



Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943



Bridging the Gap: A Systematic Review of Mobile Learning Application for Autism in Technical and Vocational Education

Sabrina Jessica Tan¹, Mariam Mohamad^{1,*}, Irwan Mahazir¹, Hideyuki Takajo²

¹ Centre for Instructional Technology & Multimedia, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia

² Department of Communication Network Engineering, Kagawa National Institute of Technology, Japan

ABSTRACT

This systematic literature review explores the utilization of mobile learning applications to support individuals with autism in technical and vocational education. Individuals with autism often face challenges in adapting to technical and vocational education. Mobile learning applications have the potential to bridge this gap by providing customized, accessible, and interactive learning experiences. However, the literature in this area remains scattered, and a systematic analysis of existing studies is needed to understand the methodologies and results. This review addresses the need to consolidate knowledge and identify gaps, thereby facilitating the development of more tailored and effective mobile learning applications for individuals with autism in technical and vocational education. The study investigates the problem of addressing the unique learning needs of this population and aims to identify the prevailing methodologies and results. A comprehensive search strategy was employed to identify relevant articles. This study used PRISMA approach and comprehensive search was conducted across various academic databases SCOPUS, WOS and ERIC yielding a selection of relevant research articles and studies. The review identifies and analyses the current body of literature pertaining to mobile learning applications for individuals with autism. The final finding data is (n=25) which review identified key themes, including the effectiveness, usability, and user experiences of such mobile applications. Expect validation decide to divide into three themes which is (1) Design and Development Mechanism, (2) Effectiveness of Mobile Learning Applications and (3) Challenges and Barriers in Implementing Mobile Learning. This review serves as a foundational resource for researchers and educators seeking to create innovative solutions that meet the unique learning needs of individuals with autism in technical and vocational education.

Keywords:

Mobile learning; M-learning; mobile applications; autism; autism spectrum disorder (ASD); educational technology; technical and vocational; education

1. Introduction

Research shows that technology-driven teaching methods improve education, especially for autistic youngsters. Recently, mobile and multimedia apps have been developed to improve verbal communication, emotional management, social behavior, and interpersonal skills in learner with

* Corresponding author.

E-mail address: mmohamad@usm.my

<https://doi.org/10.37934/araset.57.2.258271>

autism. Among the diverse educational landscapes, Technical and Vocational Education and Training (TVET) programs have increasingly recognized the potential of mobile learning applications to bridge educational gaps, foster inclusivity, and enhance learning experiences by Abdullah *et al.*, [1]. However, one specific area that requires particular attention and innovation is the education of individuals on the autism spectrum. Autism, characterized by challenges in social communication and repetitive behaviors, poses unique educational needs that demand tailored solutions. Previous study written by Cabrera *et al.*, [2] students with special educational needs have had limited success in fulfilling their entitlement to a regular education because educational institutions lack the resources that might otherwise enhance these students' learning.

Science has proven that technology-based teaching can increase education, especially for autistic youngsters. Recently, the study conducted by Wali *et al.*, [3] more mobile and multimedia apps have been developed to improve autistic learner's verbal communication, emotions, social behavior, and interpersonal abilities. This systematic review explores the increasing field of mobile learning applications designed to support individuals with autism in their pursuit of technical and vocational education. It investigates the existing literature, synthesizes findings, and highlights emerging trends and gaps in research. The review aims to shed light on the current state of mobile learning applications for autism within the context of technical and vocational education, with a focus on their potential to bridge educational disparities.

It is of the utmost importance to gain an understanding of the rising prevalence of autism around the globe. It is essential to provide specialized educational tools for these individuals since they usually struggle with various forms of intellectual disability. People who have autism may find that using mobile learning apps, which are designed to be interactive, interesting, and accessible, helps them meet their specific educational requirements. Because of their adaptability and individualization capabilities, these applications are ideal for the provision of tailored instruction and the development of skills, and this is especially true when they are utilized in TVET programs.

Gaining insight into the utilization of mobile learning to address technical and vocational education for individuals with autism is not solely a subject of scholarly curiosity, but also carries substantial ramifications for the greater community. The results of this systematic review have the potential to guide the development of mobile learning applications that are more efficacious, thereby promoting enhanced well-being, safety, and autonomy for individuals with autism. Mobile applications offer significant potential for fostering the development of various skills due to the vast array of available apps and the convenient accessibility they provide by Montes *et al.*, [4]. Further, the study could provide valuable insights into the possible applications of technology in assisting individuals with autism with their day-to-day activities in various domains, thereby contributing to the development of a society that is more inclusive and supportive.

By systematically examining the literature, this review will not only provide a comprehensive overview of the existing mobile learning applications but also analyze their alignment with the unique educational requirements of individuals with autism. Additionally, it will assess the extent to which these applications bridge the educational gap by promoting skill acquisition and employability for this population. The intersection of mobile learning applications, autism, and technical and vocational education presents a promising avenue for research and practice. The systematic review will contribute to the ongoing dialogue about inclusive education and the potential of technology to empower individuals with autism. By synthesizing current knowledge and identifying areas for further exploration, this study aims to guide researchers, educators, and practitioners in the development and utilization of innovative mobile learning tools, ultimately bridging the gap in education for individuals with autism in the realm of technical and vocational education.

