individual needs, as well as environmental adaptations and personal care support. The goal of AT is to empower individuals with disabilities to overcome barriers and achieve greater independence and inclusion in society (Layton & Wilson, 2009).

AT is described in the article as tools and equipment that improve the standard of life for people with disabilities and the elderly. AT has progressed from basic mechanical devices to complex technologies including wearables, artificial intelligence, and an Internet of Medical Things (IoMT), intending to boost social integration, enhance independence, and improve users' overall quality of life. Assistive technologies (ATs) are aids that improve the functional capacities of people with disabilities. ATs are low-tech and high-tech equipment that includes screen readers, voice recognition software, and brain-computer interfaces, as well as simple aids like magnifiers or pencil grips. Many ATs are now integrated into daily technology, for example, accessibility features in cell phones. Cloud-based solutions have initiatives like the Global Public Inclusive Infrastructure (GPII) that enable consumers to obtain personalized ATs from any device. Innovations in AI, machine learning, and the Internet of Things (IoT) are opening up new prospects for assistive devices. Impact on daily life makes ATs assist people with disabilities to overcome barriers to communication, movement, and daily chores, considerably increasing their quality of life.

AT refers to products and services that enhance the functioning of individuals with disabilities, optimizing their capabilities and reducing disability. Includes a wide range of devices, from mobility aids, like wheelchairs, to communication devices and software that assist with daily activities. AT significantly improves the quality of life, participation in society, and access to human rights for individuals with disabilities. AT is often part of rehabilitation programs, working alongside human assistance and environmental modifications. Effective AT requires accessible environments and policies, emphasizing that accessibility is a prerequisite for equal opportunities. This approach focuses on what individuals can achieve when given the right tools and support, rather than merely what they possess. Current policies often focus on funding assistive products rather than comprehensive support systems, which can limit the effectiveness of AT. Advocates for designing environments that are inherently accessible, reducing the need for specialized assistive products. Addressing systemic barriers and promoting inclusion requires societal efforts beyond individual interventions. Addressing systemic barriers and promoting inclusion requires societal efforts beyond individual interventions. Clear communication about AT and its integration with accessibility is essential for effective advocacy and policy-making (Steel, 2023).

To improve assistive technology, engaging technical volunteers and the education sector is crucial. By collaborating with skilled individuals, customized devices can be created for specialized needs, making them more affordable for people with disabilities. Additionally,

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scaling up existing efforts, enhancing connectivity, and leveraging resources can positively impact the quality of life for individuals with disabilities. They enable communication, learning, and independence, offering various tools and interfaces to support different needs and challenges. These technologies continue to evolve and improve, providing opportunities for inclusion and empowerment for users with disabilities.

2.2. Application of Technology for Students

Technologies have transformed education by making learning more interactive, engaging, and accessible. These technologies allow students to learn anytime and anywhere, breaking the traditional classroom's time and space restrictions. Mobile applications, due to their portability, multimedia capabilities, and widespread use among students, are effective tools for enhancing student engagement and learning outcomes. Apps such as MobileMath and Construct3D help students improve in subjects like mathematics and geometry by providing interactive exercises and games. These apps are designed to make learning active and engaging through direct experience and problem-solving. Mobile apps support collaborative learning, which is essential for developing higher-order thinking skills. Apps like discussion boards and blogs allow students to work together on complex problems, enhancing critical thinking, teamwork, and problem-solving abilities (Karabatzaki *et al*., 2018).

E-learning is a digital approach to education that uses the internet, computers, and other digital technologies to facilitate learning. It shifts from traditional teacher-centered learning to a student-centered approach, providing flexibility in terms of time and location. It is essential in modern education because it enhances access to high-quality education, meets the diverse needs of students, and supports lifelong learning. E-learning by application provides the flexibility to learn from anywhere at any time, which is beneficial for students with different schedules and learning paces. Digital applications can make learning more interactive and engaging, which can improve understanding and retention of information (Rasouli *et al*., 2016).

Mobile applications are crucial in modern education due to their accessibility and the ability to engage students through interactive learning methods. Applications like Kahoot, ClassDojo, Classcraft, and Socrative are highlighted as effective tools for gamification in education. These apps enhance learning by increasing student motivation and engagement, making learning more interactive and fun. Android is the most commonly used operating system among students, followed by iOS. The choice of operating system influences the accessibility and functionality of educational apps. The study suggests that application choice and operating system compatibility are critical in successfully integrating technology into the classroom (Boot *et al*., 2017).

2.3. Application of Technology for Students with Disabilities

Disability is defined as a limitation in a person's ability to perform a specific role or participate in daily life (Maryanti *et al*., 2021). It can encompass physical, cognitive, sensory, and mental health disabilities. AT plays a vital role in supporting individuals with disabilities to enhance their capabilities and access opportunities (Alper & Raharinirina, 2006). In the same view, Maryanti *et al*. (2021) in their research notes that disability is a condition that limits a person's physical, sensory, cognitive, or mental abilities, impacting their daily life tasks and interactions. People with disabilities may face challenges in mobility, communication, or accessing information due to their disabilities. Disability is defined as a deficiency in performing activities, stemming from disabilities that can be physical, psychological, or social. Types of disabilities include cognitive, developmental, intellectual, mental, and physical

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disabilities. Common disabilities are related to movement, vision, hearing, and speech. Inclusive education ensures that students with disabilities are educated alongside their peers in general classrooms. This makes research on special needs education have been well-documented (see **Table 1**).

Table 1. Previous studies relating to disability students.

