

# Educational Mobile Apps Enhancing Communication Skills in Children With Autism in Arab Countries

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## ABSTRACT

This exploratory literature review investigates the landscape of educational mobile applications designed for children with autism spectrum disorder (ASD) in Arab countries, with a specific focus on their efficacy in improving communication skills. After a comprehensive search of academic databases and digital libraries, nine studies were reviewed. These studies discussed seven Arabic-language applications designed for ASD children. Consistent with previous research findings, these applications were found to be effective in enhancing communication skills among ASD individuals. By shedding light on the few existing Arabic-language educational mobile applications for ASD children in Arab countries, this comprehensive review contributes significantly to the discourse surrounding ASD interventions. Additionally, it highlights the immediate need for linguistically and culturally sensitive educational applications, designed for a specific population of Arab children with ASD.

## KEYWORDS

Arab Countries, Arabic Language, Autism Spectrum Disorder, Communication Skills, Educational Mobile Apps

## INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by a range of challenges regarding social interaction, communication, and repetitive behaviors. ASD is termed a “spectrum” disorder because individuals with ASD present with a wide variety of symptoms, severity levels, and combinations of different features. ASD is typically diagnosed in early childhood and persists throughout a person’s life (American Psychiatric Association, 2013). A core feature of ASD is having difficulty with social communication; aspects may include deficits in nonverbal communication skills such as gestures, facial expressions, and body language (Hyman et al., 2020). Aburukba et al. (2017) observed that individuals with ASD face significant challenges in expressing themselves and communicating their needs. In some instances, they may not develop speech at all, which greatly limits their ability to communicate. Farzana et al. (2021), for example, notes that about 25% of children diagnosed with ASD experience nonverbal autism. Social communication difficulties can significantly impact a child’s ability to form and maintain relationships, engage in reciprocal social exchanges, and interpret social cues appropriately (Hyman et al., 2020). They can also hinder the ability to learn, when learning depends on communication and familiarity with a teacher (Almalki, 2022).

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The prevalence of ASD has increased worldwide, and this trend is mirrored in the Arab world (Al-Hendawi et al., 2023). In their analysis of the epidemiological landscape of ASD in the Arab Gulf, Salhia et al. (2014) found possible metabolic, autoimmune, and environmental risk factors, in addition to a prevalence range of 1.4 to 29 cases per 10,000 people. Between 2015 and 2018, 1.14% school-age children in Qatar were diagnosed with ASD (Salhia et al., 2014). Additionally, the World Population Review found a high prevalence of ASD in Arab nations like Oman (1 in 93), Bahrain (1 in 97), Qatar (151.2/10,000 or 1 in 66), the United Arab Emirates (UAE; 1 in 89), and Saudi Arabia (1 in 99) (Al-Hendawi et al., 2023). These findings emphasize the importance of early diagnosis and successful intervention (Al-Hendawi et al., 2023; Salhia et al., 2014).

Paul (2008) outlined various interventions to promote communication and language skills in children with ASD, including face-to-face interaction, augmentative and alternative communication aids (AAC), and video modeling. The most common interventions used with ASD are AAC and the Picture Exchange Communication System (PECS) (Farzana et al., 2021; Hussain et al., 2021; Paul, 2008). A recent trend in AAC intervention is using smartphones and tablets, such as the Apple iPad, as speech-generating devices (McLay et al., 2015). According to Xin and Leonard (2015), a complete high technology AAC system can be provided utilizing applications made specifically for these devices, such as Proloquo2go, MyTalk, and SonoFlex. Using these applications, children with ASD can follow the process of learning by listening to a sound, after interacting with a picture of an object. Such applications can also help parents and educators to understand children's needs and thereby avoid miscommunication (Hussain et al., 2021).

While Hussain et al. (2021) found “nearly 700 mobile device apps listed on [the] ‘Autism Apps’ section on [the] Autism Speaks website” (p. 162), publications in the field of AAC have highlighted the lack of AAC technologies supporting individuals with ASD in the Arabic language (Al-Arifi et al., 2013; Hajjar et al., 2021; Zibin et al., 2023). Sweidan et al. (2022) further note that even though Arabic is the first language of more than 300 million people, most well-known autism applications lack Arabic content. This study was driven by this observation.

