Bridging the gap: ICTs building innovative pathways for inclusive special education

Ramanathan, Hareesh N.; Kurian, Simmy; Šostar, Marko

Article

Bridging the gap: ICTs building innovative pathways for inclusive special education

Hareesh N. Ramanathan[1], Simmy Kurian[2], Marko Šostar[3,*]

[1] School of Industrial Fisheries, Cochin University of Science and Technology, Kochi 682022, India

[2] CMS Business School, Jain Deemed-to-be University, Kochi 682042, India

[3] Faculty of Tourism and Rural Development Pozega, Josip Juraj Strossmayer University of Osijek, Pozega 34000, Croatia

* Corresponding author: Marko Šostar, msostar@ftrr.hr

Abstract: Education is one of the basic needs that every child should have. Information communication technology has a significant influence on special needs children's schooling. Instead of considering learning a difficult chore, the adoption of measures such as ICT can simplify it and make inclusive education a reality. Aim: This current systematic literature review aims to determine the extent of ICT adoptions in special education scenarios. Method: This paper examined pertinent literature on ICT in special education in the period 2000 to 2023. The key articles extracted through keyword search were gathered from databases indexed in Web of Science and Scopus. The collected data were then screened using a VOS viewer for the most relevant information. From the web of Science, 31 articles were found to have connections with one another while the same process when applied to the Scopus database, helped obtain 8 articles. Results: A total of 39 articles fulfilled the search inclusion criteria of minimum two keyword occurrences. These articles were all written in English and published between 2000 and 2023. The in-depth analysis of all these articles was performed along three broad themes, viz., availability of SEN based ICTs and their impact on children with disabilities, quality of available ICT integrated curriculum for SEN and the challenges in promoting ICTs for inclusive education. Conclusions: The paper concludes that ICT integration in special education would make learning easier for children with disabilities when compared to learning using traditional methods. Implications: The paper pinpoints significant limitations in ICT use found in existing literature and the lack of it to support inclusive education. The authors make recommendations for improved ICT integrated curriculum to improve inclusivity.

Keywords: availability of ICTs; assistive technology; ICT integration; inclusive education; VOS viewer; systematic literature review

1. Introduction

Education is one of the fundamental necessities that every child should have. No distinction should be made based on a person's degree of capacity, competence, or style of life. Children with disabilities should also have access to the education they deserve. The term "inclusive education" is gaining increasing recognition in the current environment. According to inclusive education, typical or special needs students should get an education in the same classroom (UNICEF, 2017). Special needs children may take a longer time to understand and cope with the school curriculum, but they cannot be left out or ignored. The educational needs of children with special needs require special emphasis so that their knowledge base, communication skills, and quality of life, all may improve in time. Numerous

regulations and initiatives are underway to ensure children with special needs receive a high-quality education.

According to (Stein and Lord, 2023) state parties must offer a lifelong learning program that is inclusive at all levels and focused on equal opportunity rather than prejudice. One of the key developments in the current educational environment is information and communication technology. While information and communication technology tools in education provide ample scope in improving student engagement and immersive learning, children with special educational needs still remain marginalised in this regard. A study in Ghana stated that handicaps were underestimated and were not given legitimate training. Guardians hardly assumed responsibility to instruct their wards with special needs as they considered schooling as a mandate for the alleged smart kids. The government ought to make positive moves regarding the learning guidelines framework and ICT would help empower those with special needs to realize their maximum capacity (Nkansah and Unwin, 2010). Studies in the past have stated the importance of ICTs in imparting education to children with disabilities.

Although both Australia and United States have undergone several reforms towards resource reallocation for inclusive education and decreased segregation the De Bruin (2019) found that different reform journeys in each context produced different outcomes for students in each country, with Australia witnessing greater divide and the USA having achieved decreased segregation. The study also suggested the disproportionate results of these reforms across different categories of special educational needs (SEN). Another review conducted by Lynch et al. (2022) revealed that educational technologies facilitated learning among students with special learning needs and helped reduce educational and social exclusion. However, the authors also reiterated the importance of strong and multi-dimensional research involving special learners' perspective and pedagogical and curriculum design assessment to better understand the impact on the learners' experience.

The computers with word processing applications help a person with dyslexia. Systems for Cognitive Profiling Baseline Assessment software designed to evaluate students when they first enrol in school, generates reports outlining their skills and areas for improvement. Reading, spelling, writing, and math skills all can be improved in students using ICT, and it also offers more practical assistance for other subjects (Almahrag, 2022). These experiments demonstrated the significance of ICT in special education. Hence ICT-based education could make learning for students with special educational needs simpler. Learning could be made more dynamic if ICTs are incorporated into the curriculum. In many regions, children with special needs are inherently slower than their peers; therefore, integrating ICT into their daily lives could simplify learning. Having understood the benefits of ICTs in broader educational paradigm, gives way to a quest for possibilities of similar ICTs catering to special needs of children with disabilities. This article is aimed at presenting a systematic literature review on details of SEN (Special education needs) based ICT tools, curriculum support for integrating such tools and challenges in promotion of usage of such ICTs for inclusive education.

Research questions addressed in this study:

- Evidence on the availability and impact of available SEN based ICT tools on

children with disabilities.

- Teachers understanding of ICTs in Special education and its relevance

- Insights on key challenges in the application and usage of ICTs in special education.

