Aawn: An Interactive Mobile Application for Improving the Communication Skills of Arab Children with Autism

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Abstract – **Autism spectrum disorder (ASD) is a neurodevelopmental disorder that causes challenges in communication and social interaction. Since there is no single treatment for autism, autistic children need extra attention from their parents or caregivers to overcome their linguistic deficiency. Scientific studies have shown that technology-based educational methods are effective and can lead to a significant improvement, especially for autistic children. In recent years, an increasing number of mobile and multimedia applications have been developed to enhance autistic children's verbal communication, emotions, social behavior, and interaction skills. However, many of these systems are either in English or in local autistic children's native languages. Others are designed to promote specific knowledge, i.e., emotions, or are limited in their features. This paper designs and implements a prototype for Arabic mobile application, called Aawn, to help and improve Arab autistic children's, in their own language, communication and emotions, as well as educational and organizational skills. Aawn is integrated with various supporting technologies based on the Picture Exchange Communication System (PECS) and augmented with graphical features. The system is built and developed using Android Studio and various cloud-based tools. The system can be extended by artificial intelligence (AI) technologies.**

1. Introduction

Autism spectrum disorder (ADS) is a brain-development disorder that affects how a person perceives and interacts with others on a social level, causing problems in social interaction and communication [1]. Autistic children usually have a linguistic deficiency in terms of speech and conversations or reading and writing, which requires extra attention and focus compared to normal children of their age. Parents and caregivers face difficulties in interpreting autistic children's needs, feelings, and emotions, and in adjusting and organizing their daily routine and activities [2].

Unfortunately, autism is a chronic disorder that does not respond to a single treatment or prescription but requires parents' and caregivers' attention in handling autistic children. According to the American Academy of Pediatrics, 25% of children go through a normal developmental period until 18 months of age. After that, the symptoms of autism gradually appear, such as loose speech ability, sudden withdrawal from society, and failure to respond to orders [3]. ADS has become the fastest growing neurological condition, making it one of the most common neurological disorders among children in the world. Thus, it is important to give special attention to the teaching and learning process of this group of children [4].

There are many helpful traditional methods and techniques for autistic children, such as the picture exchange system (PECS) and applied behavior analysis (ABA). Based on the results of many studies, using PECS in teaching improves children's communication, speech, and social behavior [5]. Other traditional methods are also used by autism centers around the world, such as picture-word flash cards, emotions cards, puzzles, action games, and calming and sensory activities.

According to an interview conducted by our team in 2021 with autism specialists from the "First Autism Center", located in Jeddah, Saudi Arabia, which included a total of 131 autistic children from 3-16 years old, 93 males and 38 females, these methods are very effective in developing autistic children's vocabulary and improving their emotions, speech, and pronouncing skills.

Many parents register their autistic children with educational and rehabilitation centers. According to a study conducted in 2017, most of these centers are costly for autistic children's families. The preliminary results showed that the average annual total cost of autistic childcare reaches 102 thousand Saudi riyals [6]. According to our interviews with 14 parents of autistic children, those parents face difficulties in teaching their children basic skills in reading, writing or social communication. They also face financial difficulties for the lifetime costs of an autistic child, including the treatments and educational expenses.

In Arab countries, there is also a lack of resources and autism centers that can help in developing important children's skills. In addition, existing centers have high registration and education fees and need almost a daily follow-up from the children's families. All these challenges put a heavy social and economic burden on autistic children's families. On the other hand, autism centers usually accept a small group of children in every classroom for greater and better focusing on developing their skills.

Scientific studies have shown that using technology, such as mobile applications and multimedia, can help autistic children enhance their learning abilities, communication, emotions, social skills, and even organizational skills [3]. However, existing systems are either developed in English or in the native languages of local autistic children. These systems are also designed to enhance a specific skill, i.e., emotions, or are limited in their features.