No	Title	Reference
1	Literacy program for elementary school students about inclusive education in recognizing children with special needs	(Faddilah *et al.*, 2022)
2	Correlation between process engineering and special needs from bibliometric analysis perspectives.	(Nordin, 2022)
3	Design of places of worship for people with special needs	(Kurniawan, 2022)
4	Physical and mental health struggles during the time of pandemic: An overview of domestic setting	(Marcaida, 2022)
5	Strengthening literacy in children with special needs during courageous learning with family support in learning during a pandemic.	(Fitri *et al.*, 2022)
6	Perception of special needs undergraduates on the use of assistive technology for academic purposes.	(Onojah *et al.*, 2022)
7	Undergraduates with special needs' awareness towards the use of assistive technology for learning at the university level.	(Olatunji & Babalola, 2022)
8	Behaviors of concern to special education teachers in their classroom: class characteristics and class composition predictors	(Musayaroh, 2022)
9	Bibliometric analysis for understanding the correlation between chemistry and special needs education using VOSviewer indexed by Google	(Bilad, 2022)
10	Analysis comparative of physical fitness of students with disabilities and normal students	(Hidayatullah *et al.*, 2022)
11	The role of guidance and counseling teachers in dealing with deviant behavior of school students	(Zauddin & Bakar, 2022)
12	Efforts to improve the vocabulary of Indonesian language for 1st-grade elementary students with hearing impairment for through the application of mnemonic	(Kurniawati, 2022)
13	Assessment of factors responsible for child abuse among students with intellectual disabilities	(Adesokan *et al.*, 2022a)
14	Computing bibliometric analysis with mapping visualization using vosviewer on "pharmacy" and "special needs" research data in 2017-2021	(Sudarjat, 2023)
15	Webtoon comic media to improve reading comprehensions for students with hearing impairment in special primary schools	(Hartati *et al.*, 2023)
16	Physical education online class for students with hearing impairment during covid-19 pandemic	(Sultanto *et al.*, 2023)
17	Anticipation and understanding of events and mental stresses as the effect of changes and transformations in human and social life: An education perspective	(Minghat & Arpentieva, 2023)
18	Common 21st-century social vices among the youth	(Hassan & Abdulkareem, 2023)
19	A digital accessibility and inclusive design-based e-module in higher education: Does it work in a classroom with a deaf student?.	(Musayaroh, *et al.*, 2023)

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Table 1 (Continue). Previous studies relating to disability students.

No	Title	Reference
20	Effect of rhymes on social skill acquisition of children with special needs	(Sulyman & Yetunde, 2023)
21	Impact of after-school sports programs on the mental health of primary school pupils	(Saadu, 2023)
22	Teachers' perceived barriers to inclusive education	(Adesokan & Bojuwoye, 2023)
23	Digital transformation in special needs education: Computational bibliometrics	(Al Husaeni & Wahyudin, 2023)
24	Emotional maturity and emotional adjustment of adolescents with emotional and behavioral disorder	(Adesokan *et al*., 2024)
25	School feeding program in Nigeria: Special schools experience	(Dada *et al*., 2024)
26	Teachers' knowledge and use of multiple disciplinary measures in curbing pupils' antisocial behaviour	(Saadu, 2024)
27	Serial mediation effect of self-confidence in the relationship between hedonic lifestyle and consumptive behavior in generation Z.	(Anisah *et al.*, 2024)
28	Bibliometric analysis of special needs education keyword using VOSviewer indexed by google scholar	(Al Husaeni *et al*., 2022)
29	Sustaining students' mental health through the use of tiktok application.	(Gajo *et al.*, 2022)
30	Teachers' Perspectives on the education of deaf and hearing difficulty students in Indonesia: Research at SLB-B Negeri Cicendo Bandung	(Marasabessy, 2022)
31	Special education teachers' readiness and self-efficacy in utilization of assistive technologies for instruction in secondary school.	(Surajudeen *et al*., 2022)
32	Learning abilities of students with intellectual disabilities for cooking Indonesian traditional food "opak bakar": From step by step experiment to the analysis	(Apriyanti, 2022)
33	Introducing music and movement-based self-therapy for children with cerebral palsy during the covid-19 pandemic	(Syarifatunnisaa *et al*., 2022)
34	Rational emotive behaviour psychotherapy and depressive behaviour among secondary school adolescents	(Olanrewaju *et al.*, 2022)
35	Organization of extracurricular physical education at school and its role in the physical and mental improvement of students	(Saodat, 2022)
36	Improving reading comprehension skill through the school literacy movement for children with learning difficulties.	(Viyana *et al*., 2022)
37	Availability and challenges of inclusive lower primary education schools	(Egbedeyi & Babalola, 2023)
38	Psychological issues in Bangladeshi children for Covid-19: Losing interest in education.	(Riteshkarmaker, 2023)
39	Teachers' challenges in teaching English to students with special needs: How to cope with them?.	(Apriliyanti, 2023)
40	The impact of yoga on mental health.	(Kamraju, 2023)
41	Emotional intelligence as a predictor of academic stress management among undergraduate students	(Adio & Lasisi, 2023)
42	Levels of mental resistance of young mothers from urban poor families in the face of economic difficulties	(Hafina, 2023)

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Table 1 (Continue). Previous studies relating to disability students.