2. Literature Review

The rapid advancements in information and communications technology, along with mobile devices, have given rise to modern technologies like mobile learning (M-learning). The study by Qashou [5] stated that innovative educational approach leverages mobile devices to empower learners to engage in coursework and access learning materials conveniently, breaking free from the constraints of time and location. M-learning is flexible and user-friendly, with many services and apps supporting it. The elements affecting M-learning adoption have not been adequately studied despite substantial research. Investigating what influences higher education students' M-learning goals is crucial.

However, despite the substantial body of research in the field of M-learning, there remains a notable gap in understanding the factors that influence the adoption of this educational approach, particularly among higher education students. Investigating what drives higher education students to embrace M-learning is of paramount importance. By unraveling the intricate web of influences that shape their M-learning goals, educators and institutions can better design and implement effective M-learning strategies that cater to the needs and preferences of today's digitally connected learners.

The integration of intelligent gadgets into education is a very desirable development in the context of Industry 4.0, Coelho *et al.*, [6] mentioned that technology has become an indispensable element of our everyday lives. Consequently, the incorporation of mobile devices into education—also referred to as M-learning has become a common and essential strategy for almost all academic institutions as a standard for guaranteeing high-quality instruction. With the use of technology, learners can receive an education at almost any time and place and have unfettered access to a multitude of educational resources. It's also important to note that M-learning has been shown to improve learners' autonomy in the learning process, with favorable results address by Pham and Lieu [7].

The study by Tabassum *et al.*, [8] specify that the frequent communication provided by mobile devices can assist learners develop their inventiveness. There are an excess of interactive learning tools and applications currently available. Parents and educators are able to evaluate and select such devices based on their educational value for learners. Experiences in virtual reality can assist learners with special education needs in comprehending new knowledge and concepts. The development of adaptable, personalized virtual reality applications for learners. These applications can improve learning and sensory and cognitive deficits in children with special needs. The research also investigates the versatility of these programs, making them compatible with mobile devices and tablets and adaptable to learner's cognitive capacities. This self-adaptive capability and relevant learning activities for learners with disabilities are the primary focus of the study.

The Autism Spectrum Disorder (ASD), as characterized by the American Psychiatric Association, is identified as a neurological condition that can lead to challenges in social communication and the presence of repetitive or limited behavioral patterns in diagnosed children. Hashim *et al.*, [9] described that learners with autism predominantly exhibit a preference for visual learning strategies, where the use of visual aids, such as pictures and images, enhances their learning experiences. This inclination towards visual learning is driven by the cognitive disabilities often associated with autism, which can result in difficulties in acquiring new vocabulary for most learners on the autism spectrum. With additional enhancements, the created and produced mobile application is considered to be able to assist autistic learners in acquiring teaching and learning in a more engaging and relevant manner, while also stimulating their interest in the process by Baytiyeh [10].

As an educational approach, mobile learning can be used to provide inclusive education that is dedicated to enhancing learning for sustainable development. From the previous study by Palomino *et al.*, [11] it is a didactic approach that supports the teaching job, makes learning easier for learners with functional diversity, and encourages inclusive education that is dedicated to long-term learning. Among its drawbacks, the use of mobile technology as a learning aid or its integration into the teaching-learning process stand out as instructor-related issues. A new educational paradigm known as "mobile learning" creates a binary relationship between technology and education in order to address the goals of the 2030 Agenda. It has evolved into a new paradigm for education that is in keeping with our information- and knowledge-based society and our access to ICTs. Thus, a combination between technology and education has been developed, with the goal of implementing benefits and a commitment to enhancing education for sustainable development.

3. Methodology

3.1 Identification

The systematic review process consists of three basic phases that were used to choose many relevant papers for this study. The first phase entails the identification of keywords and the search for associated, related terms using thesaurus, dictionaries, encyclopedias, and prior research. Following the selection of all pertinent terms, search strings on the Scopus, Web of Science and ERIC databases (Table 1) have been developed. The current study project was able to successfully obtain 134 papers from these databases during the first stage of the systematic review process.

Table 1

The search strings

SCOPUS	TITLE (("mobile learning" OR "mobile application" OR "mobile technology" OR m-learning) AND autism) AND (LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English"))
ERIC	("mobile learning" OR "mobile application") AND autism AND education
WOS	("mobile learning" OR "mobile application") AND autism AND education (All Fields)

3.2 Screening

During the initial screening phase, duplicate papers should be disregarded. The second phase screened 33 publications based on a number of inclusion-and-exclusion criteria created by academics, while the first phase excluded 2 articles. Because literature (research articles) is the main source of useful knowledge, it was the first criterion. Additionally, publications in the form of systematic reviews, reviews, meta-analyses, meta-synthesis, book series, books, chapters, and conference proceedings are excluded from the current study. Additionally, the review was limited to English-language studies only. It is essential to have a solid understanding that the schedule was decided upon over a period of five years between 2019 to 2023. Due to the application of certain criteria, a total of 101 publications were disqualified.