This paper presents a prototype for a mobile application, named Aawn, that supports Arab autistic children, their families, and caregivers in facing daily challenges and difficulties and organizing daily routines. The application is augmented with integrated features and an interactive user interface to improve Arab autistic children's communication and social skills using their native language. The prototype is based on the Picture Exchange Communication System (PECS), which allows people with communication challenges to communicate using pictures [5]. Aawn includes the following main features:

- A collection of albums with different categories, such as shapes, animals, etc., in which the child can touch the picture to listen to the word.
- Daily regular activities in which parents can set their child's daily routine using visual schedules.
- Emotions, in which a child can learn different emotions using pictures, and their pronunciations.
- Meals collection, where the child can select from a variety of foods to include in each meal.
- Sentence structure, which helps the child make complete sentences using the pictures.

The rest of this paper is organized as follows: Section 2 discusses the related work; Section 3 proposes the system analysis and design; Section 4 illustrates the system implementation and testing using a high-fidelity prototype; and Section 5 presents the system evaluation. Finally, Section 6 provides a conclusion of the paper as well as recommendations for future research.

2. Related Work

There are many recent research studies and mobile applications that address autistic children's learning difficulties. For example, in [2], the author presented Krisha, an Android mobile application in the English language that aims to help autistic children to be more engaging with the outside world. Krisha is user-friendly and easy to use, has many activities so that autistic children can enjoy learning, and has an interactive interface that keeps them motivated and busy. The application has four main functionalities. First, emotions that help children learn about happiness, afraid, shocking, angry, and sadness. Second, emotions games can be used to answer different levels (i.e., easy, medium, and hard) of questions on emotions. Third, the daily routine is used to set the daily activity schedule with an alarm for each activity. Finally, a progress report for a child's daily routine activities is displayed every 21 days.

Furthermore, Alharbi and Huang [3] presented Ying, an Android mobile application that supports the English language and includes facial and emotion recognition. Ying integrates various computer-assisted technologies to improve the social behavior and verbal communication skills of autistic children. The application mostly depends on Microsoft Emotion API and has four main functionalities: First, "How I Feel" where a child can take a picture of himself or any family member then the application will determine their emotions.

Second, the "matching emotions game" helps to improve the child's ability to distinguish between different emotions by choosing a photo from a phone gallery that looks like the displayed emotion. Third, "Show Me Faces game," which asks the child to take a picture of each emotion verbally. Last, the "Exception Identification" game is used to test the child on eight essential emotions by displaying five photos, where four are similar and one is different, and the child must select the different one.

Yusria et al. [7] developed a "Bina Wicare" application, which is a word game used for speech therapy for autistic children in Indonesia. Bina Wicare can be used individually at home or within the classroom to help children with special needs communicate and learn multiple words. BIUTIS [8] is an Android mobile application developed for Indonesian autistic children as well. The application is based on cartoon character pictures and audios of various categories for vocabulary learning and improvement.

In addition, LetMeTalk [9] is an Android talker application that supports more than five languages including Arabic. It has a voice technique to help the child communicate with others by selecting appropriate photos according to his or her needs. The child can either use photos from the application's categories or add new photos to the different categories.

Otsimo [10] for special education is a highly acclaimed mobile application offered for multiple platforms that is specifically designed in a gamified context for the education of children with special needs. The app's primary goal is to provide a special education that is both accessible and affordable to help children reach their developmental milestones.

Opposites [11] is a mobile application for autistic children that focus on their vocabulary building skills using real-life photographs. In addition, Opposites introduces the learners with the concept of opposites and allows them to label different opposites on the same screen.

Kraleva [12] presented a picture-based application, ChilDiBu, which combines images, text and audio files that can be used to teach Bulgarian autistic children the alphabet, numbers up to 20, some basic colors, and everyday activities. Furthermore, Wan Ahmad et al. [13] developed Suara Saya, a mobile application for improving the learning and communication skills of autistic children and those with communication and speech language problems in Malaysia. The application has many functionalities, including allowing children and caregivers to add new words by uploading custom photos and sound for these words.

Table 1 shows the comparative analysis of different applications presented in the literature.

As seen from the table, there is a lack of Arabic mobile applications that include all important functions for learning and communication of Arab autistic children, such as daily routine activities, emotions learning, meals schedule, and words learning based on pictures. This work focuses on developing Aawn, a prototype for a mobile application that alleviates the missing functionalities and features of previous studies.

