

Investing in Mobile Applications to Enhance Linguistic Concepts in Children with Autism: A Critical Descriptive Study of the TAC Application as a Model

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Abstract:

Recent advancements in technology have significantly improved support for children diagnosed with autism spectrum disorder (ASD). Numerous mobile applications have positively influenced their daily lives by enhancing language skills and facilitating interaction and communication. This is particularly crucial, as children with autism often encounter learning difficulties, language deficits, and communication barriers.

This study aims to evaluate the effectiveness of smartphone applications in improving language concepts for children with ASD, specifically focusing on the TAC application, which promotes the Arabic language. The TAC application serves as a leading model for designing mobile applications that maximize benefits for this demographic.

Keywords: Autism Spectrum Disorder, Mobile Applications, Language Concepts, Autistic Children, TAC Application.

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1. INTRODUCTION

Mobile technologies have become increasingly widespread and interconnected, offering creative applications across various fields. A notable example of this innovation is the use of smartphone technology in education, which has given rise to a new form of e-learning known as mobile learning. (Fu, 2009, p. 103)

Internet-enabled mobile phones allow children to access learning resources and online courses anytime and anywhere. Technology has demonstrated its potential to support all children, including those with autism spectrum disorder. However, it is essential to reconsider and adapt technology to meet the diverse needs of all children with autism, (Sanchez. Gordon & Lujàn-Mora, 2016, p. 72) Including smartphones, tablets, and other devices. This prevailing trend has resulted in significant changes not only at the community level but also in the assessment and treatment of individuals with communication disorders. (McNaughton & Light, 2013, p. 112)

Smartphone technologies have become increasingly popular among individuals with autism. Socially, children on the autism spectrum face significant challenges in understanding verbal behaviors, such as eye contact and facial expressions. They often lack the spontaneous motivation to seek out others to share enjoyment or achievements. (Paparella, Goods , & Kasari, 2011, p. 575) As a result of these social interaction difficulties, children with autism frequently engage in solitary activities and avoid participating in social games, particularly with peers, since language disorders are a common characteristic of autism. Some researchers estimate that approximately 80% of children with autism aged five years and younger enter programs focused on non-verbal education. (Anderson, et al., 2007, p. 599)While language difficulties can severely hinder communication, specialized educators have developed various interventions to facilitate communication without relying on expressive language.

The emergence of smartphones has significantly advanced technology-based education, providing various tools and resources that can benefit children with autism. This advantage arises from several factors, including the devices' portability and constant availability, the user-friendly touchscreen interface, and the capability to produce multimedia outputs. (B.K, 2009, pp. 27-35) Although numerous software applications exist to support language development and communication through digital images, there has been limited research on the ability of children with autism to comprehend and learn from the symbolic information presented in these mobile applications. Furthermore, there is a lack of guidance on optimizing electronic applications to enhance educational tasks for children with autism.

The increasing prevalence of mobile applications designed to enhance linguistic concepts among children with autism is noteworthy. The use of smart devices for educational purposes can broaden the learning environment, making it accessible anytime and anywhere. Advancements in information and communication technology have enabled mobile applications to effectively promote and reinforce specific linguistic concepts in children with autism, facilitating their ability to follow instructions both at home and in school.

Statement of the Study Problem:

Children with autism frequently encounter challenges related to language concepts. To address this issue, the researcher proposes the use of mobile applications. This study aims to answer the following questions:

- ❖ What linguistic concepts are essential for children with autism?
- ❖ What is the impact of mobile applications on the enhancement of specific linguistic concepts for children with autism?
- ❖ What is the TAC application, and how can it be utilized to improve certain linguistic concepts for children with autism?

Importance of the Study:

This study aims to:

- ❖ Enhance linguistic concepts for children with autism.
- ❖ Propose suitable educational applications, such as the TAC application, to assist children with autism in improving their language concepts.

Objectives of the Study:

- ❖ Identify the linguistic concepts necessary for children with autism.
- ❖ Assess the impact of mobile applications on the enhancement of linguistic concepts in children with autism.