No	Title	Reference
43	The emotional intelligence dimensions among foundation students	(Bongsu *et al*., 2023)
44	Primary school teachers' competence level in the early identification of gifted children.	(Saadu *et al*., 2024)
45	Managing visually impaired students: Factors that support and inhibit inclusive programs in elementary	(Radi & Hanafi, 2024)
47	Relationship between the counselor's personal characteristics and self-development experience with individual counseling skills	(Hafina, 2024)
48	Parents' and teachers' perception of indicators for the choice of marriage partner among hearing-impaired adults	(Adesokan *et al.,* 2024)
49	Anti-bullying act of 2013 and holistic development of secondary students in term of emotional development, mental development, and social development.	(Malaguial *et al*., 2024)
50	Development of traluli program of family-resourced early intervention for multiple disability and visual impairment (MDVI) children with fine motor impairment in inclusive school.	(Rizqita *et al.*, 2024)
51	Student's perception of school-related factors of mental health problems	(Ojonugwa *et al*., 2024)
52	Secondary school violence among adolescents: The contributing factors and way forward.	(Ajani *et al*., 2024)
53	Developing the ability to add integer through live worksheets among grade II pupils with autism in mathematics learning	(Suprihatin *et al*., 2024)
54	Development of a family-based early intervention program to improve consonant letter articulation skills in children with articulation barriers	(Bela *et al*., 2024)

Disability refers to constraining people's capacity to do daily tasks, such as visual, hearing, or movement issues. Disabilities can limit access to technology, education, and communication, emphasizing the need for AT to improve functioning capacities. AT strives to offer tools and equipment that help people with disabilities enhance, maintain, or improve their ability to overcome obstacles in numerous parts of their lives. A broader perspective has been found by Boot *et al*. (2017) which defines that individuals with disabilities have a restricted ability to utilize assistive items. Challenges include cognitive disorders, multiple illnesses, and caretaker knowledge. A stronger emphasis on individuals with disabilities is required in AT efforts. Addressing these issues can help minimize health disparities and enhance the quality of life.

Mobile apps are crucial for students with special needs, offering customizable and adaptable solutions to support their unique learning requirements (Thapwiroch *et al*., 2021; Ratsame *et al*., 2021; Omolafe, 2021; Babalola & Omolafe, 2022). These apps can help improve communication, cognitive abilities, and autonomy in performing daily activities. For example, apps using pictograms or interactive features can help students with autism or Down syndrome learn basic skills and improve social interactions (Karabatzaki *et al*., 2018). Mobile technology offers an appropriate educational environment that supports learning activities outside the traditional classroom, providing flexibility and accessibility. For students with disabilities, mobile applications can enhance engagement and motivation, allowing them to learn at their own pace and according to their unique needs. Students with disabilities are defined as neurological differences affecting information processing, and impacting skills like reading, writing, speaking, and organizing information. Students with learning disabilities may

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perform as well as or better than their peers if provided with the right tools and interventions. Mobile apps can play a crucial role in providing these tools. Effective use of these technologies can bridge learning gaps, cater to individual needs, and promote inclusion, ultimately enhancing the educational experience.

Students with disabilities often require comprehensive, individualized programs that are difficult to evaluate using Randomized Controlled Trials (RCTs). These programs include multiple components tailored to individual needs, making standardization challenging. Understanding application technology for students with disabilities requires acknowledging the limitations of traditional research methods like RCTs and embracing a more flexible, comprehensive approach to evaluating and implementing interventions. By focusing on evidence-based practices and considering alternative research methodologies, educators can better meet the diverse needs of students with disabilities, ultimately enhancing their educational outcomes (Odom, 2021).

Technology-enabled learning can have a huge impact on the learning efficacy of students, especially young children with learning disabilities. Such kind of learning is not only effective but entertaining as well. Over recent years, the use of Augmented Reality (AR) technology and multimedia elements in the development of learning and training applications has intensified, signifying the many educational benefits that both learners and educators can gain. In particular, teachers can leverage the learning activities of students with learning disabilities with the use of mobile AR learning applications with multimedia elements, such as audio, graphics, animation, and video, by making them highly motivated and interested in the learning process. Given the continual advancement in mobile technology, mobile devices, such as smartphones and tablets, are becoming not only affordable but also powerful, and their utility can be further leveraged by running a wide spectrum of technologies, including AR technology, on such devices (Rochman *et al*., 2024).

3. METHODS

Design-based research is a collaborative approach that combines empirical educational research with theory-driven design of learning environments. It aims to develop interventions to address practical problems and generate theoretical understanding to inform others' work. This interactive process involves researchers acting as agents of change and participants as collaborators. It is crucial to understand how educational innovations work in practice.

Design-based research is used to develop an animated video about sedentary behavior. This Research is in the form of a design to produce a digital media product. The design is carried out by conducting a needs analysis from various sources, including a literature review and relevant research results. The design for the development of applications for students with disabilities can be seen in **Figure 1.**

3.1. Need Analysis

Needs analysis is a stage related to needs-related analysis in developing applications for students with disabilities. This stage aims to explore the design and development of the necessary digital media. This stage is carried out as a basis for designing and developing digital media, at this stage, it is carried out by conducting studies from various literature and research results which are then analyzed and processed to become the basis for designing and developing digital media.

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3.2. Design

Design is a stage carried out based on the results of previous literature studies. At this stage, the design is adjusted to the student's needs in courses to give an inclusive experience in the learning environment.