3. System Analysis and Design

The analysis of the proposed system is based on the comparative analysis shown in Table 1 and the conducted interviews with the caregivers and specialties of the First Autism Center in Jeddah to identify the main system features that are required to facilitate parents/caregivers' lives by improving basic communication and behavior skills for the Arab autistic children and to define the main functional and nonfunctional requirements that should meet the end user needs.

Figure 1 shows the system architecture diagram for Aawn, which provides an overall view of the software system. The main functional requirements for the end user, an autistic child, and parents/caregivers are summarized as follows:
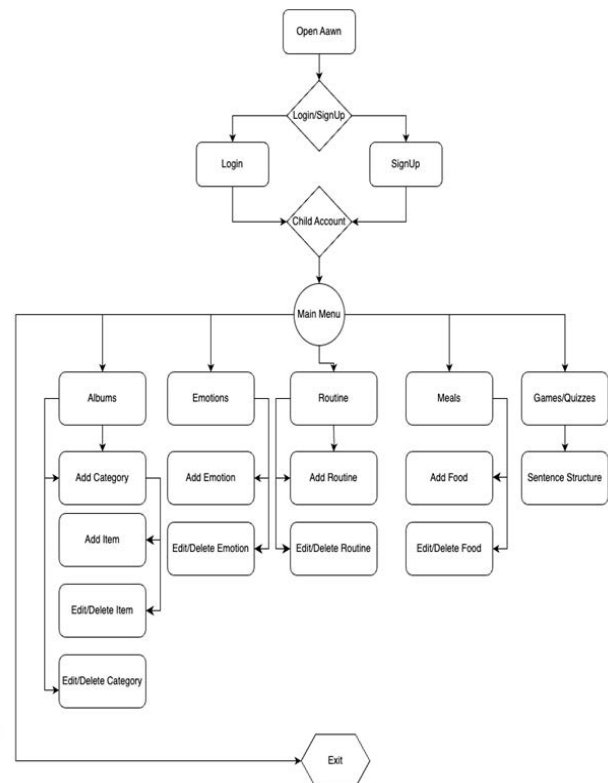

Figure 1. Aawn System Architecture Diagram

Table 1. A competitor analysis of different autistic mobile applications

Comparison Criteria	Available in Arabic	Features				Users Age	Mobile Device Type	Cost
Autism Mobile Application		Daily routine activity	Emotion's ex-pressions	Meals	Words learning based PECS			Free to use
Krisha [2]	X	√	√	X	X	Not available	Android	Not available
Ying [3]	X	X	√	X	X	2-6 years	Android	Not available
Bina Wicare [7]	X	X	X	Not available	√	Not available	Not available	Not available
BIUTIS [8]	X	√	X	X	√	Not available	Android	Not available
LetMeTalk [9]	√	X	X	X	√	12+	iPhone/Android	√
Otismo [10]	X	X	X	X	√	4+	iPhone/Android	X
Opposites [11]	X	X	√	X	√	4+	iPhone	√
ChilDiBu [12]	X	√	X	X	√	Not available	Android	√
Suara Saya [13]	X	X	X	X	√	Not available	Android	Not available
Aawn (Ours)	√	√	√	√	√	3-12	Android	√

After signing up and logging in to the system, the child has the following options, and each option is picture-based to fulfill PECS:

- Album - provides a collection of pictures within different categories, such as colors, shapes, animals, etc. The child can add a new category by specifying its label and pictures, editing, or deleting existing added categories. The child can further add a new item to the new category with its label, picture, and recorded voice.
- Emotions contain many built-in emotions, such as happiness and sadness. The child can add a new emotion, edit, or delete any added emotion.
- Routine - includes many built-in daily activities such as changing clothes, making up the bed, etc. The child can add a new routine (i.e., morning routine) and add, edit and delete an activity within the routine.
- Meals - include multiple built-in meals, and the child can add, edit, or delete the added meal.
- Games and Quizzes - include, up to writing this paper, only sentence structure games that allow drag and drop words and pictures to complete a sentence.
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Four nonfunctional requirements were considered in Aawn development: 1) Usability - as the system targets autistic children, therefore, it should be easy to understand and use; 2) Availability - since the system will help autistic children in facing their daily life difficulties, it should be available 24/7; 3) Security -the system should keep all user information protected using certain encryption techniques; and 4) Performance - the system should be fast in responding to any user action.