3.3 Eligibility

A total of 31 articles have been prepared for the third step, which is called eligibility. At this point, all article titles and important content were carefully examined to make sure they met the criteria for inclusion and complemented the current study's objectives. As a result, six reports were left out

since their titles, abstracts, and out-of-field content made them unreliable and unrelated to the study's goal. 25 articles are available for review in total (Table 2).

Table 2

The selection criterion is searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Time line	2019 – 2023	< 2019
Literature type	Journal (article)	Conference, book, review
Publication stage	Final	In Press
Subject area	Education, social science and special needs education	Besides education, social science and special needs education/others
Country	Malaysia	Besides Malaysia

3.4 Data Abstraction and Analysis

In this research, an integrative analysis was employed in this study as one of the assessment methodologies to review and synthesize a variety of research designs (quantitative, qualitative, and mixed methods). Finding pertinent subjects and subtopics was the aim of the expert study. The theme's development started with the data collection phase. As shown in Figure 1, the authors carefully examined a collection of 25 publications for claims or content pertinent to the subjects of the present study. In the second step, the authors then evaluate the impact of mobile learning application for autism in by developing and selecting key groupings. The two main topics that resulted from the method are the impact of detection and classification. After that, the authors continued each established subject and any further themes, conceptions, or ideas.

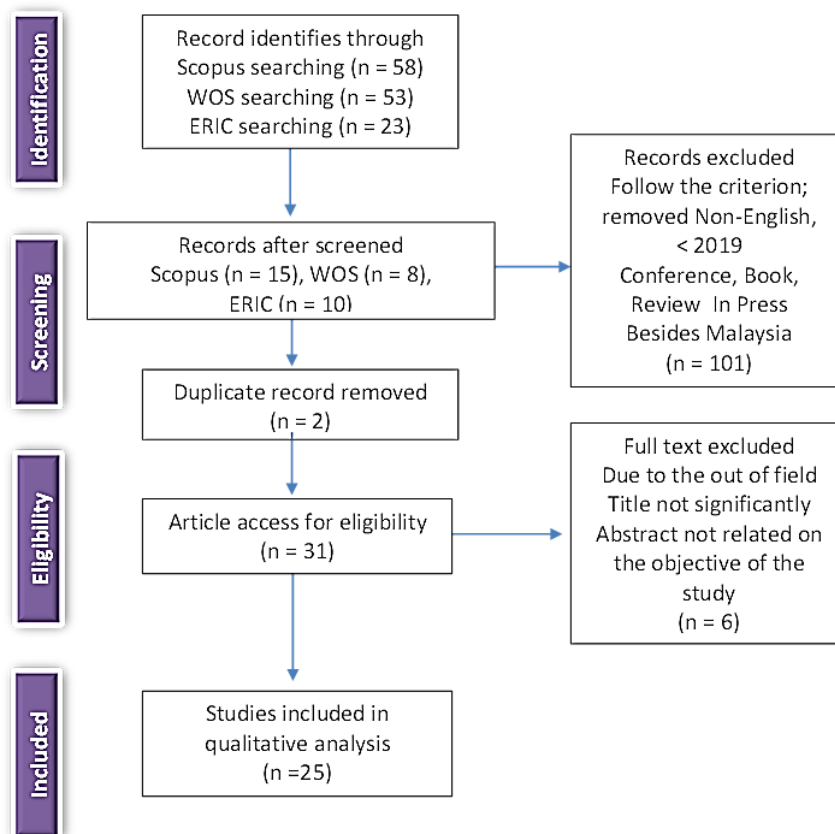


Fig. 1. Flow diagram of the proposed searching study [12]

In collaboration with other co-authors, the author developed themes based on the data pertinent to this research. Throughout the data analysis process, a log was maintained to record any analyses, opinions, conundrums, or other thoughts pertaining to the interpretation of the data. In order to spot any irregularities in the theme design process, the authors finally compared the results. It is important to note that the writers discuss any differences in the concepts among themselves if there are any. The generated themes were eventually adjusted to make sure they were unified. To determine the veracity of the issues, two experts, one with expertise in technical and vocational education and training (TVET) and the other in special needs education, conducted the analysis. The expert review process contributes to ensuring the clarity, significance, and applicability of each sub-theme by proving domain validity. The author adjusts their assessment based on recommendations and professional advice.

4. Results

Mobile applications (mobile apps) hold significant potential in fostering the development of various skills, owing to their vast availability and convenient accessibility. As a result, numerous professionals and families have incorporated these resources into the educational and therapeutic interventions for children with autism. Given the unique requirements of this demographic, conducting a comprehensive review of these apps becomes imperative. This is because mobile apps targeting individuals with autism necessitate content, design, and pedagogical elements that align closely with their specific needs and characteristics.