2. Literature Review:**2.1. Autism in Children:**

There is a growing consensus among researchers that the number of children diagnosed with autism spectrum disorder is increasing globally. These children are receiving considerable attention, particularly in the field of education. (Haida U, Melor, & Helmi, 2021, p. 133) The importance of inclusive education for all children has been emphasized, asserting that children with disabilities should have equal opportunities to receive an education. Many advocate that every learner is entitled to the same quality of education, prompting developed countries to prioritize inclusive education in their educational policies. (Amor & et al, 2019, p. 1284) All learners, including those with autism, possess a legal right to education. Nevertheless, children with autism often encounter significant challenges that hinder their academic and social success. (Nuske & et al, 2019, p. 319)

Autism is classified as a mental disorder that significantly impacts critical developmental areas, including language, communication, social skills, behavior, and interests. Initial symptoms may manifest early in development; however, social deficits and behavioral patterns may not be recognized as indicative of autism until the child fails to meet essential life

requirements. (Dijkhuis, Sonnevile, Ziermans, Staal, , & Swaab, 2020, p. 1359) Children with autism spectrum disorder often face challenges in communication and interaction due to impaired language comprehension. They typically exhibit limited interests, repetitive behaviors, and can be easily distracted by stimuli that capture their attention. While autism can be a life-long condition, appropriate treatment and services can enhance their abilities. Children with autism often struggle with social communication, particularly in auditory processing, which is their most significant deficit, while their visual sensory abilities tend to be their primary strengths.

They may have difficulty remembering or recognizing situational contexts, making communication and understanding others' needs challenging. (Crowell, A, Keluskar, & Gorecki, 2019, p. 26) By improving their skills and enhancing language abilities, independence can be fostered, leading to better communication and social interactions.

Autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by a range of challenges in social interaction, communication, and repetitive behaviors. It is termed "spectrum" because individuals with ASD exhibit a diverse array of symptoms that vary in severity and combinations of traits. (Alzahrani, 2024, p. 2) Typically diagnosed in early childhood, autism persists throughout an individual's life. A fundamental aspect of ASD is the difficulty with social communication, which can manifest as weaknesses in nonverbal skills, including gestures, facial expressions, and body language. (Tiley & Kyriakopoulos, 2021, p. 195)

In light of the significant increase in the prevalence of autism worldwide, this disorder has become more widely recognized. Many parents of children with autism are now actively seeking strategies to support their children. The rising prevalence has also attracted the attention of researchers globally, who have conducted studies and interventions aimed at facilitating language learning for autistic children. These children often face challenges in processing

sensory information, which can adversely impact their learning, particularly in language acquisition. (Mahayuddin & Mamat, 2019, p. 2179)

Children with autism, despite facing numerous challenges, have the right to be integrated into all areas of society, including learning the Arabic language. Inclusive education is essential for enabling children with autism to thrive in the future.

Language acquisition begins with mastering vocabulary, which serves as the foundation for most aspects of language and overall achievement. Therefore, vocabulary development should be regarded as a critical component of language learning. Researchers have explored various strategies, including the use of technology, to support children with autism in their language learning endeavors. (Susanto, 2017, p. 186)

2.2. Language Development in Children with Autism:

Children with autism worldwide encounter similar challenges due to their condition; however, each child possesses unique traits, preferences, and learning styles, which can present both advantages and obstacles in their learning processes. Furthermore, language acquisition is particularly challenging for children with autism, (Chu, Tang, K. P, McConnel, G. , Mohd Rasdi, H. F, & Yuen, 2019, p. 178) as communication skills are often not their strong suit. As a result, they frequently struggle with verbal communication, (Dolah & Chal, A, K, 2020, p. 7204) leading them to rely on non-verbal methods such as screaming, crying, and tantrums. Consequently, teaching them language presents a significant challenge.

Children with autism exhibit deficits in social interaction and language, characterized by disrupted conversation patterns and limited spoken language. These challenges have become increasingly prevalent among children with autism today.