Despite the importance of technology in effective interventions for ASD, the existing literature lacks a comprehensive review focusing on educational mobile applications and their impact on communication in children with ASD in Arab countries (Abou El-Seoud et al., 2015; Sweidan et al., 2022; Zibin et al., 2023). Therefore, this article explores published studies from 2013 to 2023 that examine Arabic-language educational applications for multipurpose, handheld devices and their impact on communication in children with ASD.

## METHODOLOGY

The approach to this literature review was exploratory, designed to investigate educational mobile applications for children with ASD in Arab countries. The focus was specifically on the communication skills improvements attributed to these applications. This investigation aimed to identify and synthesize findings from relevant research to provide insights into the current state of educational applications and their impact on ASD children. Exploratory literature reviews are conducted to show that there has been minimal or no previous research on the specific group, process, or activity being examined (Hunter et al., 2019). This approach can highlight gaps in the current literature and suggest areas for further investigation, thereby advancing the field (Yin, 2018).

### Literature Search Procedures

The author conducted an electronic search using nine databases: EBSCO, ERIC, Google Scholar, Education Research Complete, ProQuest, Taylor and Francis Online, Sage Journals Online, Springer LINK, and Saudi Digital Library. The search included terms for ASD combined with Arab countries' names and their recognized abbreviations. The following search string was used in all fields: *(educational apps for communication \* OR iOS devices and communication OR autism and iPads*

*\* OR autism and iOS \* OR autism and mobile applications \* OR autism and tablets) AND (Arab \* OR Egypt\* OR Libya\* OR Tunisia\* OR Sudan\* OR Bahrain\* OR Emirates OR UAE OR Oman\* OR Kuwait\* OR Qatar\* OR Saudi\* OR KSA OR Yemen\* OR Jordan\* OR Syria\* OR Iraq\* OR Gaza OR Leban\* OR “West bank” OR Gulf OR “Middle East”)*. These searches produced 483 initial results. After further examination, nine studies were identified as meeting the inclusion criteria for this review.

## Criteria for Inclusion and Exclusion

Inclusion in this review was based on five distinct criteria: (a) articles were published in English and Arabic peer-reviewed journals, (b) publication dates were between 2013 and 2023, (c) participants in studies were Arab individuals with ASD, (d) studies adopted any research design or methodology, and (e) studies focused on communication issues related to individuals with ASD in Arab countries. Sources were excluded if they were: (a) medical research on individuals with ASD or (b) theses, dissertations, books, book chapters, conference papers, review articles, or meta-analysis articles.

## Studies Included in the Review

A total of nine studies met the eligibility criteria and were incorporated into this review. Table 1 provides detailed information on each of these studies. A comprehensive coding protocol was established during the review process, encompassing: (a) author's name and publication year, (b) study objective, (c) participants' information, (d) study design/type, (e) location, (f) application types, and (g) study outcomes.

## LITERATURE REVIEW

### Educational Applications as Communication Tools for ASD Children

The literature search turned up very few studies about the use of educational mobile applications by people with ASD in Arab nations. In one such study, Wali et al. (2023) evaluated the effectiveness of the Aawn Android application for Arab children with ASD. They distributed questionnaires to caregivers at the First Autism Center in Jeddah in Saudi Arabia and parents of autistic children, aiming to assess the application's functionalities and features. Aawn, based on Picture Exchange Communication System (PECS) and integrating graphical capabilities and supporting technologies, was developed using cloud-based technologies and Android Studio. The questionnaire aimed to determine if the application improved communication, emotional, educational, and organizational skills for Arab autistic children. Of the 19 responses obtained, 71.9% strongly agreed with the application's features. Despite some respondents already using various applications for teaching autistic children, a majority preferred Arabic applications specifically designed for this purpose. The study concluded that an integrated mobile application supporting Arab autistic children was crucial for enhancing their fundamental behavior and communication abilities, thereby improving the lives of both children and parents/caregivers.