4. Implementation and Testing

As Aawn is an Android application compatible with all smartphones running the Android operating system, no other specific hardware specifications are needed. The main graphic user interface (GUI) for the Aawn high-fidelity prototype is designed with the theme color light blue.

This color was selected based on the results of an interview conducted earlier with the autism specialist at the "First Autism Center" in Jeddah, in which this color is considered highly preferred for most autistic children.

For Aawn implementation, Android Studio is used as an official integrated development environment (IDE). The Java programming language is used for coding, and Xml is used for the interfaces. For the back-end server, MySQL/phpMyAdmin is used to create and access the database, and the XAMPP

webserver is used to support the PHP programming language. The full code of the system is available at GitHub [14]

Aawn is tested using the virtual mobile device emulator provided by the Android Studio. The emulator is used to test the software code and user interface (UI).

The overall testing was successful, which means that the UI design and interaction function perfectly as expected. In the following subsections, the main six scenarios of Aawn application are described as follows.

a. Sign Up/Login Page

Figure 2 shows the main screen, sign up, login, and main menu pages. From the main screen (Figure 2 (a)), the user can login to his or her account using the "حساب الطفل -Child Account" button. The user is then transferred to the login page (Figure 2 (b)), where he or she can enter his or her credentials (email, password). On the login page (Figure 2.b), API functions are used to verify user input, check the user's existence and fetch user information from the database. The login credentials, email, and password must be the same as those entered in the registration step. If the user forgets the password, he or she can click on the "هل نسيت كلمة المرور؟- Forgot password" link to return his or her credentials. If the credentials are accepted and the user logs in successfully, the main menu page (Figure 2 (d)) will be displayed to the user. The main menu page includes five categories, "مشاعري-Emotions", "البوم-Albums", "طعامي- Meals", "العاب وأنشطة-Games and Activities", and "روتيني -Routine".

(a)   *(b)*

(c)   *(d)*

Figure 2. Main screen (a) leads to the login/sign up pages (b, c). When the child logs in successfully, the main menu page will display (d).

If the child's account does not exist, he or she can sign up using the "إنشاء حساب-Create account" link at the bottom of the login page. On the sign-up page (Figure. 2 (c)), the user must enter his or her credentials ("الاسم -name", "البريد الألكتروني- email", "كلمه password", "إعادة كلمة المرور-confirm password", and "العمر-age") and click the "تسجيل الدخول -sign up" button. The application will validate the inputs and store them in the database.

The user must fill all fields, and the password must be more than 6 digits.

The user must check and read "أوافق على الشروط والأحكام- I agree with rules and regulations" to complete and submit his or her registration and then transfer to the login page for using the application.

b. Emotion Page

This page (Figure 3) provides a collection of pictures that express six main emotions, "حزين- sad", "سعيد- happy", "غاضب- angry", "خائف - scared", "متفاجئ- surprised", and "محرج-embarrassed". The user can click on each emotion, display the picture, and click on the volume icon to play the sound of pronunciation.

The emotion page helps the child with these essential emotions and learn how to pronounce each of them. The child can add new emotions with its label, image, and recording. The child can edit or delete these newly added emotions.
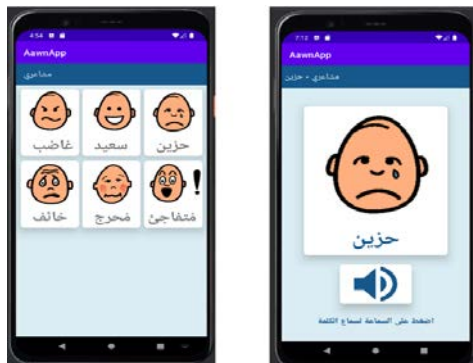