The language development of children with autism has been extensively researched, as these deficits are often regarded as a hallmark of the condition. Evidence indicates common linguistic development deficits in children with autism, including early signs such as delayed

speech and language use, atypical language production, and difficulties with pragmatic communication. (Roberts, 2014, p. 61) Typically, children with autism do not speak their first words until approximately 38 months of age, and they experience delays in both receptive and expressive language skills. (Hudry. K, Leadbitter K,, Temple K,, Slonims V, , & McConachie H, , 2010, p. 686)

The language development of children with autism is marked by various atypical language disorders, including echolalia, excessive use of specialized terminology, and variations in intonation and stress. (Roberts, 2014, p. 61) Studies indicate that echolalia, which involves the imitation and repetition of others' speech, can be categorized into three types: immediate echolalia (exact imitation), mitigated and modified echolalia, and delayed echolalia. Research has demonstrated that echolalia can function as a communicative strategy, enabling children with autism to reduce cognitive load, initiate or sustain conversations, and acquire language. Echolalic behaviors are recognized as a defining characteristic of autism and signify language development in these children, as the use of echolalic strategies evolves alongside the progression of the condition. (Roberts, 2014, p. 63)

2.3. Language Concepts for Children with Autism:

A solid understanding of various language concepts is essential for children with autism, as it enhances their ability to follow instructions and comprehend discussions. To effectively use these concepts in spoken language, children must first grasp their meanings. This foundational knowledge equips children with autism to better understand and adhere to instructions at home, in preschool, at school, and within the community. (Valencia, Rusu, C, , Quinones, D, & Jamet, E, 2019, p. 18)

Language concepts enable children with autism to comprehend direction, location, position, number, quantity, distance, sequence, characteristics, size, and similarities and differences. Mastery of these concepts fosters greater precision in their daily lives.

2.4. The Importance of Mobile Applications for Children with Autism:

In recent decades, technology has been a primary driver of human activity and productivity, with mobile applications emerging as particularly valuable resources for children with autism. These applications serve as educational tools that enhance learning by leveraging visual approaches, which children with autism often respond to positively, facilitating skill development and comprehension.

As technology becomes increasingly integrated into daily life, it is now essential for most individuals. Its applications span all sectors, including education, where it enhances efficiency and productivity. Children with autism spectrum disorder benefit from technology, as it aids them in managing daily tasks and improving interactions with others, particularly when they face challenges in expressing their needs and emotions. Consequently, advancements in technology have made education more interactive and engaging. (Valencia, Rusu, C, , Quinones, D, & Jamet, E, 2019, p. 18)

Mobile applications can aid children with autism in enhancing social interactions within their environments, particularly in education and communication, through personalized adaptations and the strategic use of technology in their daily lives. These applications can improve their communication skills, facilitate learning, and foster a positive self-image. Furthermore, mobile applications have revolutionized the realm of learning by integrating technology and electronic programs. (Hudry. K, Leadbitter K,, Temple K,, Slonims V, , & McConachie H, , 2010, p. 686)

Advancements in technology have significantly enhanced the educational process, contributing to the success of learners. Children with autism can now utilize technology for their

studies, which may prove more effective than traditional classroom learning, where teachers cannot dedicate their full attention to individual students. Autistic children require considerable care and supervision to develop their skills, a task that can be particularly challenging due to the variability in their symptoms and individual needs. Nonetheless, parents, specialists, and teachers are committed to improving their quality of life, despite their differences from typical individuals. Therefore, providing support through an interactive and engaging mobile application could help these children focus more effectively on their daily activities. (Urturi, Zorrilla, A, M., & Zapirain, B, G, 2011, p. 229)

Enhancing the skills of children with autism presents significant challenges, as each child's symptoms differ. Moreover, the cognitive abilities of individuals with autism spectrum disorder can range from giftedness to intellectual disability. Autistic children often encounter daily obstacles, including difficulties in expressing their feelings and emotions, which can result in aggressive behavior toward those around them, particularly their parents.