Hajjar et al. (2021) developed the I Can Talk application for Android/iOS in Arabic, to serve Saudi children with ASD. The application was designed to incorporate techniques that had proven results with all categories of ASD children and was built in compliance with the necessary clinical and market requirements. With the help of this application, individuals with speech impairments could communicate more effectively and clearly convey their demands. To evaluate the application, Hajjar et al. distributed questionnaires to teachers/parents of autistic children who used I Can Talk, 67 of whom responded. Of the children with autism who used the application, 64.2% were aged 4-6, 29.9% aged 7-9, and just 6% aged 10-12. Most of the participants (51%) agreed on the effectiveness of the I Can Talk application and reported that it helped improve communication and helped children with ASD to develop sentences and express themselves. However, Hajjar et al. did not apply an experimental design to test the effectiveness of the application with ASD children themselves. The

**Table 1. Summary of reviewed studies**

No.	Authors	Objective	Participants	Design/Type	Location	App Types	Outcome
1	Wali et al. (2023)	Assessed effectiveness of the Aawn Android app for Arab children with ASD	19 parents/ caregivers of ASD students		First Autism Center, Jeddah	Aawn app, Android	Results indicated that the Aawn app may assist in development of communication skills in children with ASD.
2	Hajjar et al. (2021)	Assessed effectiveness of the I Can Talk app with nonverbal children diagnosed with ASD	67 teachers/ parents of children with ASD		Saudi Arabia	I Can Talk app, Android/iOS	Participants unanimously affirmed the effectiveness of the I Can Talk app, stating that it significantly contributed to improving communication skills in their autistic children.
3	Mohammad & Abu-Amara (2019)	Evaluated effectiveness of MyVoice mobile app developed for autistic children in the UAE, aiming to facilitate interaction and expression of feelings and needs	One child with ASD	Experimental single-subject study	UAE center for autism	MyVoice app, iOS	The child exhibited notable improvement in interaction levels within a week of using the application. Overall, parents expressed high satisfaction with MyVoice during the experimentation period.
4	Safi et al. (2021)	Assessed effectiveness of a language intervention utilizing a virtual voice assistant (Apple Siri) that supported the Arabic language in children with ASD	Three children aged 4 to 11, diagnosed with minimal or nonverbal communication skills associated with ASD	Single-case A-B-A design	Schools in UAE		The outcome revealed positive effects of the virtual voice assistant intervention, including enhanced pronunciation and increased interactions with siblings. Mothers expressed satisfaction with the program and potential benefits for children facing speech and social difficulties, particularly when implemented in a home setting.
5	Hamid et al. (2022)	Designed an app utilizing augmented reality to enhance development of nonverbal communication skills in children with ASD	20 children with ASD aged 5-6		Schools in Qatar	AR-QU-CUBE app, augmented reality	Results indicated enhancements in communication skills and the recognition of basic human emotions among children with ASD.

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Table 1. Continued

No.	Authors	Objective	Participants	Design/Type	Location	App Types	Outcome
6	Sweidan et al. (2022)	Created the Autistic Innovative Assistant, an Android app designed to instruct Arabic-speaking autistic children in linguistic and mathematical concepts while enhancing their social skills in an interactive learning environment	100 children with ASD aged 9-14	Quantitative approach	Jordan Specialized Center for Autism	Autistic Innovative Assistant app, Android	Results showed genuine enthusiasm and significant skill improvement across various categories among children who used the app, compared to those who did not use it.
7	Al-Qahtani & Al-Saleh (2020)	Assessed the impact of the Livox Arabia app on the development of communication skills in autistic children in Saudi Arabia	Four teachers and seven mothers of ASD students	Qualitative case study	Two autism centers in Riyadh	Livox app, Android	Participants acknowledged the advantages of the app for their children with ASD, highlighting improvements in communication, language development, demand expression, and attention enjoyment, as well as user-friendly features in Arabic.
8	Al-Arifi et al. (2013)	Developed Touch-to-Speak app to support Arabic-speaking individuals with speech and language impairments in daily conversations	14 children with ASD, one speech pathologist, one teacher, and one psychiatrist	User-centered design approach	One intellectual education institute in Riyadh	Touch-to-Speak app, iOS	The app had a positive impact on students with ASD, and teachers found it facilitated a better understanding of their students' needs after its use.
9	Al-Wakeel et al. (2015)	Assessed usability of two Arabic mobile apps, Tap to Talk and Touch to Speak	14 children, comprising eight autistic and six non-autistic children	Mixed method study	King Saud University and Autism Center in Riyadh	Tap to Talk and Touch to Speak apps, iOS	Participants highlighted the advantages of the apps for informal communication in ASD children's daily lives.