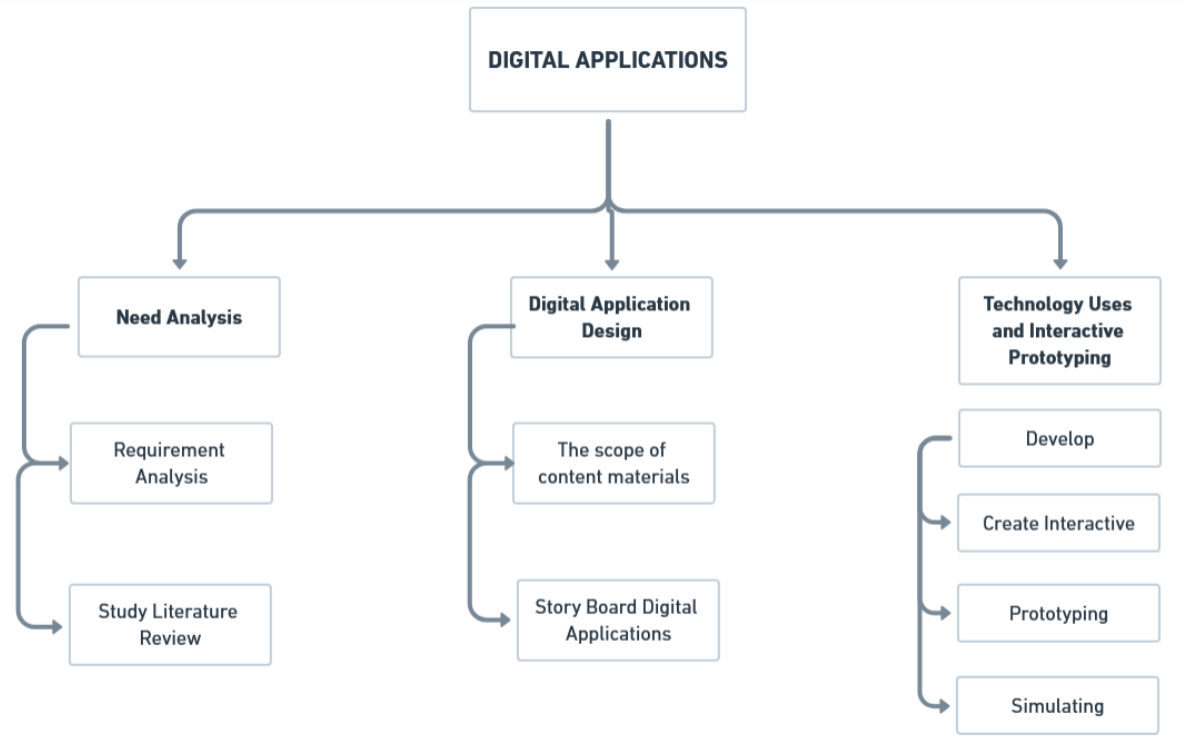

Figure 1. The design for the development of digital applications.

3.3. Technology Used and Interactive Prototyping

Making an application for students with disabilities is the core stage of this research process, namely the stages of developing applications. There are three stages, develop high-fidelity designs that include detailed visuals, colors, and typography, design tools to create an interactive prototype, simulate the user experience, and ensure the design includes features like drawing tools, text input, shapes, and real-time collaboration.

4. RESULTS AND DISCUSSION

4.1. Needs Analysis

Needs analysis is carried out using bibliometric analysis, the bibliometric was done by Google Scholar using the keywords “Assistive technology”. Search results are stored in two files, *.ris and *.csv. Data processing uses automatic analysis using the VOSviewer application and manual analysis using Microsoft Excel. Data mapping is done after the data selection process. Data mapping is analyzed to find developments, research trends, and other fields and terms often associated with the study material in research.

Table 2 displays the top 10 most influential articles in AT and disability research considering the total number of citations. The 10 most influential articles earned a total of 636 citations. Additionally, the study provides the spotlight on the issue of assistive technology, how it is related to disability, and the benefits of embracing inclusion for persons with various types of disabilities in educational circumstances. Additionally, the study provides the spotlight on the

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issue of assistive technology, how it is related to disability, and the benefits of embracing inclusion for persons with various types of disabilities in educational circumstances.

Based on the VOSviewer results (**Figure 1**), a co-occurrence analysis of the trend topics with a minimum incidence of 4 clusters of 36 keywords that met the threshold level. The topic 'information technology' was determined to be highly related to 'accessibility, 'automation', 'brain-computer interface', 'disabled people', 'human-computer interaction ', 'information and communication technologies', 'information and communication technologies', 'information technology', 'internet of things', 'mobile computing', 'mobile devices', 'mobile technology', 'mobile telecommunication', and 'people with disabilities' which were clustered in the red cluster. The topic 'artificial intelligence', 'assistive technology', 'assistive technology development', 'communication software', 'computer interface', 'computer system', 'computers', 'devices', 'robotics', 'software', and 'user-computer interface' were all highlighted in green.

Table 2. The top 10 most influential articles.

Title	Author/Year	Source	Total citations
Smart wheelchairs: a literature review	(Simpson, 2005)	Journal of rehabilitation research and development	435
Movaid: a personal robot in everyday life of disabled people and elderly people	(Dario *et al.*, 1999)	Technology and Disability	95
A computer-aided telephone system to enable five persons with Alzheimer's disease to make phone calls independently	(Perilli *et al.*, 2013)	Research in Developmental Disabilities	38
Communicating critical information using mobile phones to populations with special needs	(Sullivan *et al.*, 2010)	International Journal of Emergency Management	13
Technology-assisted programs for promoting leisure or communication engagement in two persons with pervasive motor or multiple disabilities	(Lancioni *et al.*, 2011)	Disability and Rehabilitation: Assistive Technology	13
Enabling devices, empowering people: the design and evaluation of trackball edge white	(Wobbrock *et al.*, 2008)	Disability and rehabilitation: assistive technology	9
Using text messaging in the treatment of eating disorders	(Hazelwood, 2008)	Nursing times	9
Wearable computer system reflecting spatial context	(Lee *et al.*, 2008)	International workshop on semantic computing and applications	8
User experience of mobile controlled games for activation, rehabilitation, and recreation of elderly and physically impaired	(Sirkka *et al.*, 2012)	Studies in health technology and informatics	6

Furthermore, the topic 'access to information', 'disability', 'internet', 'Mhealth', 'mobile phone', 'quality of life', 'smartphone', 'telecommunication', and 'telemedicine' were placed in the blue cluster. Finally, the topic 'communication', 'interpersonal communication', and 'technology' were clustered in the yellow cluster. These results refer to many clusters of co-occurring trend themes in our research endeavor, each of which might represent a distinct field or area of research within the wider subject as shown in **Figure 2**. Detailed information on how to use bibliometrics is explained elsewhere (Al Husaeni & Nandiyanto, 2022; Rochman *et al.*, 2024).