In light of the increasing number of applications for autism, it is essential to facilitate communication for children with autism across various environments. Mobile applications enhance specific linguistic concepts and enable learning activities to take place anytime and anywhere. These electronic applications are designed to provide detailed information and customizable visual features that support learning for children with autism. (Urturi, Zorrilla, A, M., & Zapirain, B, G, 2011, p. 229)

Such features can be employed to teach language concepts by emphasizing shape similarities and improving shape-based generalizations, which often manifest as matching elements through images based on shape or color. Consequently, children with autism who have limited speech may not intuitively recognize the names associated with images, such as the image itself, the depicted object, its shape, or its color. Their understanding of objects is largely

influenced by the type of image presented. Therefore, these differences suggest a non-typical approach to learning words through images for children with autism. (Valencia, Rusu, C, , Quinones, D, & Jamet, E, 2019, p. 18)

A variety of mobile applications have been specifically developed for children with autism to enhance language concepts and improve their quality of life. Many children with autism are visual learners, (Hartley C & Allen M, L, 2015, p. 24) which explains their attraction to mobile technology for both educational and recreational purposes. Numerous applications have been created to incorporate visual support tailored to the unique needs of these children, thereby improving communication and expanding interaction opportunities. Consequently, the use of mobile applications can significantly enhance language and communication skills in children with autism who have limited verbal abilities. (Hartley C & Allen M, L, 2015, p. 25)

3. The Role of Assistive Technology in Enhancing Linguistic Concepts in Children with Autism: A Critical Descriptive Study of the TAC Application as a Model

Language and communication are among the greatest challenges faced by children with Autism Spectrum Disorder (ASD). The TAC (Arab Child Communication) application emerges as a technological solution specifically designed to bridge this gap by employing alternative and augmentative communication (AAC) strategies. The following is a critical descriptive overview of the application in terms of effectiveness, design, and educational value, examining the technical, psychological, and educational aspects, along with an analysis of its long-term impact on the linguistic and social development of children with autism.

3.1. Methodological Framework and Educational Philosophy:

The TAC application is grounded in the philosophy of Alternative and Augmentative Communication (AAC) procedurally based on the Picture Exchange Communication System (PECS). Its academic strength lies in transforming traditional behavioral strategies into an "interactive digital environment." This digital transformation enhances learning efficiency

through the principle of "immediate response," whereby the child receives instant auditory and visual feedback upon pressing a symbol, reinforcing the conditional association between need and expression. Researchers Leaf and Cihon emphasize in their studies on digital learning that: "Effective applications succeed in converting the principle of discrete trial training (DTT) into interactive interfaces that ensure learner responses with near-zero error rates (errorless learning) through intelligent software assistance systems." (Leaf, Cihon, Ferguson, & Milne, 2020, p. 165)

The application is distinguished by its input flexibility, allowing the integration of realistic images. Scientifically, many children with autism experience "difficulty with abstraction," so capturing an image of the child's own blue cup and placing it in the app is far more effective than using a generic cartoon icon of a cup.

The application primarily relies on the Picture Exchange Communication System (PECS), a scientifically validated methodology for training nonverbal individuals to communicate. Bondy and Frost, the founders of PECS, note in a research paper on digitization: "The transition from exchanging physical pictures to digital images in applications allows the child to overcome the obstacle of physical communication, as speech synthesis algorithms provide immediate voice to the images, enhancing the neural connection between the symbol and the word." (Bondy & Frost, 2001, p. 732) Thus, the app transforms traditional pictures into a digital medium, enabling the child to carry their "vocabulary" on a single device instead of large paper files. Based on our observations, the application depends entirely on the presence of a trainer or caregiver implementing the six stages of PECS, making the app a tool rather than a self-instructional teacher.

The application is designed with consideration for the sensory sensitivity of children with autism, featuring an interface free of visual distractions and bright colors that might cause

sensory overstimulation. According to a study by Bellini and Akullian, which developers continue to rely on: "Video modeling through digital media surpasses live modeling because it eliminates social distractions and allows complete visual focus on the targeted language skill, making it the most efficient technological tool for teaching verbal imitation." (Beukelman & Light, 2020, p. 158) The application also allows the addition of real images from the child's environment (such as a picture of their room or their own toy), which is vital because children with autism often struggle with generalization (understanding that a drawing of an apple represents the real apple they eat).