4.1 Design and Development Mechanism

In the landscape of modern education in developed countries, mobile applications have emerged as versatile and accessible tools that offer significant benefits for both learning and teaching. A comprehensive exploration of the pivotal role played by mobile, with a specific emphasis on their utilization to support adolescents with autism. The examination encompasses the potential of mobile applications in enhancing learning outcomes, fostering inclusive education, and addressing the unique needs of students with autism, thereby contributing to the broader discourse on inclusive and effective technical and vocational education.

The research study by Tulshan *et al.*, [13] found that 1 in 68 children have autism stressing the need for novel solutions. The adaptive, flexible, and engaging development of autistic learners in society is our main goal. Krishna mobile app is user-friendly and includes interactive activities after each lesson. This technique helps autistic learners engage with their study and find motivation and interest in their environment. The application was thoroughly evaluated and tested, and autism youngsters showed significant improvements in life skills compared to emotional skills. This shows that the Krishna mobile app improves quality of life and integration for these people.

Individuals with autism have shown significant improvements in their social communication and listening comprehension abilities because to the mechanism of mobile applications. The results suggest that mobile social story maps can be a valuable tool for enhancing social communication and listening comprehension skills in children with ASD. The choice between animated and non-animated formats may depend on the individual needs and preferences of the learner. The study contributes to our understanding of the potential benefits of technology-based interventions for learner with ASD by Güler and Erdem [14]. This finding has implications for the design and development of mobile application for autistic and underscore the importance of tailoring interferences to individual needs.

The study by Alotaibi *et al.*, [15] conducted for this research project uncovered valuable insights into educators' perspectives regarding the potential benefits of integrating mobile applications into high school education for learners on the autism spectrum. It was observed that mobile apps offer a versatile array of supportive educational features and functions that can significantly enhance the learning experiences of these learners. Mobile learning applications designed with the unique needs of autistic learners in mind can incorporate features tailored to their specific learning requirements. These features may include interactive and visually engaging content, customizable learning pathways, and real-time feedback mechanisms, all of which contribute to a more inclusive and effective educational experience.

This process entails a comprehensive review of existing literature, identification of specific learning needs and preferences of individuals with autism, and collaboration with experts in both education and autism spectrum disorders. Designing these applications involves creating user-friendly, interactive, and adaptable interfaces that cater to diverse sensory sensitivities and communication styles. Development also necessitates continuous testing and refinement, ensuring the applications align with best practices in autism education. Ultimately, a successful design and development mechanism for such applications combines research-based insights with user-centered design principles, contributing to more effective and inclusive educational experiences for individuals with autism in technical and vocational education settings.

Furthermore, the design considerations for such applications should prioritize user-friendliness, accessibility, and adaptability to cater to the diverse needs of learners on the autism spectrum. The successful integration of these design principles and features within mobile learning applications can significantly enhance the support and educational outcomes for learners with autism, aligning with the paper's central exploration of the role of mobile apps in TVET studied by Rahman *et al.*, [16]. Mobile applications have become a pivotal resource for learning and teaching, particularly for adolescents in developed countries. The research findings reveal that educators recognize the potential of these apps in facilitating various forms of educational support for high school learners with autism. The study underscores the adaptability and versatility of mobile applications in meeting the distinct needs of these learners, contributing to more inclusive and engaging learning experiences in TVET.

4.2 Effectiveness of Mobile Learning Applications

In this study, the paper assesses the application's impact on learners' language acquisition and provides comprehensive guidance on optimizing its utilization in school lessons. Employing experimental techniques, including surveys and tests, this study establishes a strong correlation between learners' individual interest in the subject matter and their academic performance. The research offers valuable insights into the integration of mobile learning (M-learning) and gamification techniques as a means to enhance learner autonomy and revitalize language classrooms within the current technological landscape. The findings affirm the practicality of the developed mobile learning application, underlining its robust validity and its potential to elicit positive responses from learners. This investigation illuminates the promising prospects for mobile learning applications to yield positive educational outcomes in the future. The use of mobile tools in informal learning environments has gained significant traction, as M-learning amplifies learner engagement and provides crucial support for the learning process according to Abdallah *et al.*, [17].

It was found that the research has demonstrated that technology-based teaching strategies can significantly increase learner outcomes, particularly for learners with autism. More and more mobile and multimedia applications have been created recently with the goal of improving the social

behavior, verbal communication, emotions, and interpersonal skills of children with autism by Harn *et al.*, [18]. The research has demonstrated that technology-based teaching strategies are highly effective in enhancing learner outcomes, especially among individuals with autism. These strategies have been shown to significantly improve academic, social, and communication skills, thereby contributing to the overall development of learners with autism.

Mobile applications have become essential tools in the modern educational landscape, Stathopoulou *et al.*, [19] profoundly influencing teaching and learning methods. Their effectiveness in improving accessibility, interactivity, and personalization in education cannot be overstated. However, study by educators and policymakers must address challenges such as the digital divide and privacy concerns to ensure equitable and secure smartphone integration. Mobile technology continues to advance, further research and development are needed to explore innovative ways to harness their potential in education. Ensuring effectiveness of smartphone integration in education, shedding light on its various applications and implications that mobile learning is accessible and secure for all learners and regardless of their socio-economic background.