Figure 3. "Emotions" page (left) allows the child to select any emotion and go to the page of the emotion, e.g., حزين - sad (right), to hear its pronunciation.
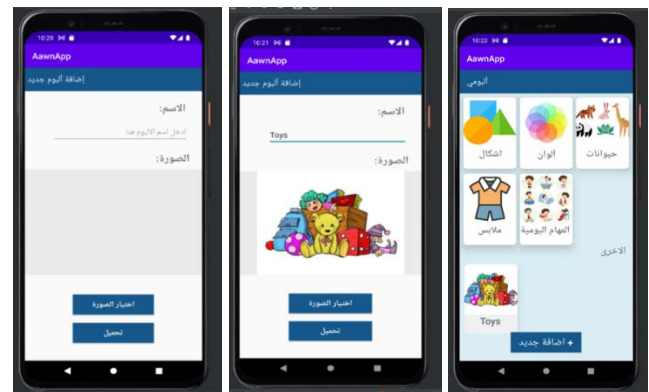
c. Album Page

This page (Figure 4 (a)) contains different main built-in albums, which are "حيوانات-Animals", "ألوان-Colors", "أشكال>-Shapes", "ملابس>- Clothes", and "المهام اليومية>- Daily tasks". The user can click on any album, e.g., ألوان-Colors (Figure 4 (b)), and then display the items included in that album, click on any item, e.g., "أحمر- red", to display the picture, and click on the volume icon to play the sound of pronunciation (Figure 4 (c)). The user can add a new album and add items to this album by clicking on ("+ إضافة جديد- add new +") filling all the fields, its label, uploading a picture, and recording a voice for that item. The new album and its items will be saved to the database and connected with the user account such that they will be displayed each time the child logs in to the application. Figures 4 (d-i) show adding a new category "ألعاب - toys" and adding a new item "سيارة-car" to that category.

d. Meal Page

This page (Figure 5 (left)) shows the five main meals of the day, "وجبات الإفطار- Breakfast", " وجبات خفيفة ١-snack 1", "وجبات العشاء- dinner", "الغداء -lunch", and "وجبة خفيفة ٢ -snack 2". By clicking on each meal, the user can display different foods included in the meal (Figure 5 (right)). For example, if the user clicks on "وجبات العشاء- dinner", a page with different food in that meal will be displayed, "لبن-Yogurt", "بيض-Eggs", "خضار- Vegetables", etc. These food pictures help the child to select and inform his or her preferences for the meal. In addition, the child can add food by clicking on the ("+جديد إضافة- Add new +") button, filling all the fields, and uploading a picture.
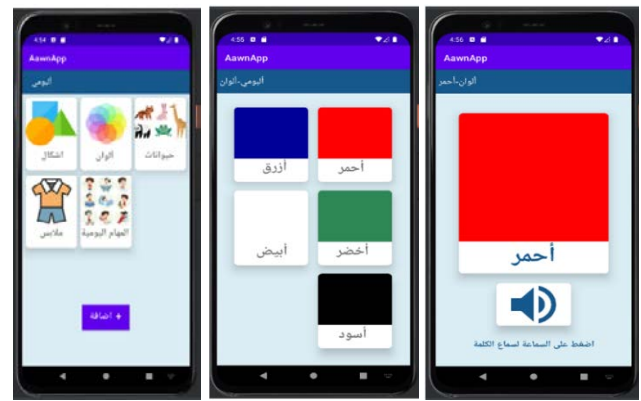
(a)   *(b)*   *(c)*