Studies have shown that integrating technology-based interventions with the principles of applied behavior analysis leads to faster vocabulary acquisition in children with autism compared to traditional methods, due to the software's ability to provide immediate visual and auditory reinforcement. (Ganz & Simpson, 2019) We have also observed that the application extends beyond teaching vocabulary to focus on functional communication. In autism, a child may memorize object names (labeling) but not request them (manding). TAC addresses this gap by requiring the child to use the picture to obtain a reward, thereby building a neural circuit linking "language" and "goal achievement."

Furthermore, the design of this application may help reduce tantrums caused by frustration from the inability to express oneself, which is one of the most significant behavioral challenges in children with autism. Critical analysis indicates that TAC acts as a "safety valve"; once the child has a means to express hunger or pain through the application, the intensity of behavioral stress decreases significantly.

3.2. Software Engineering and Application Infrastructure:

From a technical perspective, the application was developed using advanced frameworks (such as Flutter or its equivalents) to ensure high compatibility across different operating systems (cross-platform). The software architecture is characterized by the following: (Odom, Thompson,, & Hedges, 2015, pp. 3807-3812)

Local Data Management (Offline Architecture): relying on internal databases (such as SQLite) to ensure service continuity without requiring an internet connection, which is essential to guarantee the uninterrupted "voice" of the child.

In addition to the "Visual Noise Reduction" feature, the application interface is programmed to adhere to minimalism principles:

Position stability: The locations of basic icons (such as the words "Yes" or "No") are fixed. Programmatically, this converts the action into "muscle memory" (Motor Planning), enabling the child to press the spot without conscious thought, similar to typing on a computer keyboard without looking.

White spaces: Precise technical gaps are maintained between images to prevent "motor interference," where a child with motor coordination difficulties might accidentally press two images simultaneously.

Speech processing algorithms: Integration of Arabic text-to-speech (TTS) engines with voice customization options provides a familiar linguistic environment for the child. In addition to the multisensory integration feature, when a symbol is pressed, the application performs two simultaneous programmed functions:

Instant zoom effect: visually enlarging the selected image to confirm the choice.

Auditory feedback: immediately pronouncing the word. This technical linkage enhances "neuroplasticity," as the child's brain begins to associate the visual form with the sound frequency, often facilitating the development of verbal speech later on. (Odom, Thompson,, & Hedges, 2015, pp. 3807-3812)

3.3. Visual Design and Cognitive Processing:

The application employs a "cognitive load reduction" strategy by designing icons that conform to global AAC standards. The symbols are organized according to the modified Fitzgerald Key system, a color-coding method that classifies words into categories (verbs, nouns, and adjectives), enabling the child to intuitively and visually construct grammatical rules.

The application utilizes the "visual representation gradient," selecting images based on the child's cognitive ability: (Beukelman & Light, 2020, pp. 158-160)

Real Photos: The application allows parents to use the camera to capture pictures of real objects, addressing the child's "generalization" issue, where they do not understand that a drawing of a chair represents their wooden chair at home.

Simplified Icons: These are designed with clear, bold outlines and flat colors without gradients or shadows, as shadows may be perceived by the child as separate body parts.

Advanced applications like TAC rely on a universal color system called the Fitzgerald Key to organize symbols, assisting the child in programmatically constructing sentences mentally.

Yellow: for people (me, mom, dad).

Green: for verbs (want, eat, drink).

Blue: for adjectives (hungry, sad, cold).

Orange: for nouns/things (apple, water, toy).

This color-coding reduces visual search time and helps the child progress from selecting a single picture to constructing a complete "colored sentence." Modern TAC software also allows for gradual "icon hiding." This technique enables the therapist to hide 80% of the vocabulary

and initially show only 5 icons to avoid distracting the child, then gradually increase the number programmatically as their skills develop. This is called "technical fading" of support.

Below are some examples from the study model application:

The TAC application emphasizes Modern Standard Arabic due to the prevalence of local dialects in clinical speech and language therapy settings, as well as in informal daily communication at home, during leisure activities, and in various contexts at school and work, as illustrated in Figure 01.



Figure 01: TAC Application Interface.

Source: TAC Application

The TAC application features a main menu titled "Concepts and Skills," as depicted in Figure 02. The content is organized into four primary categories. Users can select any image from these categories, with each image accompanied by a relevant linguistic concept to aid comprehension.