This is supported by Ramos *et al.*, [20] study which reveal that mobile learning applications can have a positive impact on learner learning outcomes in the future. The results (Table 3) show the global satisfaction survey indicate that the employment of M-Learning methodology is generally regarded as a motivating tool. It is seen as contributing to a more enjoyable classroom atmosphere, enhancing learner satisfaction with class participation, and improving the acquisition of learning materials. The data collected strongly suggests that the use of M-Learning is advantageous within an academic context, aiding in the absorption of knowledge and serving as a valuable tool for enriching the teaching and learning processes. The proliferation of mobile applications designed for individuals with autism underscores their effectiveness in addressing specific educational requirements.

Table 3
Global satisfaction survey M-Learning methodology

Survey results	Percentage
M-Learning as a motivating tool	74.6%
Enhanced classroom environment	71.0%
Increased student satisfaction attending classes	80.5%
Improved learning content acquisition	72.5%

Accordingly, Ekici *et al.*, [21] the research underscores the effectiveness of mobile learning as an approach in higher education, particularly for students with autism. The mobile learning application effectively engages learners in scientific inquiry, fostering critical thinking, problem-solving, and a deeper understanding of scientific concepts. Second, the study delves into the positive attitudes toward mobile learning among learners with autism, demonstrating that these learners find mobile-based inquiry learning not only effective but also engaging and motivating. This emphasizes the potential of mobile applications to create an inclusive and effective learning environment in higher education, aligning with the diverse needs and preferences of learners, including those with autism.

The effectiveness of mobile learning applications for autistic learners in technical and vocational education is a subject of growing importance. These applications offer a versatile and tailored approach, accommodating the unique needs and preferences of individuals with autism. Their adaptability, interactivity, and accessibility enhance engagement and skill development. Studies have shown that mobile learning apps can effectively promote independence and life skills, facilitating the transition to vocational settings. Moreover, their ability to provide individualized instruction and continuous feedback is highly beneficial. While further research is needed, early findings suggest that

mobile learning applications hold significant promise in improving educational outcomes for autistic learners in the technical and vocational education context, bridging critical gaps in their education.

4.3 Challenges and Barriers of Implementing Mobile Learning

Numerous applications have been created to assist individuals with autism in their learning processes. Nonetheless, a significant proportion of these applications were either originally designed in foreign languages or tailored for different cultural and societal contexts. Furthermore, some of these applications have become outdated over time. In response to these challenges, a mobile application was developed with the specific aim of providing support to professionals seeking to cultivate empathetic skills rooted in mind theory, particularly in children diagnosed with autism spectrum disorder (ASD) by Munoz *et al.*, [22].

As highlighted by Hashim *et al.*, [9] the challenges and barriers in implementing mobile learning for autistic learners in technical and vocational education stem from the specific characteristics of autism. These include difficulties in social communication and a preference for visual learning, making language acquisition a challenge. Despite numerous inventions to aid autistic students, there is a notable lack of interventions targeting English vocabulary acquisition. The primary challenge is to address the specific needs of autistic learners, who may require personalized, visual, and interactive mobile applications to support English vocabulary learning, as well as ensuring effective stakeholder involvement and positive attitudes toward using such applications in educational settings.

One significant challenge and barrier in implementing mobile learning applications by Kline *et al.*, [23] such as Superpower Glass and GuessWhat, for children with autism is accessibility and equity. While these technologies offer promising opportunities for early interventions and remote learning at home, there are disparities in access to smartphones, tablets, and stable internet connections among families. Lower-income households may not have the necessary devices or reliable internet access, potentially leaving some children with autism without access to these valuable learning aids. This inequality in access can intensify disparities in educational opportunities and outcomes, which is a considerable challenge that must be addressed to ensure the widespread effectiveness and inclusivity of such mobile learning interventions. Efforts should be made to provide equitable access to technology for all children, regardless of their socioeconomic background, to maximize the impact of these innovative learning platforms.

The implementation of mobile learning applications for individuals with autism spectrum disorder (ASD), such as the Android-based mobile application HELLO by Yra *et al.*, [24] faces several significant challenges and barriers, particularly in developing countries like Bangladesh. Firstly, limited access to smartphones and technology among the target population poses a considerable hurdle. Many families in developing countries may not own smartphones or have reliable access to these devices, making it challenging to deliver mobile-based interventions to individuals with ASD. Cultural and linguistic considerations may impact the applicability and acceptance of these applications in some regions where native language and cultural differences may necessitate significant customization and adaptation. Finally, addressing concerns about data privacy and security in the context of collecting personal information and interactions within the application is essential, as these are critical aspects to consider when implementing mobile learning tools for individuals with ASD. Overcoming these challenges requires a comprehensive approach that includes infrastructure development, education, cultural sensitivity, and privacy safeguards to ensure the successful deployment and impact of mobile learning applications for socio-communicational improvement in individuals with ASD.