Note. ASD = autism spectrum disorder, UAE = United Arab Emirates.

accuracy and dependability of data are greatly increased when participants are concentrated in one area, given specific tasks to do using an application, and then asked to complete a survey.

Mohammad and Abu-Amara (2019) developed the MyVoice iOS application with the aim of enhancing communication skills and abilities in children with autism in the United Arab Emirates. MyVoice allows users to interact in Arabic and offers customization features, including categories, pictures, audio, and notifications, thus providing flexibility for parents and caregivers. The researchers conducted a two-month experimental study using a single-subject research design, involving one autistic child. Prior to the study, MyVoice underwent evaluation by two autistic therapists and parents at local autism centers. The child exhibited notable improvement in interaction levels within a week of using the application, attributed to the child's familiarity with the PECS approach. Overall, parents expressed high satisfaction with MyVoice during the experimentation period.

Safi et al. (2021) conducted a single-case A-B-A study of three children from the United Arab Emirates, 4 to 11 years old, who were diagnosed with ASD with minimal and nonverbal communication. The aim of the study was to determine the effectiveness of an expressive language

intervention, using a virtual voice assistant (VVA; Apple Siri) specifically supportive of the Arabic language. As Safi et al. explained, VVAs serve as tools offering children opportunities to enhance their verbal communication skills by providing a platform for listening and responding verbally. Additionally, interaction with virtual characters can expose children to nonverbal cues, potentially improving their ability to interpret such cues through repeated exposure.

Prior to the intervention, the three participants' proficiency with Apple smartphones and tablets was evaluated. Safi et al. then distributed an iPad to each participating family and trained parents and participants on the VVA intervention. The study involved participants using a VVA, specifically Siri, for a duration of three months. The intervention comprised two 10-minute sessions daily, typically after school and on weekends, within the children's natural environment (home). Mothers initiated each intervention session by activating Siri with a prompt like "Hey Siri." Subsequently, the child was given the opportunity to replicate the same behavior. If the child did not respond appropriately, the mother repeated the modeling behavior. If the child showed disinterest, the session was terminated, with a plan to reattempt later in the day. Safi et al. found positive changes in participants' expressive verbal vocabulary, production of short phrases, and social interactions after the VVA intervention, when compared to traditional language stimulation activities like toy use, picture cards, and storybooks. Children effectively engaged with the VVA platform, exhibiting improved expressive vocabulary. The intervention phase demonstrated enhanced verbal output and social interactions, as compared with the conventional baseline. Notably, children demonstrated improved pronunciation and increased interactions with siblings. Mothers reported satisfaction with the program, suggesting that VVA interventions could be beneficial for children with speech and social difficulties when implemented at home.

Additionally, Hamid et al. (2022) created the AR-QU-CUBE, an augmented reality application, and assessed its effectiveness with 20 children aged 5-6 years with ASD in Qatar. The application employed 3D shapes, and an interactive virtual environment displayed on devices like iPads or tablets, aiming to enhance nonverbal communication skills. The quasi-experimental study focused on a single experimental group of children with ASD, using pre- and post-comparative analyses, without a control group for ethical considerations. The group's progress was measured through post-assessments and a follow-up after one month. Results revealed improvements in communication skills and the recognition of basic human emotions, such as happiness, surprise, sadness, anger, fear, and pain. Researchers attributed these gains to the practical application in both school and home settings, emphasizing the extensive use of electronic applications on tablets and mobile devices among the experimental group members.

Sweidan et al. (2022) developed the Autistic Innovative Assistant (AIA), a smartphone application specifically tailored for Arabic-speaking children with autism. The AIA utilizes interactive games and activities to teach social, communication, linguistic, and mathematical skills. The application offers an immersive learning experience using vibrant images, engaging voices, and informative videos. To systematically evaluate the application, the researchers launched it at the Jordan Specialized Center for Autism, with a test group of 100 autistic children between the ages of 9 and 14. The evaluation employed three approaches to gather impressions, including: application usage reports from supervisors, a detailed survey measuring specific points and statistically evaluating Autistic Innovative Assistant, and interviews with supervisors. The test period lasted one month, during which supervisors ensured that children accessed all AIA categories. Results were promising, indicating a genuine enthusiasm among children for the application and significant skill improvement across various categories, as compared with those who did not use it. However, Sweidan et al. did not employ an experimental design to assess the application's effectiveness on ASD children. The accuracy and reliability of data are significantly enhanced when participants are assigned to specific tasks utilizing the applications.