2. Methodology

The systematic literature review approach was used in this paper to evaluate various articles under consideration. The data were collected from various journals indexed in Scopus and Web of Science databases in the period 2000 to 2023. ICT, Information and Communication Technology and Special Education are the keywords used to refine the specific data from both databases. Papers written in the English language were selected for evaluation. Papers written in any other languages, conference proceedings and accessible journals were excluded. VOS viewer was used for identifying and screening the research articles. Forty-three items were obtained after the initial screening using keywords from the Web of Science. Among those forty-three items, thirty-one articles shared citations with other articles. Twenty-eight articles were screened from Scopus which met the requirements of the paper, whereas only eight of them shared occurrence. Finally, a total of thirty-nine extracted articles were then inspected in detail to conclude the themes derived. A detailed table was prepared to document the findings from the key articles extracted in the process. The authors further summarized the findings from each of these articles in the discussion section.
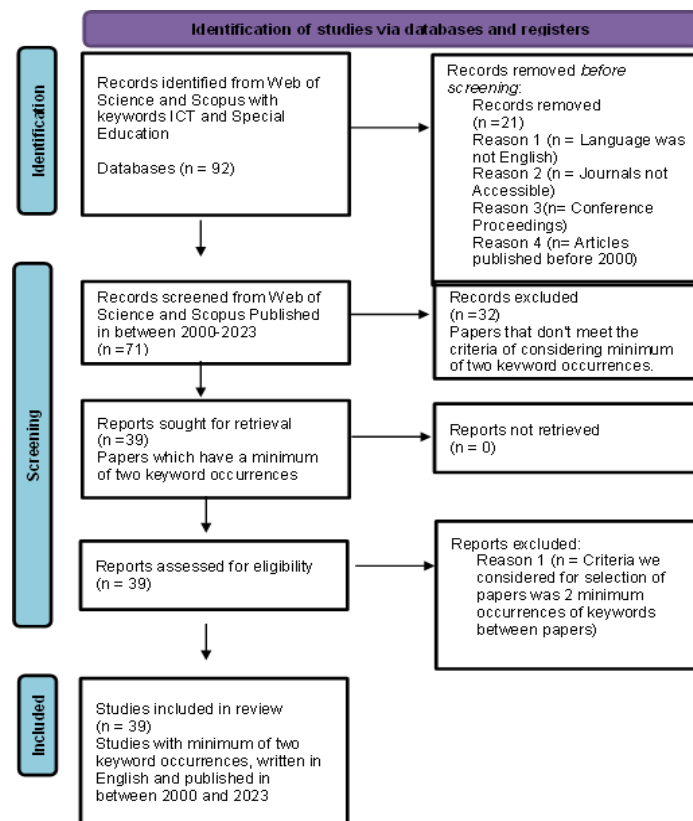

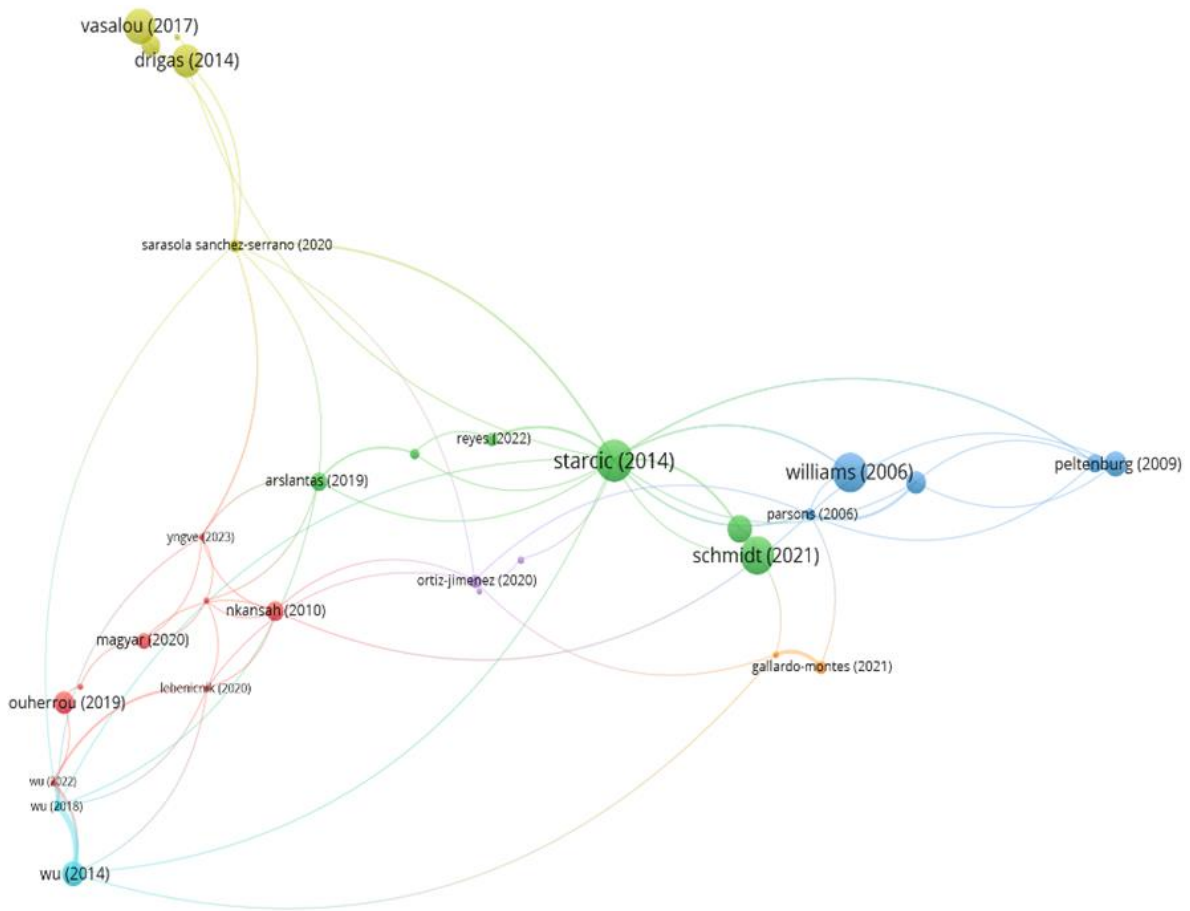**Figure 1.** Selection path for the articles considered in the review.

Figure 1 depicts the selection path for the articles considered in the review. VOS viewer is a software tool that helps to demonstrate bibliographic networks. VOS viewer generally supports three variants of visualizations: Network visualization, Overlay visualization, and Density visualization. Several author keywords are retrieved after compiling Scopus and Web of Knowledge information. It is then analysed using VOS Viewer to generate visualizations based on compiled articles. Clusters can be made for keywords, documents, co-authorship, authors, etc., even though VOS viewer is mainly used for bibliographic coupling.

Figure 2 depicts the cluster of keywords formed from articles in Web of Knowledge. From 43 publications gathered from the Web of Science, 237 author keywords were recognized. Of these, 31 items satisfied the requirement for at least two occurrences of each item. ICT was an important keyword used for finding articles from the Database. Education, technology, inclusion, assistive technology, students, mobile learning, communication technology, impact, disability, special education, etc. were some of the several keywords that are connected to the primary keyword ICT.

Figure 2. Keyword cluster from the database on ICT in special education.