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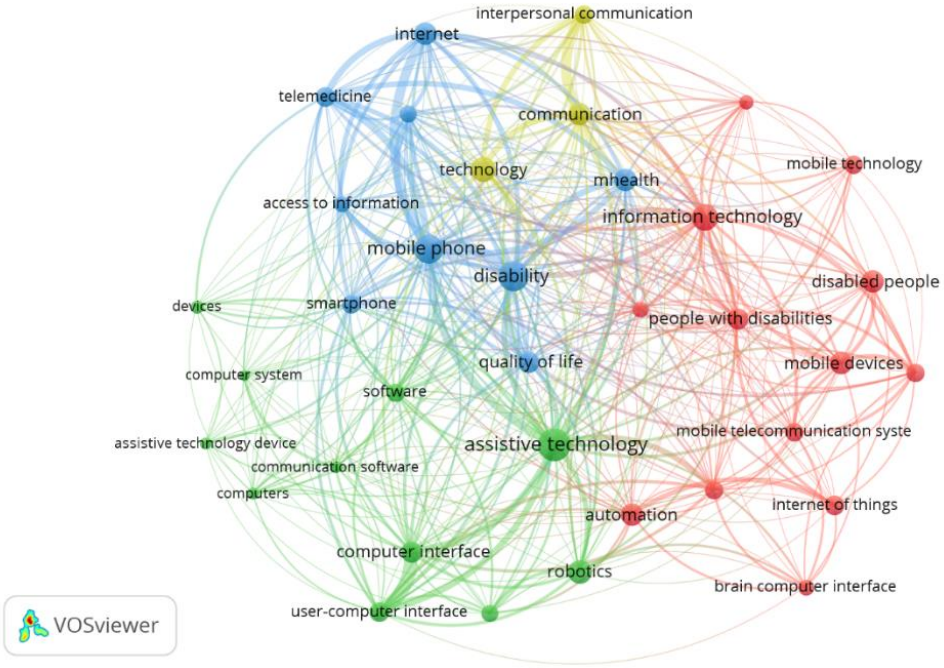

Figure 2. The network visualization of trend topics.

Table 3 displays a brief description that includes the total occurrence (TO) of each keyword, the links (L) of each keyword, indicating the various occurrences of each keyword along with related terms, and the total link strength (TLS), which displays the total occurrence of each term with other keywords in the entire subject . However, an outline of each topic or cluster provided Cluster 1 is the most significant cluster related to information technology and has 31 items containing 29 links with 90 total link strength in the framework of AT and disability research. Additionally, cluster 2 the most prominent cluster connected with AT contains 49 items with 31 links and 121 total link strength. Also, the largest cluster in cluster 3 is concerned with disability, which comprises 43 items containing 32 links and 117 total links of strength. Subsequently, the major in cluster 4 related to technology has 30 items, 29 links, and 74 total links of strengths. These findings indicate that information technology, assistive technology, disability, and technology are the most common topics in AT and disability research.

Table 3. Descriptive summary of each cluster.

Keyword	TO	Links	TLS	Keyword	TO	Links	TLS
Cluster:1 - Information technology				**Cluster:2 - Assistive technology**			
Accessibility	11	21	41	Artificial intelligence	14	19	34
Automation	24	28	48	Assistive technology	49	31	121
Brain-computer interface	12	13	26	Assistive technology development	7	15	19
Disabled people	23	22	41	Communication software	7	20	31
Human-computer interaction	16	25	51	Computer interface	21	22	75

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Table 3 (Continue). Descriptive summary of each cluster.

Keyword	TO	Links	TLS	Keyword	TO	Links	TLS
Cluster:1 - Information technology				**Cluster:2 - Assistive technology**			
Information and communication technologies	10	20	34	Computer system	6	18	24
Information technology	31	29	90	Computers	7	19	29
Internet of things	19	16	30	Devices	9	15	25
Mobile computing	17	19	45	Robotics	26	24	53
Mobile devices	23	21	47	Software	15	28	59
Mobile technology	17	17	25	User-computer interface	19	24	74
Mobile telecommunication	16	18	37				
People with disabilities	22	30	66				
Cluster:3 - Disability				**Cluster:4 - Technology**			
Access to information	12	26	55	Communication	24	30	85
Disability	43	32	117	Interpersonal communication	15	25	60
Internet	23	25	85	Technology	30	29	74
Mhealth	24	28	78				
Mobile phone	41	34	140				
Quality of life	22	29	72				
Smartphone	17	23	54				
Telecommunication	14	23	59				
Telemedicine	19	22	68				

Note: 36 items, 4 clusters, Links 1420, Total link strength 1036

4.2. Digital Applications as Assistive Technology Process

The creation of digital applications as AT for people with disabilities requires a user-centered approach and careful consideration of process requirements. A framework for designing and creating low-cost AT emphasizes user involvement throughout the identification, creation, and implementation phases (Pousada *et al*., 2021). This approach can lead to higher user satisfaction and better matching between person and device. To ensure sustainability and reduce abandonment rates, digital AT for older adults should be adaptable to changing needs (Olphert *et al*., 2009). Innovative applications for students with visual disabilities can facilitate learning and promote autonomy, though obstacles to their implementation persist. Digital health interventions offer significant potential to improve access to AT globally, supporting various aspects of service delivery and workforce

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development. The digital application provides a straightforward solution that includes strong components, such as built-in timers and other features.