Figure 02: Main menu of Concepts and Skills.

Source: TAC Application



Figure 02: The main menu of Skills learning

Source: TAC Application



Figure 02: The main menu of Single-concept learning.

Source: TAC Application

Skills are categorized into four subcategories, as illustrated in Figure 03: communication and self-care, new vocabulary, and word assembly. Each subcategory includes a corresponding set of images and audio signals. For instance, when a user selects shapes, a list of various shapes appears, and children with autism can click on each image to hear the associated audio signal. As depicted in Figure 04, this screen presents images of different shapes, allowing children to click on an image and listen to the corresponding word, thereby facilitating the development of basic communication through various gestures.



Figure 03

Source: TAC Application



Figure 04

Source: TAC Application

Children with autism can utilize this application, to construct complete sentences that include images of the desired communication elements. From a selection of images, children can choose specific pictures to form sentences such as "I change my clothes" and "I wash my hands," as illustrated in Figures 5 and 6, respectively. These sentences incorporate adjectives, verbs, prepositions, and more. Similarly, images representing body parts are provided, each corresponding to a specific body part, as shown in Figure 7. Children can click on an image to hear the associated word, facilitating their ability to initiate basic communication.



Figure 05

Source: TAC Application



Figure 06

Source: TAC Application



Figure 05

Source: TAC Application

Figure 8 displays a collection of fruit images, allowing children with autism to click on an image, listen to the word, and begin learning basic communication. The application also features images in various colors, enabling children to press an image and hear the corresponding word, as depicted in Figure 9. The animal screen contains images of different animals, where children can click on an image to listen to the word, similar to the functionality shown in Figure 10. Additionally, the transportation screen presents images of various means of transport, allowing children to click on an image and hear the word, as illustrated in Figure 11.

The use of mobile applications is an effective means of developing and enhancing linguistic concepts in children with autism.