Figure 3 depicts the bibliographic coupling map formed on the database created from the 43 papers that are related to one another. There are 7 clusters made up of 31 items. Attitudes and factors, assessment and training, barriers, perception on tools and assessment, inclusive education and gamification, and intervention for special education were the chief themes identified from those clusters.

Figure 3. Bibliographic coupling map based on the database from the Web of Knowledge.

Figure 4 depicts the bibliographic coupling network constructed from relevant articles indexed in Scopus. Twenty-eight articles were gathered from the database of Scopus and eight of them are connected. **Table 1** is the descriptive summary of the articles that fulfil the inclusion criteria used by the authors for screening.
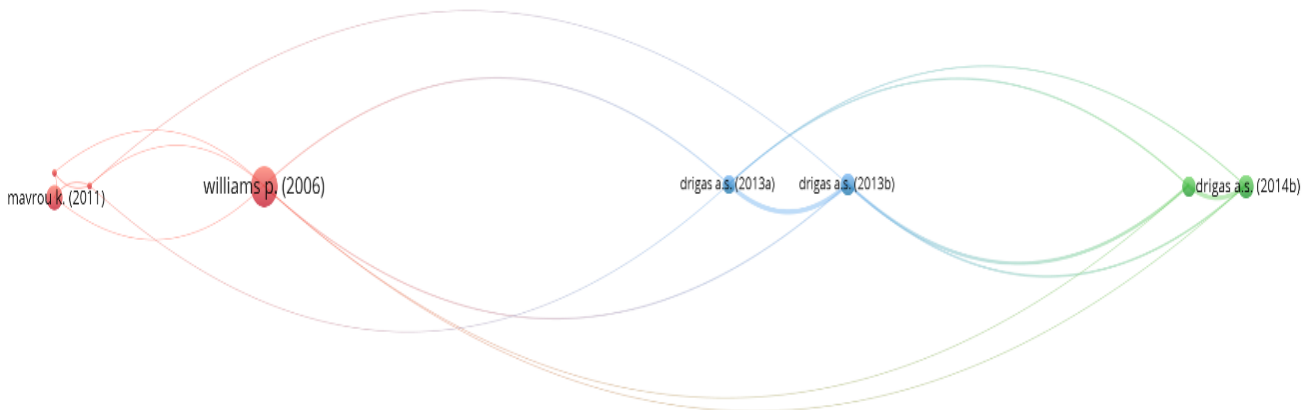

Figure 4. Bibliographic coupling map based on the database from Scopus.

Table 1. Descriptive summary of included studies.

Sl. No.	Citation	Purpose	Methodology	Result
Attitude Towards ICT and Factors contributing to ICT Use				
1	(Krausz et al., 2020)	To examine how Hungarian teachers see inclusive education for kids with special needs.	Quantitative	• Teachers in public schools generally lack advanced abilities to work with pupils who require special education.
2	(Ouherrou et al., 2019)	To examine how children with and without cognitive difficulties communicate their emotions through their facial expressions in a virtual learning environment.	Quantitative	• Interactions with virtual learning settings help kids feel various things. • It helps people fight despair and raises their educational levels.
3	(Yngve et al., 2021)	To determine how an ICT intervention would affect the engagement of upper high school pupils with disabilities in the classroom	Quantitative	• Providing youngsters with tablets boosts participation and attendance. • Utilizing an ICT intervention to increase special educational needs students' school attendance is appreciable.
4	(Iskrenovic-Momcilovic and Momcilovic, 2021)	To ascertain the opinions of teachers in conventional and special primary schools about the use of ICT for individualized instruction	Quantitative	• Teachers viewed ICT as a tool for individualization with a positive attitude. • Primary school teachers from both regular and special education programs believe that using ICTs in the classroom is inappropriate. and that they are simply for amusement.
Need for Intensive SEN based ICTs Training for Inclusive Education				
5	(Gallardo Montes et al., 2023)	To analyse the perception of ICT training for educators from Granada working on autistic people.	Quantitative	• Although the educators had already participated in several training sessions, they still need more digital training. • Fewer educators agreed that they understood how a certain piece of software operates. • Educators didn't know which application could help the specific person. • Male educators were more equipped than the rest of the population to use technology to assist persons with autism
6	(Montenegro-Rueda and Fernandez-Batanero, 2023)	To adapt and verify a survey to evaluate the level of ICT expertise and digital competency of expert education instructors for the care of children with special educational requirements	Quantitative	• Instruments tailored to the context of special education are still lacking. • Questionnaire enables the assessment of instructors' strengths and weaknesses. • Classroom education may be improved by teachers who are proficient at using technology and digital tools.
7	(Mavrou, 2011)	To describe Cyprus's policies and practices for using assistive technology and integrating disabled children into society	Qualitative-case study	• Assistive technology affects improving the independence of people, thus leading to social inclusion. • Six area needs further research and development including teacher training, ongoing assessments and follow-up procedures, technicality, development, and maintenance.
8	(Ortiz-Jimenez et al., 2020)	To look at how teachers are using ICTs in the classroom to help kids with impairments	Quantitative	• Compared to the public centres in rural areas, urban public centres are better maintained and provide better programs. • ICT adoption is supported more in urban schools than in rural schools. • Efficient teacher training influences how technologies are used in schools.

Table 1. (*Continued*).