The process proposes a framework requirement to inform the designers and implementers of digital assistive technologies to facilitate the development of more adaptable user-centered systems that can accommodate the changing needs and decrease the rate of abandonment of these technologies (Olphert *et al*., 2009). In addition, Bakırlıoğlu & Kohtala (2019) present a framework for designing and creating low-cost and do-it-yourself AT for disabilities, which includes three phases: identification, creation, and implementation, and shows the coherence and applicability of the framework. applies a user-centered and active perspective. The high match between the individual and the assistive equipment emphasizes the need to include the user in the development and choice process.

The flowchart illustrates the process of using digital applications as AT for students with disabilities. It starts with the user navigating to the home page, where they can begin the application. The user then chooses to start the process, which involves either importing an image or a presentation. If an image or presentation is imported, the application processes it. The user then has the option to add files, which can include audio, video, or other types of content. After adding files, the application makes a decision based on the content and user input. Finally, the results of the process are displayed to the user. Throughout the flowchart, there are exit points, allowing users to leave the application at any time. This flexibility ensures that the application can be used effectively by students with varying needs and preferences. The process of flowcharts illustrations can be seen the **Figure 3**.

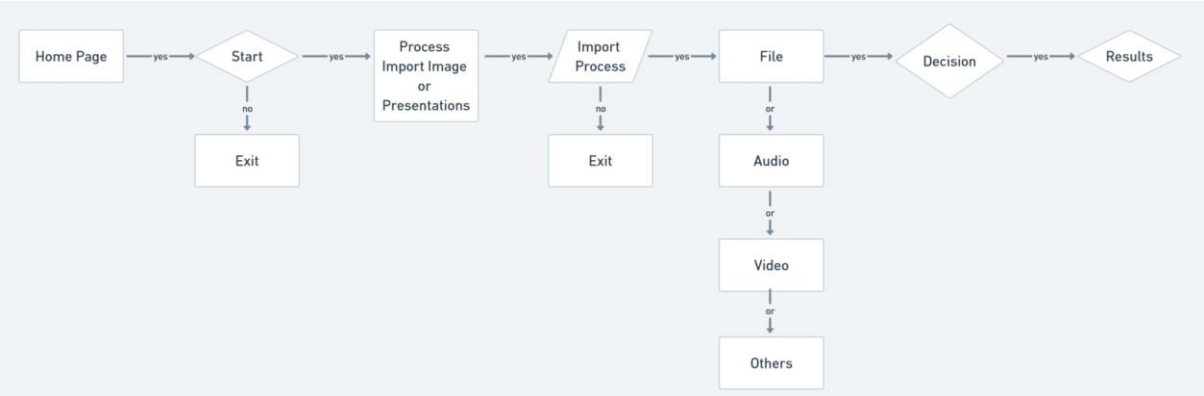

Figure 3. Digital applications flowchart.

The image in **Figures 4** and **5** displays the home screen of the application. A navigation button and a prominent logo show in the interface that is clean and intuitive. A search bar and settings icon are located at the top, allowing users to easily find and customize the application's features, and the overall design aims to provide a user-friendly experience, making it accessible and effective for students with diverse needs as seen.

The home page of a technological assistance program displays the first screen on the left side, complete with a backdrop and a conspicuous "NEXT" button that directs users to the next stage in the application. The right side displays the next panel, where users may select from choices such as "Files", "Audio", "Video", and "Others". b shows how the homepage is user-friendly and supports easy navigation for users.

Once there is an application, the most recent development in AT that individuals with visual disabilities are using in the classroom demonstrates how AT helps students with visual disabilities learn through creative applications. For students, visual disabilities can be used in different ways to help students with sight disabilities. For example, zooming or enlarging text

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and images to make them larger or more accessible to see, as well as built-in speakers combined with text-to-speech software, can help broadcast materials aloud (Newton & Dell, 2011). For audio disabilities, it can be used as an assistive listening system, in combination with microphones and built-in speakers to enhance the speaking volume; in combination with recording software, it enables the recording of presentations for students to review if the teacher's speaking speed is too fast or the learning environment is too noisy, combination with speech-to-text software and microphones can help transform the presenter's voice into readable text on the screen for students (Mountapmbeme *et al*., 2022).

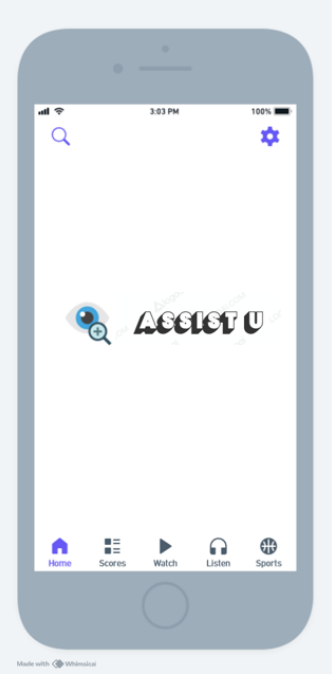

Figure 4. Application display on mobile phones.