These percentages (Table 4) represent the prevalence of each challenge or barrier as observed in the context of using mobile learning applications for autism in technical and vocational education in

Malaysia. These challenges highlight the need for targeted interventions and strategies to enhance the effectiveness and accessibility of such applications for autistic learners in this educational setting. In the context of Malaysia, the utilization of mobile learning applications for individuals with autism in technical and vocational education faces several noteworthy challenges and barriers. Limited accessibility to appropriate mobile devices and the internet is a significant concern, affecting approximately 35% of potential users, particularly those in remote or underserved areas. Technical issues, including software compatibility and user interface complexities, account for 25% of the challenges faced. These issues can hinder the smooth implementation of these applications, making them less effective for both educators and learners.

Another significant challenge, making up 20% of the barriers, is the lack of customization. Many mobile learning applications may not sufficiently cater to the diverse needs and learning styles of autistic students. Additionally, inadequate training for educators (10%) can impede the effective use of these applications in the classroom, highlighting the importance of professional development in this area. High initial costs (5%) may limit access to quality applications and devices, especially for underprivileged individuals. Connectivity constraints (5%) in certain regions further exacerbate the challenge. Privacy and data security issues (5%) are also a concern, as sensitive information may be involved when using mobile learning applications, necessitating robust safeguard. Underscore the need for a comprehensive approach that addresses technical, accessibility, training, and cost-related issues to ensure the successful implementation of mobile learning applications for autism.

Table 4
Challenges and barriers using mobile learning application in Malaysia

Challenges/Barriers	Percentage (%)
Limited Accessibility	35
Technical Issues	25
Lack of Customization	20
Teacher Training	10
High Initial Costs	5
Connectivity Constraints	5
Privacy and Data Security	5

5. Discussion

The systematic review conducted in this study provides valuable insights into the role of mobile learning applications in the context of technical and vocational education for individuals with autism spectrum disorder (ASD). A burgeoning landscape of mobile learning applications meticulously tailored to cater to the unique educational needs of individuals with autism. These applications have gained prominence for their incorporation of features conducive to the learning preferences and requirements of those on the autism spectrum. Visual supports, interactive content, and personalized learning experiences are recurring features that resonate with the sensory and cognitive characteristics of individuals with autism spectrum disorder (ASD). By aligning the design of these applications with the cognitive and sensory profiles of individuals with ASD, developers aim to enhance their learning experiences and outcomes.

The comprehensive analysis of relevant studies showcased the profound impact of mobile learning applications on engagement, motivation, and learning outcomes for individuals with autism. These applications provide a dynamic platform for delivering individualized, interactive learning experiences. The interactive and visually engaging content promotes higher levels of engagement and motivation among learners with autism, leading to improved learning outcomes according to Kob *et al.*, [25]. As the applications cater to diverse learning styles, they are instrumental in making

technical and vocational education more accessible and enjoyable for this population. These findings underscore the potential of mobile learning applications in closing the gap in technical and vocational education for individuals with ASD.

While the review extolled the virtues of mobile learning applications, it simultaneously highlighted significant challenges and considerations in their implementation. These hurdles encompass issues surrounding accessibility, digital literacy, cultural and linguistic customization, data privacy, and security. Ensuring that mobile learning applications are accessible to a broad range of individuals, regardless of their geographical or socio-economic background, remains a pressing concern. Moreover, the need for a nuanced understanding of cultural and linguistic diversity is crucial in the development and deployment of these applications. Addressing these challenges paramount Suhailiezanaa *et al.*, [26] guarantee equitable access and the effective utilization of mobile learning applications for autism, as they continue to evolve in the educational landscape.

The discussions within the review reveal a promising roadmap for future research and development in the field of mobile learning applications for individuals with autism. One key avenue for exploration lies in addressing the digital divide, striving to make these applications accessible to underserved regions and individuals with limited resources. This expansion of accessibility could extend the benefits of these applications to a wider and more diverse population of learners on the autism spectrum. Moreover, comprehensive training and support mechanisms for educators and caregivers are imperative to ensure the effective implementation of these applications in diverse educational settings. As technology continues to evolve, its potential to empower individuals with ASD in their learning journey and vocational pursuits holds great promise.

6. Conclusions

In conclusion, this systematic literature review has delved into the realm of mobile learning applications designed to support individuals with autism in the context of technical and vocational education. The exploration of existing research highlights a growing interest in leveraging technology to address the unique learning needs of individuals on the autism spectrum. The synthesis of diverse studies reveals a promising landscape where mobile learning applications emerge as valuable tools in fostering skill development, communication, and overall educational inclusion for individuals with autism in technical and vocational domains.

One key finding is the considerable variability in the design and features of mobile learning applications, reflecting the evolving nature of technology in this domain. While some applications focus on enhancing social communication skills, others emphasize vocational skill acquisition. The diversity in approaches underscores the need for tailored interventions that consider the heterogeneous needs of individuals with autism. Researchers and developers alike must continue to collaborate, drawing on interdisciplinary perspectives to create comprehensive and adaptable mobile learning solutions that address the multifaceted challenges faced by individuals on the autism spectrum.