(d)   *(e)*   *(f)*
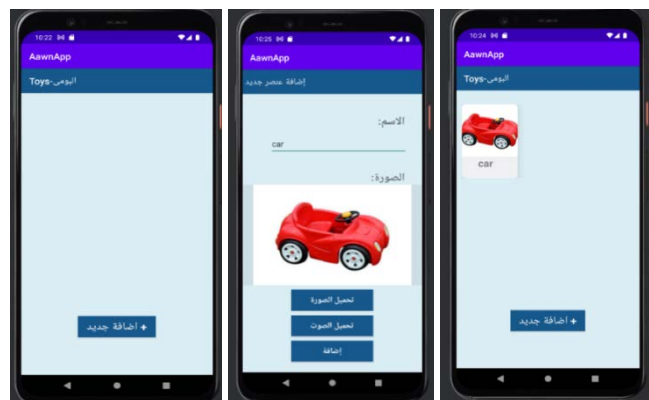
(g)   *(h)*   *(i)*

Figure 4. The "ألبومي - Album" page (a) leads to different pages of existing categories, e.g., "ألوان – colors" (b), where the child can select any color, e.g., "أحمر – red", and listen to the pronunciation of "red" (c). The " إضافة جديد - Adding a new category" page (d) allows users to insert labels and images for the category, e.g., Toys, and the new category is listed under the built-in categories (e, f). The "Add new item" page (g) allows the addition of an item, e.g., Car, and the new item will be listed under the newly added category "Toys" (h, i).

e. Routine Page

This page (Figure 6) contains different main daily routines, such as "تغيير الملابس -Changing Clothes", "حل الواجبات -Brushing teeth", "تفريش الأسنان -Doing Homework", and "ترتيب الفراش -Making up the bed".

The child can click on any of the routines, display the picture and click on the volume icon to play the sound of pronunciation. The child can add a new routine by clicking on ("إضافة جديد + -Add new +"). Additionally, the child can edit/delete this routine.

Figure 5. The "طعامي -Meals" page (left) contains the three main daily meals and two snacks, where the child can click on a specific meal, e.g.," العشاء -dinner", and display and click the food options under that meal (right). The child/parent can add a new food to any meal and edit/delete the newly added food.

Figure 6. The "Routine" page contains different daily routines such as brushing teeth, etc. The child can open a routine, listen to its pronunciation, add a new routine, and edit/delete an added routine.

f. Sentence Structure Game

This page (Figure 7) provides a sentence structure game to improve a child's language. The child can play the game and obtain the result at the end of the game, which will appear on the screen. The idea of this game is to give the child different words. The child should make a complete sentence of these words using drag and drop (Figure 7 (a)) and then click the "تحقق -Verify" button.

If the user arranged the words incorrectly, he or she will get "حاول مرة أخرى -Try again" page (Figure 7 (b)). Otherwise, he or she will get the "أحسنت - Well done" page (Figure 7 (c)), which allows the user to try a new sentence structure game by clicking on the "انتقل للتالي -Next Game" button.

| (a) | (b) | (c) |

Figure 7. The "ترتيب الكلمات - Sentence structure game" page (a), where the child can arrange a few random words to make a complete sentence. If the sentence structure is incorrect, the "حاول مرة أخرى -try again" page will be displayed. Otherwise, the "أحسنت -excellent" page (b) is displayed, and the child can go to the next sentence structure game.

5. System Evaluation

To measure the effectiveness of the Aawn application and to see the importance of the functionalities, services, and features that the application provides, we distributed questionnaires among caregivers of the First Autism Center in Jeddah and autistic children's parents.

We obtained a total of 19 responses, 14 from the parents and five from the caregivers. In the questionnaires, we asked the parents and caregivers about their opinion on the features of the Aawn application with options from 1-5, where 1 means "strongly disagree" and 5 means "strongly agree". The overall results of a total of 19 responses are shown in Figure 8. From the questionnaire results analysis it can be seen that on average 71.9% of the responses strongly agreed with overall Aawn mobile application features and activities. Even though we have noticed that 80% of the caregivers and 21.4% of the parents are already using different general applications, Arabic and English, in teaching autistic children, most of them (100% of the caregivers and 72.7% of the parents) preferred using specified Arabic applications for autistic children. We conclude that an integrated mobile application that supports Arab autistic children is important to facilitate both children and parents/caregivers' lives by improving basic communication and behavior skills for children.

6. Conclusion

Autism is a chronic disorder that is difficult to treat. Autistic children need continuous attention by parents and caregivers.