Al-Qahtani and Al-Saleh (2020) conducted a qualitative case study to evaluate the Livox Arabia application's impact on communication skill development in autistic children in Saudi Arabia. The



Livox app, designed for Android tablets, aids individuals with disabilities, particularly nonverbal autistic children, in learning educational skills and expressing their needs. The study was conducted at two autism centers in Riyadh, utilizing interviews and focus groups with four teachers and seven mothers of children with ASD. Results highlighted the application's advantages, including enhancing communication, language development, demand expression, and attention enjoyment, as well as its user-friendly features in Arabic. Main obstacles identified were the application's high cost and unavailability on the iOS system. However, the study did not employ an experimental design that would examine the application's positive impact by studying ASD children themselves.

Al-Arifi et al. (2013) conducted a study in Saudi Arabia introducing Touch-to-Speak, a portable AAC tool designed to support Arabic-speaking individuals with speech and language impairments in daily conversations. This tool translates pictures into well-structured Arabic sentences, accommodating Modern Standard Arabic and various local dialects. Targeting 14 children with ASD and elderly individuals post-stroke, the study assessed the application's impact on communication and educational activities in learning contexts. Testing involved interviews with speech pathologists, teachers, and a psychiatrist, along with application trials with students of varying disabilities, educational levels, and ages. Results indicated that Touch-to-Speak served as a mediator to expedite communication in educational settings, fostering more effective learning after students acquired basic sentence structuring skills. The application helped teachers understand students' needs and feelings, promoted class participation, and helped draw attention to students who wished to share thoughts or experiences.

Al-Wakeel et al. (2015) conducted a mixed methods study assessing the usability of Arabic versions of the iOS applications Tap to Talk and Touch to Speak. The research involved 14 participants, comprising eight autistic and six nonautistic children in different age groups. The study, conducted in the usability lab of King Saud University and Autism Center in Riyadh, Saudi Arabia, utilized eye tracking and Morae® for qualitative and quantitative analysis. The participants were asked to use both applications for 10-15 minutes and then complete a questionnaire with their parents' help. While both applications were deemed easy to use for nonverbal children expressing their needs in daily life, some drawbacks were noted. For instance, Touch to Speak had a multipage picture display, causing unpredictability, and the central display of pictures in Tap to Talk was found distracting. Participants highlighted the advantages of Tap to Talk's ability to display a large number of pictures on one page, as well as Touch to Speak's use of Modern Standard Arabic, making it suitable for informal communication in children's daily lives.

All in all, educational applications have become a cornerstone in the teaching strategies for children with ASD across various cultural and linguistic settings. The incorporation of mobile applications into educational frameworks for ASD children addresses unique learning needs by offering personalized, engaging, and flexible learning opportunities (Abou El-Seoud et al., 2015; Sweidan et al., 2022; Zibin et al., 2023). This review synthesizes findings from recent studies on the use of educational mobile apps by people with ASD in Arab nations, illustrating their application as teaching aids, their role in mastering learning objectives, the rationale behind their recommendation for children with ASD, and their effectiveness in improving communication skills.

## EDUCATIONAL APPLICATIONS AS TEACHING AIDS

Educational apps serve as significant teaching aids by providing interactive and engaging content that caters to the diverse needs of learners with ASD. The adaptability of applications such as Aawn, I Can Talk, MyVoice, AR-QU-CUBE, and the AIA supports personalized learning experiences. These applications leverage graphical capabilities, cloud-based technologies, and augmented reality to create immersive learning environments that capture the interest of children with ASD, thereby facilitating a more effective learning process (Hajjar et al., 2021; Hamid et al., 2022; Mohammad & Abu-Amara, 2019; Sweidan et al., 2022; Wali et al., 2023).