Sl. No.	Citation	Purpose	Methodology	Result
Quality of ICT integrated curriculum for special educational needs				
9	(Wu et al., 2014)	To determine if there is a digital gap in Taiwan between students with learning challenges and their counterparts who are not impaired	Quantitative	• There are no appreciable inequalities in access to ICTs. • Year by year, students without LD steadily improved their computer skills, while finally, those with LD did not. • Students with learning disabilities should be provided with detailed academic guidance.
Availability of SEN based ICT tools and Impact on children with disabilities				
10	(Gallardo-Montes et al., 2021)	To assess applications for enhancing the skills and knowledge of autistic children	Quantitative	• There are many applications available in the Play Store for autistic children that help them in learning language and skills. • Apps made for mathematical skill development lack specialization of skill.
11	(Drigas and Kokkalia, 2014)	To evaluate whether ICTs can help children with special needs in Kinder Garden	Quantitative	• Appropriate educational tools can make changes in students with special needs. • Use of ICT made positive changes in educators, staff, and therapists. • Usage of different tools helps the students learn concepts more easily than before.
12	(Arslantas, Yildirim and Arslantekin, 2021)	To create and assess a middle school English vocabulary drill program for visually impaired pupils' educational efficacy.	Both qualitative and quantitative	• The designed web-based drill program can be used to instruct pupils who have visual impairments. • The program's practical aspects make sure that the pupils have enough practice time.
13	(Peltenburg, Heuvel-Panhuizen, and Doig, 2009)	To assess students with special needs capacity for learning using an ICT-based examination that incorporates a dynamic visual tool that might be helpful for kids as they work through math issues.	Quantitative	• Performance of students improved while ICT-based examinations were conducted. • Classroom involvement increased due to the implementation of dynamic tools.
14	(Lozano-Martinez et al., 2011)	To evaluate the efficiency of educational software in inducing emotions and social competencies in children with autism	Quantitative	• The educational software helped children to develop social skills and emotions. • Software helped children to understand and overcome tasks aimed at social skills.
15	(Schmidt et al., 2021)	A spherical video-based virtual reality (SVVR) smartphone app was created, implemented, and formatively tested to analyse the usage of VR with people with ASD.	Quantitative	• For persons with autism spectrum conditions, virtual reality has been recognized as a potential technique for therapeutic and educational treatments. • Google Cardboard was simple to use, training took minimal time, and complexity was moderate. • Offers the ideal balance of convenience and immersion.

3. Findings

3.1. Availability of SEN based ICT tools and their impact on children with disabilities

The availability of Special Educational Needs (SEN) based Information and Communication Technology (ICT) tools has significantly improved over the years, playing a crucial role in supporting the education and development of children with disabilities. Having, said that there are certain aspects like accessibility, affordability,

and ongoing support need to be addressed to ensure that the benefits are realized by a broader spectrum of children with disabilities. (Gallardo-Montes et al., 2021) analysed 88 applications that aimed to improve certain instrumental abilities including reading, writing, speaking, and mathematics among children with special needs. The Google Play Store search revealed that very few specialized applications aimed at developing mathematics skills were available. Instead, majority of applications focused on developing reading and spoken language skills. (Asimina Vasalou, 2017) analysed the application of a digital game named "Games Matter" that was created for kids with dyslexia. The authors discovered that students with special needs spontaneously joined in on the "Game Talk" by focusing on both student-student and student-teacher interactions. By encouraging teacher and student-initiated interventions, the game promoted a strong feeling of social engagement and playfulness while opening the door to novel learning strategies. (Maria-Dolores, 2015) conducted case-based research on impaired children who used the PLAIME (Platform for the Integration of Handicapped Children in Music Education) program to study their capacity for musical learning, gauge the development of their ICT abilities, and monitor their behaviour. According to the results of the study, these children had a fair grasp of music, good behavioural development, and computer platform management skills. (Drigas et al., 2014) inspected the important works related to the use of computer-based applications in diagnosis and intervention purposes to enhance learning among ADHD (attention deficit hyperactivity disorder. Young learners may be assisted and trained with the use of these instruments, which can also improve their quality of life and functional independence. (Arslantekin, 2021) conducted a qualitative and quantitative study to determine how well a middle school English vocabulary practice software was designed to help visually impaired pupils in learning English vocabulary on the web. The web-based program was found to provide fast access, customized training, and a progress tracker to its users. An assessment of the learners revealed that the learners had made significant progress, and they were able to retain the acquired knowledge. (Arslantas, 2022) in a mixed method approach attempted to examine the digital literacy capabilities of university students who are visually impaired in Turkey. The paper's main conclusions indicated that these pupils' digital literacy had been significantly improved due to their daily use of the internet. The authors also discovered that while these students were adept at getting information, they lacked the necessary abilities to manage it, collaborate, communicate, and produce digital material. (Laamanen et al., 2021) investigated the attitude of students with special needs towards an adaptive trust-based electronic assessment system for learning authentication (TESLA) and discovered that the system was generally well-received by these students. The method had a dual advantage in that it not only verified the originality of the student's work but also produced results of the e-assessment that could be trusted. Another study showed that Virtual reality proved effective for therapeutic and educational treatments among children with ASD (Autism Spectrum Disabilities). The Google Cardboard was found to provide an ideal mix of balance and immersion (Schmidt et al., 2021). Another study revealed that educational software helped children to develop social skills and emotions (Lozano et al., 2011). (Peltenburg et al., 2009) found that student's involvement in classrooms

considerably improved with the use of dynamic tools and enhanced their performance in examinations.

While, the review of the existing literature, reveals the sparse availability of the right kind of ICTs to cater to different kind of disabilities, there is ample evidence to prove that ICT interventions wherever employed have reaped positive results among the children with disabilities.

3.2. Attitudinal barriers to quality ICT integration in curriculum for students with special needs

This section discusses the findings of articles relating to the attitude towards ICT use in special education and factors that could lead to its improved usage. Research still reports a mix of teacher opinion regarding the usability of ICTs in special education which include both positive as well as negative mindsets. While one study reported that primary school teachers from both regular and special education programs believe that using ICTs in the classroom is inappropriate and that they are simply for amusement (Iskrenovic-Momcilovic and Momcilovic, 2021), (Magyar et al., 2020) conducted another research to examine Hungarian teachers' perceptions of special education requirements and researched their preferred methods for teaching students with special needs. The authors' employed route analysis to find notable connections between the elements affecting instruction and learning. The only important element that affected the use of ICT teaching materials was the quality of the curriculum offered. The authors point out a major observation that teachers who acquired knowledge of Special Educational Needs (SEN) in their university education courses were more competent and possessed profound skills to use ICT tools in SEN education. Hence, they concluded that while integrated education could have several positive outcomes it also posed unique challenges that called for adjustments in curriculum in both schools as well as special education teacher training colleges. (Ouherrou et al., 2019) employed the idea that usage of ICTs in special education were useful in removing learning barriers. For different learner types, the use of information and communication technology (ICT) in special education provided a range of development possibilities. The paper also reiterated that children with learning impairments felt the same emotions in virtual learning settings as their classmates without learning disabilities. (Moa Yngve, 2021) stated that an ICT intervention could boost the school's involvement among upper secondary school children with SEN. The authors found that after the ICT intervention, there was a notable decline in the reported need for modifications to school activities, and about 30 percent of the children improved on their attendance. (Unwin, 2010) stated that laws and procedures continued to significantly marginalize persons with impairments. The discussed findings highlight the diverse attitudes of educators towards the use of Information and Communication Technology (ICT) in special education. Research indicates a mix of positive and negative opinions among teachers, with some perceiving ICT as inappropriate and merely for amusement. Notably, the study by Iskrenovic-Momcilovic and Momcilovic (2021) reported such views among primary school teachers from regular and special education programs. The articles reviewed indicate varying attitudes towards ICT in special education,