Figure 8

Source: TAC Application

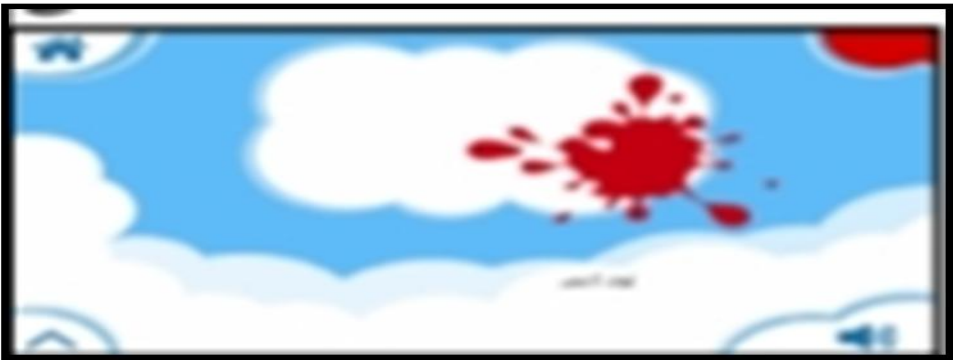


Figure 9

Source: TAC Application

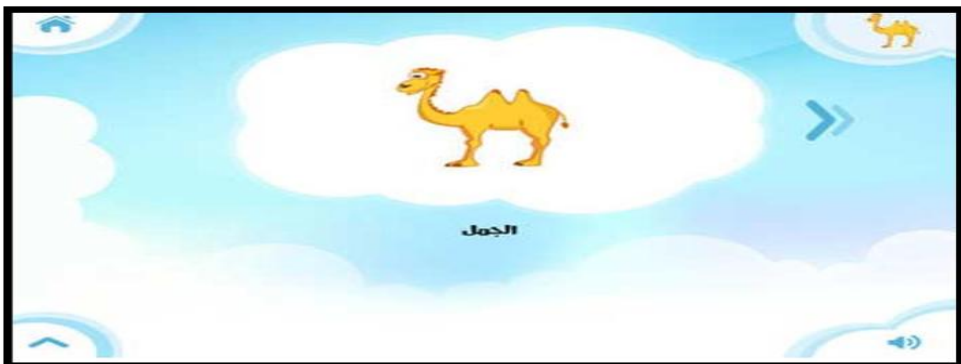


Figure 10

Source: TAC Application



Figure 11

Source: TAC Application

3.4. Critical analysis of the study model application:

3.4.1. Advantages of the application:

- ❖ **Cultural and linguistic appropriateness:** bridging the gap in specialized Arabic content by providing symbols that reflect the local environment, an aspect lacking in global translated applications. The application offers a clear voice that helps the child connect the image with the spoken word, potentially stimulating "spontaneous speech" in some children. Additionally, the symbols and images mimic the Arab environment (clothing, food, and customs), facilitating social integration.
- ❖ **Individual customization:** the ability to incorporate real-life images, which eases the process of "cognitive generalization" for children who have difficulty understanding abstract symbols.
- ❖ The application provides a highly consistent environment; it does not become boring or change its tone of voice, thereby reducing the child's anxiety.
- ❖ It overcomes the problem of losing physical cards and offers ease of portability, in addition to the feature of instant icon pronunciation, bridging the gap between the symbol and the sound.

- ❖ The application offers a safe environment for making mistakes without embarrassing social consequences, reducing the child's stress.

3.4.2. Disadvantages of the application:

- ❖ **Rigid rules:** Digital systems may struggle to automatically conjugate complex Arabic verbs, resulting in stereotyped language.
- ❖ **Lack of analytical data:** Many of these applications lack Learning Analytics systems that provide specialists with accurate statistical reports on the child's language development progress.
- ❖ **Device dependency:** There is a risk that the child may become "attached" to the tablet as a toy rather than a communication tool. If the battery runs out or the device malfunctions, the child may experience a complete breakdown due to losing their "voice."
- ❖ **Cost and accessibility:** Although the application may be available, tablets may not be affordable for all Arab families, creating a digital divide in access to therapeutic services.
- ❖ The risk lies in the "response mechanism." Programming often relies on multiple-choice or drag-and-drop, which may develop only "visual recognition" skills, while the child remains unable to produce spontaneous language without the device. Additionally, excessive digital reinforcement (sounds and colors) may become a "distraction" rather than a motivator.
- ❖ **Neglecting physical social interaction:** in the traditional system, the child must approach another person and hand over the picture (social communication), whereas in applications, communication may become "closed off" between the child and the screen, potentially reinforcing isolation rather than alleviating it.
- ❖ This approach faces the dilemma of "generalization." The child may master imitating the word within the application but fail to use it when interacting with a real person because the digital environment lacks the "dynamic context" of daily life.

- ❖ Programming is often "linear" or limited in pathways, while human communication is "random and unpredictable." The criticism is that the child may memorize the "correct answer" within the application without understanding the underlying "social meaning."

4. CONCLUSION:

The implementation of educational applications to improve linguistic concepts is crucial for facilitating communication and social interaction among children with autism. These mobile applications can augment traditional communication methods by leveraging technology to create dynamic, interactive, and personalized learning experiences. They offer opportunities for practice, feedback, and interaction within a controlled and engaging environment, leading to significant advancements in linguistic concepts and communication skills. Additionally, these applications can aid in the development of social skills by simulating social scenarios and teaching vocabulary, both of which are essential for children with autism.

The TAC application is a pioneering technological tool in the Arab educational field. To maximize its effectiveness and elevate it from a "communication tool" to a "comprehensive integration tool," the study recommends integrating the application within an Individualized Education Plan (IEP) under the supervision of a speech and language specialist. It is also recommended to incorporate predictive artificial intelligence technologies in the future, which suggest symbols based on geographic location or temporal context to reduce the effort the child expends searching for vocabulary (for example, when in the kitchen, food icons appear at the forefront). Additionally, adaptive artificial intelligence could be used, requiring the child to interact with the external environment (such as the application asking the child to take a picture of a real object at home before moving to the next stage). Supporting local dialects is crucial: Modern Standard Arabic is essential, but the child needs to interact in their family's dialect (colloquial) to feel a sense of belonging; therefore, there should be an option to manually record the voice for each card.

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