## **Mastery of Learning Objectives**

The structured and repetitive nature of educational applications allows children with ASD to master learning objectives through consistent practice. Applications designed for ASD learners, such as those mentioned in the studies by Wali et al. (2023), Hajjar et al. (2021), and others, include features that target specific developmental areas including communication, emotional understanding, organizational skills, and basic educational concepts. By engaging with these applications, children can practice at their own pace, which reinforces learning and aids in the mastery of various skills.

## **The Rationale Behind Technology Use With Children With ASD**

Technology, especially technology with educational applications, is recommended for use with children with ASD for several reasons. First, the interactive and engaging nature of applications can meet the unique learning preferences of children with ASD, many of whom find traditional educational methods challenging. The visual and auditory stimuli provided by applications can enhance attention and motivation. Furthermore, the customization features of applications allow for the accommodation of individual learning styles and the pacing needs of each child. The ability to control the environment and predictability of application-based learning can also reduce anxiety and increase comfort for learners with ASD (Abou El-Seoud et al., 2015; Hajjar et al., 2021; Hamid et al., 2022; Mohammad & Abu-Amara, 2019; Sweidan et al., 2022; Wali et al., 2023; Zibin et al., 2023).

## **Improving Communication Skills**

Communication is a critical area of development for children with ASD. Educational applications specifically designed for this demographic have shown significant promise in improving communication skills. Studies by Mohammad and Abu-Amara (2019), Safi et al. (2021), and others have demonstrated that applications like MyVoice and the use of virtual voice assistants can enhance verbal communication, including pronunciation, production of short phrases, and the use of expressive language. Applications that serve as AAC tools, such as Touch-to-Speak, facilitate nonverbal communication, allowing children to express their needs and emotions effectively. The interactive and responsive nature of these applications encourages children to engage in communication, thereby improving their ability to interact with others.

Overall, the integration of educational apps into the learning and development process for children with ASD offers a modern approach to education that aligns with the digital age. These applications serve as effective teaching aids that significantly contribute to the mastery of learning objectives, particularly in communication, emotional understanding, and basic educational concepts. The recommendation of technology use, especially applications, for children with ASD is supported by their ability to provide personalized, engaging, and flexible learning experiences. Consequently, educational applications have emerged as vital tools for enhancing the communication skills and overall development of children with ASD, supporting their integration into society and improving their quality of life (Al-Arifi et al., 2013; Al-Qahtani & Al-Saleh, 2020; Al-Wakeel et al., 2015; Hajjar et al., 2021; Hamid et al., 2022; Mohammad & Abu-Amara, 2019; Safi et al., 2021; Sweidan et al., 2022; Wali et al., 2023).

## **DISCUSSION**

The comprehensive review highlights significant improvements in communication skills among children with ASD, using educational mobile applications. Specifically, out of 242 participants from the included studies, 142 exhibited substantial advancements in their communication abilities (Al-Arifi et al., 2013; Hamid et al., 2022; Mohammad & Abu-Amara, 2019; Safi et al., 2021). These findings underscore the efficacy of iOS and Android applications as AAC interventions, affirming the potential of technology-assisted tools in bridging communication gaps for ASD children in Arab nations.



This review also revealed a limited availability of Arabic apps for ASD children in Arab countries, with only seven identified apps currently available (Aawn, I Can Talk, MyVoice, AR-QU-CUBE, AIA, Livox, and Tap to Talk). Notably, the Touch-to-Speak application by Al-Arifi et al. (2013) is no longer available on the market. Consequently, there is an urgent need to expand the evidence base and identify suitable linguistically and culturally Arabic educational applications for ASD children with complex communication needs. These findings align with previous research indicating a scarcity of dedicated mobile applications supporting the Arabic language (Alghamdi, 2021; Al-Hendawi et al., 2023). A subsequent search identified additional Arabic educational applications not discussed in previous research, including BabNoor, the first AAC application in Arabic catering to autistic children and individuals with other disabilities. Another noteworthy application was Tawasol AAC, designed to enable people with communication difficulties and children with ASD to express themselves in Arabic, using a wide range of symbols. Further research, through experimental research design, is essential to assess the acceptance of these applications by ASD children and their caregivers. This study contributes to the ongoing discourse on the limited availability of Arabic-language applications for individuals with ASD, urging the exploration and development of more inclusive and culturally sensitive solutions.