with some perceiving challenges while others emphasize its positive impact. The studies underscore the importance of curriculum quality, teacher training, and targeted interventions to maximize the benefits of ICT in fostering inclusive education for students with special needs. ICTs positively affect the learning process for people with impairments, and those in charge of delivering special education were aware of this. Nevertheless, the authors stated the need to take particular measures to ensure that these experiences reach the target audience to the full. Mohamed (2018) indicated that the special education teachers' attitudes towards using computers were generally positive. The most notable positive attitudes were found towards the following key themes: special education considerations, staff development considerations, computers use in society, and computers and quality of instruction issues. Further to this discussion it is imperative to bring forth the specific models or curricular approaches that strengthen ICT integration in special education. Friend et al. (2010) stated that although legislations and policy changes have helped co-teaching evolve as a strategy to ensure inclusive learning there are complexities of conceptualizing and implementing collaboration in special education. Dede (2000) has suggested use of research-based curriculum projects and technologies that enable online virtual communities of practice using advanced tools to solve real-world problems. Different curricular approaches improve success for all types of learners and may differentially enhance the performance of at-risk students.

3.3. Challenges in promoting ICTs for inclusive education

Fuentes (2023) reported that though teachers had received some form of ICT training for dealing with people with disabilities, the training they received was not adequate. They also stated in their paper that there was a strong correlation between ICT training and its persistent use by educators. (Fernández-Batanero, 2023) developed a measure to assess special education teachers' understanding and proficiency in use of (ICT) information and communication technology tools for engaging students with special needs. (Ortiz-Jiménez, 2020) suggested that some key interventions were required with regard to strengthening teachers' training oriented towards linking ICTs and special education needs for children with disabilities. ICT interventions would at least enhance the use of existing ICTs in schools. The authors emphasized the spread of both awareness as well as the didactic use of the ICTS by the teachers to benefit the learners, especially those with disabilities. At this juncture, it is also noteworthy to cite the work by (Sánchez-Serrano, 2020) where the authors conducted a thorough review of the literature on ICT and learners with disabilities that were published between 2009 and 2019 and came up with the conclusion that while ICTs were crucial to support learning among students with disabilities, teachers' access to ICT training was far below what was required. The writers also mentioned the lack of quality research publications in this field of study and the poor level of applicability of previous efforts. The findings from multiple studies underscore the inadequacy of ICT training for teachers dealing with students with disabilities highlighting the importance of spreading awareness and promoting didactic uses of ICTs by teachers to benefit learners, especially those with disabilities.

4. Discussion

4.1. Evidence on the positive outcomes of ICT implementation on special education

The detailed analysis of literature revealed that ICTs in special education could have a positive influence on students with special needs. It could increase the learners' attention span and comprehension levels. However, many schools' convenience themselves and refuse to wholeheartedly embrace ICTs due to lack of right resource and skewed mindsets. As (Iskrenovic-Momcilovic and Momcilovic, 2021) in their article analysed the teacher perception on the impact of ICTs on regular and special education and concluded that teachers believed that ICTs can have an adverse impact on special needs children's social behaviour. This negative attitude among special educators hampered its widespread use. Teachers felt that ICTs should only be used at home and not in classrooms. On the contrary, (Ouherrou et al., 2019) highlighted that ICT integration in special education would enhance emotional health among students with learning disabilities. When interacting with virtual learning settings, students would be subjected to a wide range of experiences. It would help them to fight despair and improve their educational levels. (Yngve et al., 2021) also looked into the role of ICTs in special education and found that gadgets like tablets boosted learner participation and attendance among students with special needs. (Lozano-Martínez et al., 2011) emphasized that programs were available to help learners with autism spectrum disorders experience emotions. The results showed that the students did better on tasks testing their ability to identify and understand emotions. Employing educational software to teach social and emotional skills benefited students with autism who could improve their ability to execute tasks using these tools. Similarly, (Schmidt et al., 2021) studied that participants with autism indicated that spherical video-based virtual reality was simple to use and had a favourable effect on users. For learners with autism spectrum conditions, virtual reality has been recognized as a potential technique for therapeutic and educational treatments. Google Cardboard, one such application of virtual reality was found to be simple to use and required minimal training. It offered the ideal balance of convenience and immersion to its users. Switching to such a hardware arrangement has an impact on learning and immersion.

(Arslantas et al., 2021) examined the effects of ICT interventions on language learning among visually challenged students and found that learners could acquire computer literacy and language skills at the same time. The paper stated that an effective intervention would increase visually impaired students' achievement and productivity. ICT interventions also helped in improving the mathematical skills of students with special needs. The introduction of ICT made changes in the ability of students to grasp the mathematical concepts. (Peltenburg et al., 2009) evaluated an ICT-enabled approach and a standardized test format to assess participants' mathematical ability. Students with disabilities reacted favourably to ICT-enabled formats when tools were carefully selected for each learner based on their proficiency. Students' performance on ICT-based examinations and classroom involvement increased due to such implementations. (Gallardo-Montes et al., 2021)

emphasized the need to encourage fundamental instrumental abilities in autistic children by both families and professionals. The authors emphasized the need to build a prosperous, autonomous, and high-quality existence with the aid of skills. The skills that aided the development were oral language, reading, writing, and mathematics. There were specific ICT tools that were effective in improving the said skills, among learners with special needs. To name a few Autisms, Otsimo, Soy Visual, MITA, etc., are certain apps that cater to children with Autism. Most applications were available for reading and speaking language instruction. These apps were kept up to date with excellent material. However, regrettably, only some applications concentrated on mathematical ability and writing skills. However, having access to a broader selection of apps focusing on fundamental skills would be helpful for families and professionals.

(Drigas and Kokkalia 2014) researched the benefits of ICTs in special education, beginning with preschool. It was evident that teaching students with physical, sensory, and learning difficulties required the use of ICTs in the classroom. It was clear that ICTs could help a child with special needs in a variety of developmental domains. Hence it can be concluded that ICTs have proved to have a positive impact on learners with special needs and more tools addressing various skills could be developed to support the all-round development of the children with special needs.