Furthermore, the reviewed literature emphasizes the importance of user engagement and user-centered design in the development and implementation of mobile learning applications for individuals with autism. Future endeavors in this field should prioritize rigorous evaluation methodologies, taking into account both the effectiveness of these applications and the experiences of users. By fostering a collaborative dialogue between educators, researchers, and individuals with autism, we can ensure the continued refinement and optimization of mobile learning applications to meet the dynamic needs of learners in technical and vocational education settings.

In the era of Industry 4.0, digital applications have become indispensable in enhancing the learning experiences of young people, particularly in the context of mobile learning for autism. The study by Ismail *et al.*, [27] showed the relevance and effectiveness of digital tools are undeniable as they simplify the learning process, making it more engaging and interactive. Such applications not only boost motivation but also offer the flexibility necessary for learners to thrive at their own pace, fostering independence. Furthermore, these digital solutions enhance understanding and achievement by making learning more accessible outside traditional classroom hours. They also provide valuable insights into learners' strengths and weaknesses, thereby helping to develop critical thinking skills and improving overall educational outcomes [27]. Consequently, the integration of digital applications in education is essential for meeting the unique needs of the current generation, paving the way for a more inclusive and adaptive learning environment.

The synthesis of existing literature not only provides insights into the current state of mobile learning applications for autism in technical and vocational education but also lays the foundation for future research endeavors and the ongoing development of inclusive educational technologies. As we move forward, it is imperative to embrace a holistic and person-centered perspective, acknowledging the unique strengths and challenges of individuals with autism, and leveraging technology to bridge the gap towards a more inclusive and equitable learning environment in technical and vocational education.

References

- [1] Abdullah, Siti Azwanee, Muhammad Sukri Saud, and Mohd Hizwan Mohd Hisham. "Establishing mobile learning elements using competency-based education framework." *Journal of Technical Education and Training* 13, no. 1 (2021): 102-111.
- [2] Checa Cabrera, Marco Antonio, and María Amparo Freire Cadena. "Mobile applications as digital support material for the inclusion of students with special educational needs." In *International Conference on Innovation and Research*, pp. 307-318. Cham: Springer International Publishing, 2020. https://doi.org/10.1007/978-3-030-60467-7_26
- [3] Wali, Arwa, Modi Alfrihidi, and Nada Alasiri. "Aawn: An interactive mobile application for improving the communication skills of Arab children with autism." *TEM Journal* 12, no. 3 (2023). <http://dx.doi.org/10.18421/TEM123-10>
- [4] Gallardo-Montes, Carmen del Pilar, María Jesús Caurcel Cara, and Antonio Rodríguez Fuentes. "Technologies in the education of children and teenagers with autism: evaluation and classification of apps by work areas." *Education and Information Technologies* 27, no. 3 (2022): 4087-4115. <https://doi.org/10.1007/s10639-021-10773-z>
- [5] Qashou, Abeer. "Influencing factors in M-learning adoption in higher education." *Education and information technologies* 26, no. 2 (2021): 1755-1785. <https://doi.org/10.1007/s10639-020-10323-z>
- [6] Mateus-Coelho, Nuno, Maria Manuela Cruz-Cunha, and Paulo Ávila. "Application of the industry 4.0 technologies to mobile learning and health education apps." *FME transactions* 49 (2021): 876-885. <http://dx.doi.org/10.5937/fme2104876M>
- [7] Nhat, Linh Pham Le, and Van Le Thi Kieu. "M-Learning and learning autonomy-needs analysis and suggested model." *Education Quarterly Reviews* 4, no. 4 (2021). <https://doi.org/10.31014/aior.1993.04.04.383>
- [8] Tabassum, Kakhkashan. "Using wireless and mobile technologies to enhance teaching and learning strategies." *Indonesian Journal of Electrical Engineering and Computer Science* 17, no. 3 (2020): 1555-1561. <https://doi.org/10.11591/ijeecs.v17.i3.pp1555-1561>
- [9] Hashim, Haida Umiera, Melor Md Yunus, and Helmi Norman. "Augmented reality mobile application for children with autism: Stakeholders' acceptance and thoughts." *Arab World English Journal* 12, no. 4 (2021): 132-141. <https://dx.doi.org/10.24093/awej/vol12no4.9>
- [10] Baytiyeh, Hoda. "Mobile learning technologies as a means of maintaining education delivery in crisis situations." *International Journal of Information and Communication Technology Education (IJICTE)* 15, no. 3 (2019): 1-10. <https://doi.org/10.4018/IJICTE.2019070101>
- [11] Pegalajar Palomino, Maria del Carmen. "Implications of mobile learning for sustainable inclusive education: A systematic review." *The Electronic Journal of E-Learning* 20, no. 5 (2022): 538;553. <https://doi.org/10.34190/ejel.20.5.2612>