While this review contributes valuable insights into the utilization of educational applications for children with ASD in Arab countries, several limitations warrant consideration, as these limitations potentially impact the generalizability of the findings. The reliance on small sample sizes and predominantly survey and observational study methodologies, as opposed to controlled experiments, introduced a potential bias into the results. Notably, only three studies in this review implemented controlled experimental designs (Hamid et al., 2022; Mohammad & Abu-Amara, 2019; Safi et al., 2021). This indicates a gap in methodological rigor across the broader body of research. This review was also unable to assess the outcomes of the included studies. A meta-analysis would be advantageous in substantiating and strengthening these findings. Other limitations may be associated with this study's use of keywords, as search strings incorporating synonyms and the inherent constraints of specific keywords could have influenced outcomes. In addition, most of the reviewed studies focused on children, thereby limiting the generalizability of findings to other age groups within the ASD spectrum. A final constraint in this study pertains to the broader applicability of AAC interventions, which extends beyond ASD to include individuals with diverse impairments, such as cerebral palsy, intellectual disability, developmental disability, and stroke. However, this review specifically focused on research articles involving children with ASD.

These limitations underscore the need for future research endeavors to address methodological shortcomings, incorporate larger and more diverse samples, and employ controlled experimental designs to enhance the robustness and applicability of findings. This will contribute to a more comprehensive understanding of the efficacy and impact of mobile applications and devices as tools for supporting individuals with ASD, across various age groups in Arab communities. Further, it is important to recognize that each child with ASD is unique, and a single intervention may not be universally applicable. Therefore, there is a need to delve deeper into understanding the causal effects of features in AAC-based mobile apps on the development of speech and social skills in children with ASD (Al-Hendawi et al., 2023).

## CONCLUSION

This review recognizes the emerging integration of Arabic language support in AAC-based mobile applications for children with ASD. It provides valuable insights from the nine reviewed studies to assist in further exploration of the potential of mobile applications to augment communication abilities among ASD children in Arab countries. The findings suggest the need for a more meticulous approach when designing applications for children with autism, emphasizing usability and alignment with the language preferences of the target users.

Allen et al. (2016) present five key factors to consider when selecting applications for children with ASD. First, applications should be rooted in scientific principles, or substantiated by empirical research. Second, a preference is given to those applications allowing the creation and integration of personalized visual supports, using the tablet's camera. This customization enhances communication specificity, broadens interaction opportunities, and aids caregivers in utilizing content conducive to children's symbolic understanding. Third, caregivers should consider the fine motor skills required for effective engagement with a given application, recognizing deficits often observed in children with ASD. Fourth, the time and resources needed to teach children with ASD how to use a specific application should be considered, particularly in the absence of standardized guidelines that place the onus on caregivers to devise strategies. Lastly, application affordability is a crucial factor, as iPads and their applications are not always cost-effective for different families, and often lacking the technical support associated with conventional AAC devices. Notably, empirically supported applications can be expensive, such as Proloquo4Text 2.0, now available in an Arabic version priced at £199.99/\$249.99 dollar. This may understandably tempt some parents to consider more economical alternatives, potentially compromising on empirically validated efficacy or essential functionality for their children. This comprehensive evaluation aims to guide future developments in the field, ensuring that applications not only align with empirical evidence, but also cater to the unique needs and circumstances of ASD children and their caregivers.

The use of educational applications in facilitating communication for ASD children is vital for their development, as educational applications can serve as a bridge—one that enhances traditional AAC approaches by leveraging technology to facilitate more dynamic, interactive, and personalized communication strategies. These applications offer the potential to significantly improve communication skills by providing opportunities for practice, feedback, and interaction in a controlled, engaging environment. They can also help develop social skills through simulated social scenarios or interactive storytelling, both of which are crucial for children with ASD (Safi et al., 2021; Sweidan et al., 2022; Wali et al., 2023).

In summary, the use of mobile devices and applications shows promise for enhancing communication skills among children with ASD. Nevertheless, it is important to interpret the current findings cautiously, considering the limitations evident in the existing literature. Future research endeavors should employ more robust methodologies, including randomized controlled trial designs, to enhance the generalizability of findings beyond the scope currently observed in the available literature.

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## **CONFLICTS OF INTEREST**

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

## **PROCESS DATES**

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