The literature analysis reveals that Information and Communication Technologies (ICTs) in special education can have a positive influence on students with special needs, improving their attention span and comprehension levels. However, challenges such as resource limitations and certain negative mindsets in schools hinder the widespread adoption of ICTs. Although ICTs have demonstrated a positive impact on learners with special needs, addressing challenges in social behavior, emotional health, attendance, and skill development. The literature suggests the need for more tools catering to various skills to further support the holistic development of children with special needs.

The need for national strategic policy for ICT implementation in education promoting inclusive education is an important ingredient for the successful integration of ICT innovations brought about in the classrooms to reap wider benefits and be sustainable. The linkage of such innovations with national policy, help drive innovations in a streamlined manner with clears goals and targets (Kozma, 2008). The national education policy in India for instance not only aims at providing seamless equitable education opportunities to all but also envisions to empower the teachers through teacher education programs to integrate technology into their teaching learning processes. This policy also provides for a creating universal resources of learning in accessible formats and e-repositories of books that are made available to all (Mandula et al., 2016). Another aspect of key importance is of preparing teachers for inclusive education through continuous training needs assessment and training to build competencies for integrated and strategic use of educational technology. The inclusion is a crucial part of the school at the base of the principle of equal opportunities (Dipace, 2013).

4.2. Insights on key challenges in the application of ICTs in special education

The studies considered under the review highlighted various aspects of ICT (Information and Communication Technology) implementation in education, particularly focusing on teachers' attitudes, assessment tools, rural-urban disparities, age-related challenges, and the digital gap among students with special learning needs.

(Krausz et al., 2020) studied the Hungary-based teachers' attitudes toward using ICT to promote inclusive education and found that although these teachers employed ICT tools throughout their teaching procedures to a considerable extent, and sought various ICT tools for teaching, however, they did little to explore e-learning resources or developmental programs for students with disabilities. The authors concluded that ICT training should be provided to instructors so that they could instruct students with special needs. (Montenegro-Rueda and Fernández-Batanero, 2023) stated that there were several tools available for assessing a teacher's perception and skill. However, there were still no tools designed specifically to assess ICT proficiency in a special education environment. Tools that possess the capacity to gauge ICT proficiency in both the general education and in special education would be of great value. Similarly, (Ortiz-Jimenez et al., 2020) talked about the difference in the ICT implementation in urban and rural schools. Compared to public centres in rural areas, urban public centres were better maintained and provided better programs. ICT adoption was found to be better in urban schools than in the rural areas. This paper too suggested that teacher training would be helpful in enhancing usage of ICT technologies. Another article by (Montes et al., 2023) also highlighted that it was challenging for teachers above the age of 50 years to use ICTs in education when compared to the younger teachers, hence the only way to enhance the usage of ICTs in special education was to provide adequate training. (Wu et al., 2014) investigated the digital gap among students with special learning needs and their counterparts without such special needs in Taiwan and found that there are no discernible access disparities to ICTs. However, these groups differed in their level of competency in specific ways. Year on year, students without learning disabilities steadily improved their computer skills, while those with learning disabilities did not. According to the authors, students with learning disabilities needed an intensive hand holding approach to support their academic needs. (Mavrou, 2011) outlined using a case study approach, the laws and guidelines Cyprus has for utilizing assistive technology to aid the learning needs of children with special needs and integrate them into society. The authors concluded that additional research was needed to come up with appropriate guidelines in the areas of teachers' training, design of support systems, consistency in curriculum design, follow-up assessment, fund management, and technical assistance. The article further stated that assistive technologies helped in improving the independence of people with disabilities, thus leading to social inclusion but the key areas that needed considerable improvement were further research and development including teacher training, ongoing assessments and follow-up procedures, technicality, development, and maintenance as well as socio-economic and cultural barriers to ICT adoption.

While ICTs are not in themselves ends but could lead to better academic outcomes in special education. However, the socio-economic factors defining the geographic location of implementation have an impact on the accessibility of ICT resources, the nature of ICTS that could be made available and the practices in these locations (Vrasidas et al., 2009).

The key focus areas that emerged from these articles included:

- Teachers' Attitudes
- Assessment Tools for ICT Proficiency
- Urban-Rural Disparities in ICT Implementation:
- Age-Related Challenges for Teachers:
- Digital Gap Among Students
- Assistive Technology

4.3. Recommendations to address the challenges

Teachers' Attitude: Teachers who come into the field of special education from diverse fields of study may need to be indoctrinated with technology mindset from the start of the teacher training programs. Continuous inputs on the use and benefits of technology on children with special needs could be provided to teachers through classroom teaching, field exposure as well as research assignments. Grounded in the belief of the positive outcomes from the use of technology, teachers would become leaders in the use and implementation of technology in special educations

Assessment Tools for ICT Proficiency and assistive technologies: There is need to develop improved tools to help support the learning needs of children with different types of disabilities. The digital divide which is prevalent through the urban-rural parlance may be addressed by policy makers across the globe through collaborative solutions by partnering with technology solution providers, school leadership and social welfare agencies.

To sum up, implementation of ICTs in special education, could be made more effective by developing tools catering to a wider spectrum of disabilities so that a diverse set of learners may be integrated into the learning process. The existing literature review shows that the number of tools available for improving mathematical skills are relatively less when compared to the same for language and social skills. Not only is there a need to develop tools, but the need for ongoing orientation and training of teachers is also of utmost importance. Teachers must be sensitized on the benefits of using these SEN based ICTs and then be trained in the use of technology so that they are better equipped to use the tools appropriately. Only if the teachers are competent to use ICT tools will they be likely to explore the possibility of their use to engage students with special needs. The installation and maintenance of ICT tools requires an ongoing effort with adequate policy and resource support. Greater time and energy investments are required to prepare ICT integrated curriculum for special education using the universal design for learning principles (UDL) to achieve inclusivity. Teacher education institutions also need to beef up efforts to provide intensive training to special educators on the availability and use of ICTs in special education, so that these special educators in turn may be able to curate customised learning for students based on their special needs. Training

particularly to help teachers integrate technology with their classroom resources to create better learning, to enable them to create new learning content using the universal design principles of accessibility as well as help teachers create assessments that meet the different learners needs. A mechanism for monitoring and evaluation of ICTs in special education institutions must be devised and be made part of the teacher appraisal process. Appropriate incentives may also be provided to both students and special educators to encourage the use and integration of technology in the teaching learning process.