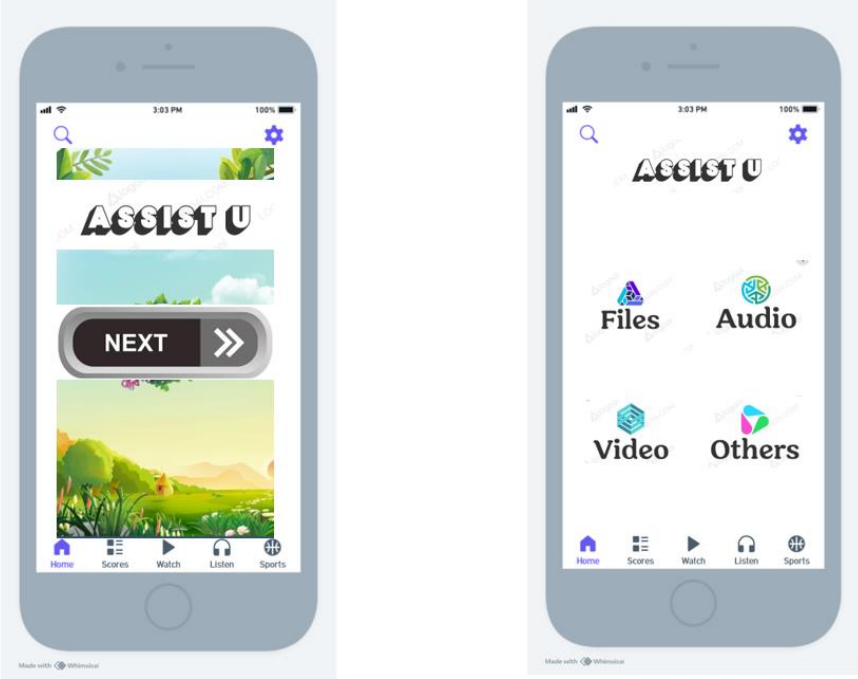

Figure 5. Homepage.

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Extremity disabilities can be connected to other hardware or devices, allowing students to input information such as special keyboards, touch panels, writing instruments, and pointing tools. Mobility disabilities have several functionalities that may help with limited mobility (Kapsalis *et al*., 2024; Zapata *et al*., 2023). It allows students to send information from their device to the teacher; adjustable stands can also be used to lower or maneuver the screen to fit the student's needs best. For Speech disabilities, microphones and built-in speakers can be used to increase a student's speaking volume, Using Text-to-Speech (TTS) software to vocalize student-typed messages (Peters & Anderson, 2019). Attention disabilities can allow teachers to integrate multimedia into lessons and presentations to give students more aspects to focus on, such as visuals, videos, and animations (Boonmoh *et al*., 2021). The image showcases the selection file pages of an AT application for mobile phones. Each page represents a different file type: Files, Audio, Video, and Others. Each page features a prominent icon representing the file type, along with "Back" and "Upload" buttons. These buttons allow users to navigate back to the previous page or upload files of the corresponding type. The consistent design across the four pages ensures a user-friendly experience, making it easy for students to understand and navigate the application. The clear labels and buttons facilitate the selection and upload of files, enhancing the accessibility and effectiveness of the assistive technology, as seen in **Figure 6**.

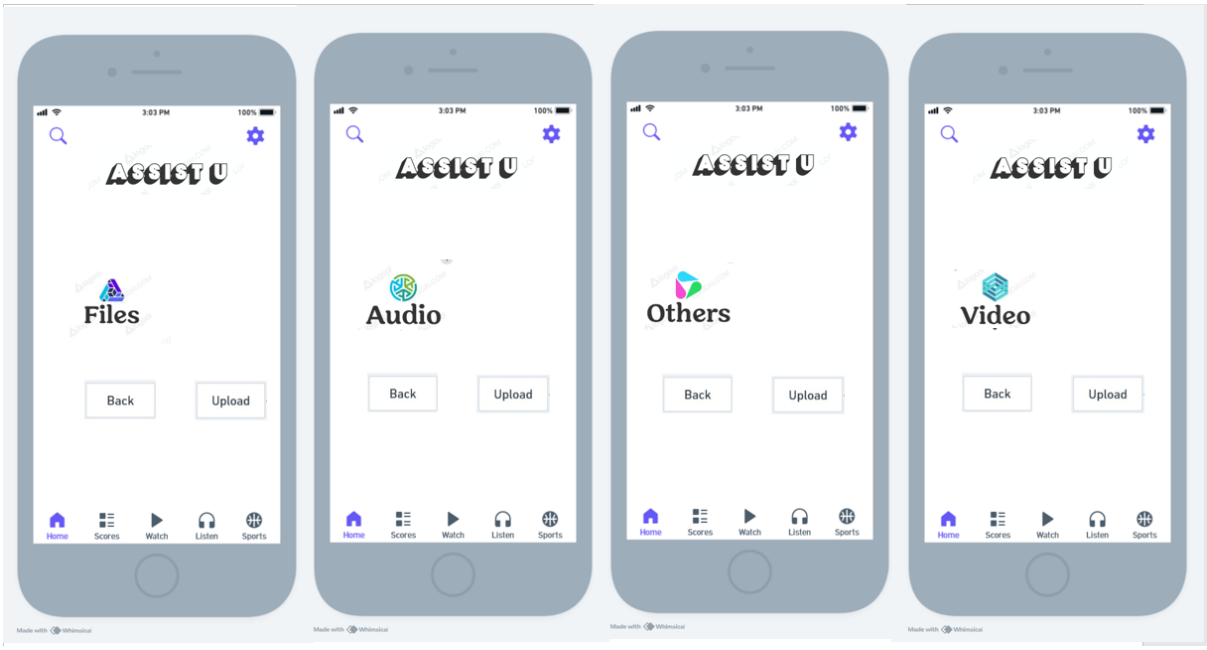

Figure 6. Selection file page displays.