However, most parents of autistic children face difficulties in teaching their children basic skills. In Arab countries, there is a lack of resources and autism centers that can help educate these children and develop their learning and communication skills.
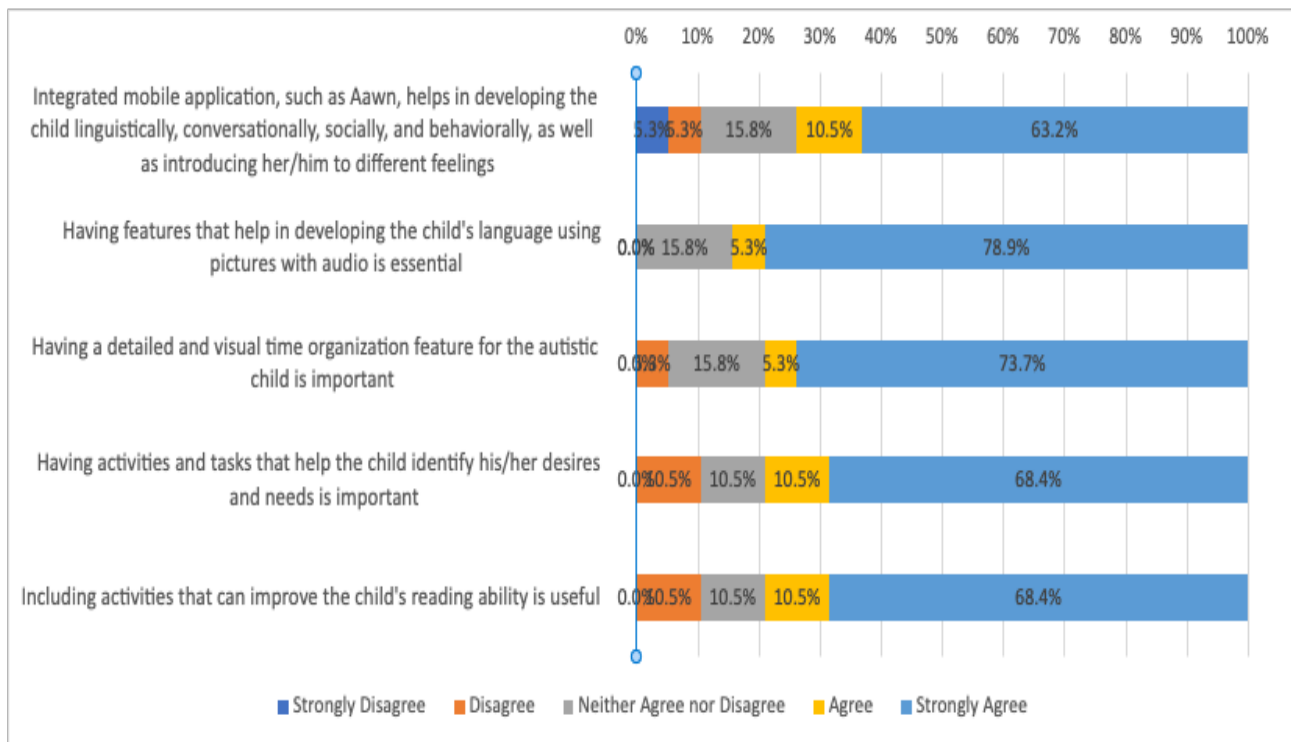

Figure 8. Aawn System Evaluation

To overcome this issue, we presented an Android mobile application prototype, Aawn, for improving Arab autistic children's communication and emotions, as well as educational and organizational skills.

The prototype of Aawn has been implemented with many augmented features and an intuitive and easy-to-use user interface. To identify the importance of Aawn and its main functions, we conducted a survey with autistic children's parents and caregivers from the First Autism Center in Jeddah and found that an average of 71.9% strongly agree with the importance of such application in developing the child's learning, communication, and daily routines.

There are still many future directions for improving Aawn by adding more features. Examples of such features are artificial intelligence (AI)-based games, such as using emotion recognition to test the child's ability to recognize different facial emotions, pronouncing and speech recognition to recognize words correctly, progress reports for children to be available to parents, adding user custom routine features, and adding fuzzy child detection functions. It is also important to evaluate the user's experience using the Aawn application and making improvements based on their comments.

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