5. Limitations

This study presents a systematic literature review of ICTs in special education, teachers' perception on the use of such tools for inclusive education as well as the barriers to the use of technology tools for special education. However, the authors have based their assessments and recommendations are purely on the basis of secondary data and these ideas need to be validated on the basis of a quantitative study in due course of time. The extensive literature review suggested the need for stronger policy driving the ICT implementation strategies in special education which involved students, special educators as well as the policy makers. However, these finding would only be validated through a quantitative study.

6. Conclusion

ICT, or information and communication technology in special education, is gaining greater recognition as a viable field of study. ICT integration in special education can improve students' educational experiences and quality of life. Children with special needs can benefit from immersive technological aids that meet their educational requirements. Visual demonstrations make learning more accessible and more effective for children with special needs. The usage of ICT tools, improves both visual and oral interaction and comprehension. Various ICT Application are available to students with special needs and enable them to be part of an inclusive society. ICT may be better used in classrooms if educators are given the proper training. The governments may also assist the schools by providing more flexible funding options and improved infrastructure support, to assist in the deployment of ICTs. A paradigm shift, from the use of traditional teaching methods to a more technology enabled instructional method is inevitable therefore ICTs need to be embraced by special education systems for the benefit of students with special needs. The key areas that may require special emphasis include the creation of a wide variety of ICT tools and assistive devices that may address the needs of different support needs of children with disabilities, continuous sensitization and training of teachers backed by follow-up mechanism to check on their progress. Support from community of stakeholder like technology solution providers, school leadership, parents' community and policy makers could together collaborate to make a difference to cause of technology in special education.

Author contributions: Conceptualization, HNR, SK and MŠ; methodology, HNR and SK; software, HNR; validation, HNR, SK and MŠ; formal analysis, HNR and

References

Almahrag, Khalid Mohammed (2022). "USING ICT TO SUPPORT STUDENTS WITH DYSLEXIA." Human Research in Rehabilitation 36-43. https://doi.org/10.21554/hrr.042204

Andrea Magyar; Anita Krausz; Ildiko Dora Kapas; Anita Habok. 2020. "Exploring Hungarian teachers' Perceptions of Inclusive Education of SEN Students." Heliyon6 open Access. May 6. https://doi.org/10.1016/j.heliyon.2020.e03851.

Arslantekin, Tugba Kamali; Arslantas, Soner Yıldırımb and Banu Altunay(2021). "Educational Affordances of a Specific Web-based Assistive Technology for Students with Visual Impairment." INTERACTIVE LEARNING ENVIRONMENTS VOL. 29, NO. 6, 1037–1054. https://doi.org/10.1080/10494820.2019.1619587

Asimina Vasalou; Rilla Khaled; Wayne Holmes; Daniel Gooch (2017). "Digital Games-based Learning for Children with Dyslexia: A Social Constructivist Perspective on Engagement and Learning During Group Game Play." Computers and Education. November. https://www.sciencedirect.com/science/article/abs/pii/S0360131517301458?via%3Dihub.

Cowen, Pamela (2010). ICT and Special Educational Needs: A Tool for Inclusion Edited by Lani Florian and John Hegarty. British Journal of Educational Studies.https://doi.org/10.1111/j.1467-8527.2006.339_9.x

De Bruin, K. (2019). The impact of inclusive education reforms on students with disability: an international comparison. International Journal of Inclusive Education, 23(7–8), 811–826. https://doi.org/10.1080/13603116.2019.1623327

Dede, C. (2000). Emerging influences of information technology on school curriculum. Journal of Curriculum Studies, 32(2), 281–303. https://doi.org/10.1080/002202700182763

Dipace, A. (2013). Inclusive education: strategies and opportunities for preparing teachers through the use of ICT in the Italian compulsory school. DOAJ (DOAJ: Directory of Open Access Journals). https://doi.org/10.20368/1971-8829/838

Drigas, Athanasios S; and Georgia K Kokkalia.(2014). "ICTs and Special Education in Kindergarden." iJET 35-42.https://doi.org/10.3991/ijet.v9i2.3278

Drigas, Athanasios S; Rodi-Eleni Ioannidou; Georgia Kokkalia; and Miltiadis D Lytras.(2014). "ICTs, Mobile Learning and Social Media to Enhance Learning for Attention Difficulties." Journal of Universal Computer Science 1499-1570. doi: 10.3217/jucs-020-10-1499

Fernández-Batanero; Marta Montenegro-Rueda & José María. (2023). "Adaptation and Validation of an Instrument for Assessing the Digital Competence of Special Education Teachers." European Journal of Special Needs Education. https://doi.org/10.1080/08856257.2023.2216573

Friend, M., Cook, L., Hurley-Chamberlain, D., & Shamberger, C. (2010). Co-Teaching: An Illustration of the Complexity of Collaboration in Special Education. Journal of Educational and Psychological Consultation, 20(1), 9–27. https://doi.org/10.1080/10474410903535380

Gallardo Montes, Carmen del Pilar; Antonio Rodriguez Fuentes; and Maria Jesus Caurcel Cara. (2023). "ICT training for Educators of Granada for working with People with Autism." Heliyon 1-16. DOI: 10.1016/j.heliyon.2023.e13924

Gallardo-Montes, Carmen del Pilar; Caurcel Cara, Maria Jesus; and Emilio Crisol Moya; Sonia Jarque Fernandez, (2021). "Assessment of Apps Aimed at Developing Basic Instrumental skills in autistic Children and Teenagers." Mathematics. May 3. 10.3390/math9091032

Iskrenovic-Momcilovic, Olivera and Ana Momcilovic. (2021). "ICT in Teaching for Children with Intellectual Disabilities." Journal of Intellectual Disabilities. https://doi.org/10.1177/1744629521995376

Istenic Starcic, Andreja and Bagon, Spela. (2014). "ICT-supported learning for Inclusion of People with Special Needs: Review of Seven Educational Technology Journals,2007-2011." British Journal of Educational Technology Vol 45 No 2 202–230.http://dx.doi.org/10.1111/bjet.12086

José Israel Reyes, Julio Meneses & Efrem Melián. (2021). "A Systematic Review of Academic Interventions for Students with Disabilities in Online Higher Education." European Journal of Special Needs Education 569-586.https://doi.org/10.1080/08856257.2021.1911525

José Luis Sarasola Sánchez-Serrano; Alicia Jaén-Martínez; Marta Montenegro-Rueda; José Fernández-Cerero. (2020). "Impact of the Information and Communication Technologies on Students with Disabilities. A systematic Literature Review 2009-2019." Sustainability. October 17. https://www.mdpi.com/2071-1050/12/20/8603.