AT refers to products, devices, equipment, or software designed to maintain or improve an individual's functioning and independence, promoting their well-being. These products can include items like spectacles, hearing aids, wheelchairs, communication boards, and therapeutic footwear (Smith *et al*., 2018). The goal of AT is to enhance the quality of life for individuals with disabilities by increasing their inclusion and participation in society (Boot *et al*., 2017). AT encompasses a range of devices, interventions, and environmental modifications that enable individuals with disabilities to enhance their functional abilities and participate more fully in various aspects of life. It includes both hardware devices and software applications tailored to individual needs, as well as environmental adaptations and personal care support (Bricout *et al*., 2022). The goal of AT is to empower individuals with

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disabilities to overcome barriers and achieve greater independence and inclusion in society (Löbe & AboJabel, 2022).

Figure 7 showcases the upload and download display pages of an AT application for mobile phones. On the left, the page displays a grid of uploaded files with a status indicating "Upload Complete" and a "Download" button. This allows users to download their uploaded files. On the right, the page shows a similar grid of files with a status indicating "Download Complete" and a "Done" button. This suggests that the download process has finished successfully. The consistent design and clear messaging across both pages make it easy for users to understand the status of their files and take appropriate actions. This feature enhances the accessibility and effectiveness of the assistive technology, ensuring that students can easily manage their uploaded and downloaded content.

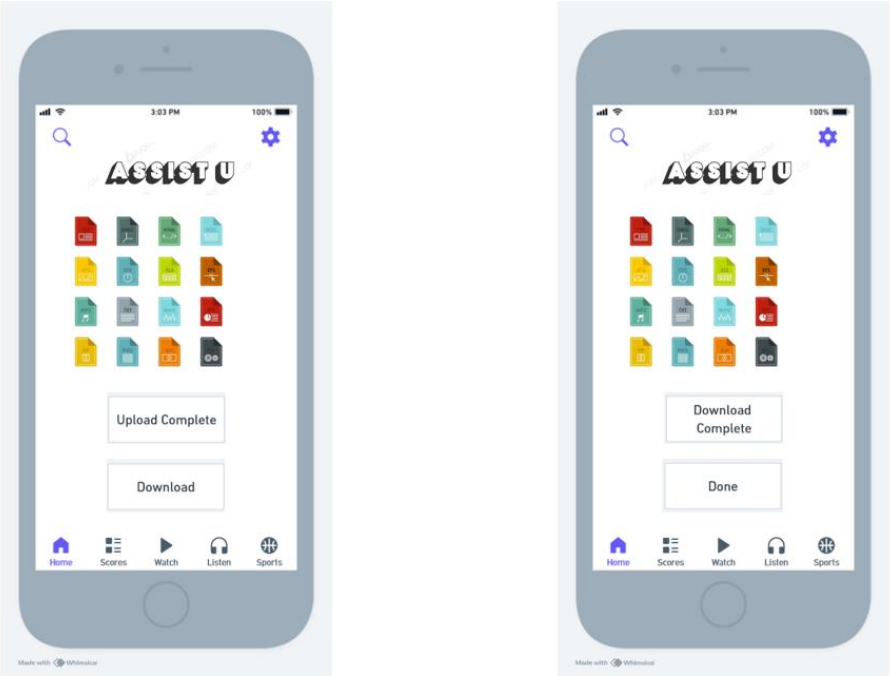

Figure 7. Upload and download display page.

To improve assistive technology, engaging technical volunteers and the education sector is crucial. By collaborating with skilled individuals, customized devices can be created for specialized needs, making them more affordable for people with disabilities. Additionally, scaling up existing efforts, enhancing connectivity, and leveraging resources can positively impact the quality of life for individuals with disabilities (Beingolea *et al.*, 2021). Assistive technologies play a crucial role in education and accessibility for individuals with disabilities. They enable communication, learning, and independence, offering various tools and interfaces to support different needs and challenges (Alnahdi, 2014). These technologies continue to evolve and improve, providing opportunities for inclusion and empowerment for users with disabilities (Botelho, 2021).

Disability refers to a condition that limits a person's ability to perform certain tasks or participate in daily activities (Babik & Gardner, 2021). It can encompass physical, cognitive, sensory, and mental health disabilities. AT plays a vital role in supporting individuals with disabilities to enhance their capabilities and access opportunities (Zorec *et al.*, 2024). Disability refers to the constrain of people's capacity to do daily tasks, such as visual, hearing, or movement issues (Babik & Gardner, 2021). Disabilities can limit access to technology, education, and communication, emphasizing the need for AT to improve functioning

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capacities (Simeoni, *et al*., 2023). Individuals with disabilities have a restricted ability to utilize assistive items (Yilma *et al*., 2024). Challenges include cognitive disorders, multiple illnesses, and caretaker knowledge. A stronger emphasis on individuals with disabilities is required in AT efforts. Addressing these issues can help minimize health disparities and enhance the quality of life (Boot *et al*., 2018).

5. CONCLUSION

Adopting digital applications as AT marks a significant advancement in creating more inclusive and accessible educational environments for students with disabilities. These tools offer a range of features that address the diverse needs of students, including customizable displays, interactive and multisensory learning opportunities, and integration with other assistive technologies. Digital apps are becoming increasingly beneficial for students with disabilities, including features such as text-to-speech conversion, adaptable keyboards, and learning tools. These apps improve the educational experience of students with disabilities as a user by offering individualized assistance. However, their efficacy is dependent on aspects such as student needs, accessibility features, and technical support availability. Continuous research and development are required to guarantee that these applications continue to fulfill changing requirements. Collaboration among educators, technologists, and students can result in more inclusive learning environments.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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