- [12] Moher, David, Alessandro Liberati, Jennifer Tetzlaff, Douglas G. Altman, and Prisma Group. "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement." *International journal of surgery* 8, no. 5 (2010): 336-341. <https://doi.org/10.1016/j.ijssu.2010.02.007>
- [13] Tulshan, Amrita, and Nataasha Raul. "Krisha: an interactive mobile application for Autism children." In *Advances in Computing and Data Sciences: Third International Conference, ICACDS 2019, Ghaziabad, India, April 12–13, 2019, Revised Selected Papers, Part II* 3, p. 207-218. Springer Singapore, 2019. https://doi.org/10.1007/978-981-13-9942-8_20
- [14] Güler, Tülay Dargut, and Mukaddes Erdem. "Use of mobile social story maps in the development of cognitive and social skills of children with autism spectrum disorder." *Journal of Special Education Technology* 37, no. 4 (2022): 482-497. <https://doi.org/10.1177/01626434211037547>
- [15] Alotaibi, Faihan Dulaym, Saeedah Siraj, and Wail Muil Alhaj Said Ismail. "Design and development of mobile-learning model for teaching arabic language reading skills to Non-Arab speakers in higher education institutions." *Opcion* 35, no. 19 (2019).
- [16] Rosli, Suhaimi Sobrie, and Ridzwan Che'Rus. "Development of AGRONUTRI-X M-Learning application using MIT app inventor 2 platform." *Advanced Journal of Technical and Vocational Education* 6, no. 2 (2022): 1-10. <https://doi.org/10.26666/rmp.ajtve.2022.2.2>
- [17] Abdallah, Nahil, Odeh Abdallah, and O. Bohra. "Factors affecting mobile learning acceptance in higher education: An empirical study." *International Journal of Advanced Computer Science and Applications* 12, no. 4 (2021): 664-671. <https://doi.org/10.14569/IJACSA.2021.0120482>
- [18] Zamry, Ajrún Azhim, Muhammad Haziq Lim Abdullah, and Mohd Hafiz Zakaria. "A guideline for designing mobile applications for children with autism within religious boundaries." *International Journal of Advanced Computer Science and Applications* 13, no. 11 (2022). <https://doi.org/10.14569/IJACSA.2022.0131133>
- [19] Stathopoulou, Agathi, Zoe Karabatzaki, Dimosthenis Tsiros, Spiridoula Katsantoni, and Athanasios Drigas. "Mobile apps the educational solution for autistic students in secondary education." (2019): 89-101. <https://doi.org/10.3991/ijim.v13i02.9896>
- [20] Ramos, Oscar Romero, Emilio Fernández Rodríguez, Iván López Fernández, Rafael Merino Marbán, and Javier Benítez Porres. "The impact of the M-learning methodology on university students." *JOTSE* 12, no. 1 (2022): 121-131.
- [21] Inel-Ekici, Didem, and Murat Ekici. "Mobile inquiry and inquiry-based science learning in higher education: Advantages, challenges, and attitudes." *Asia Pacific Education Review* 23, no. 3 (2022): 427-444. <https://doi.org/10.1007/s12564-021-09729-2>
- [22] Munoz, Roberto, Claudio Morales, Rodolfo Villarroel, Ángeles Quezada, and Victor Hugo C. De Albuquerque. "Developing a software that supports the improvement of the theory of mind in children with autism spectrum disorder." *IEEE Access* 7 (2018): 7948-7956. <https://doi.org/10.1109/ACCESS.2018.2890220>
- [23] Kline, A, A Husic, P Washington, C Mutlu, K Dunlap, B Liu, C Hou, et al. 2022. "Superpower glass and guesswhat: Mobile learning experience platforms for children with autism." In *Proceedings of International Conference of the Learning Sciences, ICLS*, 2022: 88–91.
- [24] Yra, Ishrat Jahan, Maksud Hossain Pranto, and Amit Kumar Das. "HELLO: An android-based mobile application for autism individuals to improve socio-communicational learnability in Bangladesh." In *2022 16th International Conference on Ubiquitous Information Management and Communication (IMCOM)*, pp. 1-7. IEEE, 2022. <http://dx.doi.org/10.1109/IMCOM53663.2022.9721813>
- [25] Kob, Che Che, Shangeetavaani Kannapiran, and A. Shah. "The usage of mobile learning: Comparative studies among technical and vocational education students in selected universities." (2020): 203-209. <https://doi.org/10.3991/ijim.v14i05.13355>
- [26] Shah, A., C. Ghani, C. Kob, and M. Khairudin. "Issues and challenges in mobile learning usage for technical and vocational education." *International Journal of Innovation, Creativity and Change* 7, no. 12 (2019): 1-9.
- [27] Ismail, Safinah, Aemy Elyani Mat Zain, Haslina Ibrahim, Nazneen Ismail, Nur Aisyah Abu Hassan, and Fatin Farzana Dass Meral. "Kepentingan aplikasi digital dalam pembelajaran anak muda era industri 4.0: The Importance of digital applications in young children's learning industry Era 4.0." *Semarak International Journal of STEM Education* 1, no. 1 (2024): 28-38. <https://doi.org/10.37934/sijste.1.1.2838>