Kozma, R. B. (2008). Comparative Analysis of Policies for ICT in Education. In Springer eBooks (pp. 1083–1096). https://doi.org/10.1007/978-0-387-73315-9_68

Krausz, Anita; Andrea Magyar; Ildiko Dora Kapas; and Anita Habok. (2020). "Exploring Hungarian teachers' Perceptions of Inclusive Education of SEN Students." Heliyon. DOI: 10.1016/j.heliyon.2020.e03851

Lozano-Martinez, Josefina, Francisco-Javier Ballesta-Pagan, and Salvador Alcaraz-Garcia. (2011). "Software for teaching emotions to students with autism spectrum disorder." Revista Cientifica de Educomunicacion 139-148. https://doi.org/10.3916/C36-2011-03-05

Luis Ortiz-Jiménez; Victoria Figueredo-Canosa; Macarena Castellary López and María Carmen López Berlanga. (2020). "Teachers' Perceptions of the Use of ICTs in the Educational Response to Students with Disabilities." Sustainability. November 13. Sustainability 2020, 12, 9446; doi:10.3390/su12229446

Lynch, P., Singal, N., & Francis, G. A. (2022). Educational technology for learners with disabilities in primary school settings in low- and middle-income countries: a systematic literature review. Educational Review, 76(2), 405–431. https://doi.org/10.1080/00131911.2022.2035685

Mandula, K., Parupalli, R., Vullamparthi, A. J., Murty, A. S., Magesh, E., & Nelaturu, S. C. B. (2016). ICT based special education assessment framework for inclusive education in India. In 2016 3rd International Conference on Computing for Sustainable Global Development (INDIACom) (pp. 1644-1647). IEEE.

Maria-Dolores Cano; Ramon Sanchez-Iborra. (2015). "On the use of a Multimedia Platform for Music Education with Handicapped Children: A Case Study." Computers & Education 254-276.https://doi.org/10.1016/j.compedu.2015.07.010

Mavrou, Katerina. (2011). "Assistive Technology as an Emerging Policy and Practice: Processes, Challenges and Future Directions." Technology and Disability 41-52. DOI: 10.3233/TAD-2011-0311

Merja Laamanen; Tarja Ladonlahti; Alexandra Okada; Sanna Uotinen; David Bañeres. 2021. "Acceptability of e-authentication in Higher Education Studies: Views of Students with Special Educational Needs and Disabilities." International journal of educational technology in higher education. https://doi.org/10.1186/s41239-020-00236-9

Michael Ashley Stein; Janet E. Lord. (2023). "United Nations Convention on rights of person with disabilities." https://legal.un.org/avl/pdf/ha/crpd/crpd_e.pdf

Moa Yngve; Elin Ekbladh; Helene Lidström & Helena Hemmingsson. (2023). "Information and Communication Technology to Improve School Participation among Upper Secondary School Students with Special Educational Needs." Scandinavian Journal of Occupational Therapy 30:3, 311-321, https://doi.org/10.1080/11038128.2021.1998610

Mohamed, A. H. H. (2018). Attitudes of special education teachers towards using technology in inclusive classrooms: a mixed-methods study. Journal of Research in Special Educational Needs, 18(4), 278–288. https://doi.org/10.1111/1471-3802.12411

Nihal Ouherrou; Oussama Elhammoumi; Fatimaezzahra Benmarrakchi; and Jamal El Kafi. (2019). "Comparative Study on Emotions Analysis from Facial Expressions in Children with and without Learning Disabilities in Virtual Learning Environment." Education and Information Technologies. January 5. https://doi.org/10.1007/s10639-018-09852-5.

Nkansah, Godfred Bonnah; and Tim Unwin. (2010). "The contribution of ICTs to the delivery of special educational needs in Ghana: Practices and Potential." Information Technology for Developement 191-211. https://doi.org/10.1080/02681102.2010.497273

Ortiz-Jimenez, Luiz, Victoria Figueredo-Canosa, Macarena Castellary Lopez, and Maria Carmen Lopez Berlanga. (2020). "Teachers' Perceptions of the Use of ICTs in the Educational Response to students with Disabilities." Sustainability. https://doi.org/10.3390/su12229446

Peltenburg, Marjolijn; Marja van den Heuvel-Panhuizen; and Doig, Brian. (2009). "Mathematical Power of Special-needs Pupils: An ICT-based Dynamic Assessment Format to Reveal Weak Pupils' Learning Potential." British Journal of Educational Technology 273-284. https://doi.org/10.1111/j.1467-8535.2008.00917.x

Schmidt, Matthew; Carla Schmidt; Noah Glaser, Dennis Beck; Mark Lim; and Heath Palmer. (2021). "Evaluation of a Spherical Video-Based Virtual Reality Intervention Designed to Teach Adaptive Skills for Adults with Autism: a Preliminary Report." Interactive Learning Environments 345-364. https://doi.org/10.1080/10494820.2019.1579236

Ting-Feng Wu; Ming-Chung Chen; Yao-Ming Yeh; Hwa-Pey Wang; Sophie Chien-Huey Chang. (2014). "Is digital divide an Issue for Students with Learning Disabilities?" Computers in human behaviour 112-117. DOI: 10.1016/j.chb.2014.06.024

Tugba Kamali Arslantas, Abdulmenaf Gul. (2022). "Digital Literacy Skills of University Students with Visual Impairment: A Mixed-methods Analysis." Education and Information Technologies 5605–5625. DOI: 10.1007/s10639-021-10860-1

UNICEF (2017). Including children with disabilities in quality learning: what needs to be done? UNICEF. https://www.unicef.org/eca/sites/unicef.org.eca/files/IE_summary_accessible_220917_brief.pdf

Vrasidas, C., Zembylas, M., & Glass, G. V. (2009). ICT for Education, Development, and Social Justice. IAP.

Yngve, Moa; Elin Ekbladh; Helene Lidström, and Helena Hemmingsson. (2021). "Information and Communication Technology to Improve School Participation Among Upper Secondary School Students with Special Educational Needs." Scandinavian Journal of Occupational Therapy 311-321. https://doi.org/10.1080/11038128.2021.1998610