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A-Speak: Augmentative and alternative communication application for Thai individuals with complex communication needs

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ABSTRACT

Background: Augmentative and alternative communication (AAC) is the approach that enhances communication competence in individuals with complex communication needs. With the advancement of technology, there are varieties of AAC applications with colored-graphic symbols and speech output, improving communication's intelligibility compared to low-tech AAC systems. However, those AAC applications had some features that were not entirely suitable for Thai users, such as symbol appearance, speech intonation, etc.

Objective: This study aimed to develop the first version of the Thai AAC application, A-Speak, based on Thai culture, lexicon, and intonation and remove other constraints that other AAC applications had, such as variation in voice-output age and gender. The proficiency of A-Speak regarding communication functions was also examined.

Materials and methods: The participants comprised 15 individuals with cerebral palsy and complex communication needs. The participants were trained to use the A-Speak application, installed on a tablet, to communicate. The training procedures consisted of 3 phases: Phase 1: Train to select icons; Phase 2: Shift to different categories; and Phase 3: Use A-Speak to communicate. The researchers trained the participants to achieve adequate operational skills (i.e., Phases 1 and 2) before beginning Phase 3. In Phases 1 and 2, switches were employed to facilitate participants with limited mobility to operate A-Speak by finger. The researchers also taught the participants' caregivers to continue training them at home. The researchers collected the participants' communication abilities regarding communication functions in the recorded form. The data was reported into code numbers according to communication proficiency.

Results: After receiving A-Speak training, all participants showed improvement in their communication abilities across a variety of communication functions. Participants showed significant progress in 10 out of 12 communication functions. The communication function in which participants exhibited the most improvement was explaining skills, whereas the communication function that showed the least development was storytelling skills.

Conclusion: A-Speak AAC application reduced the constraints that possibly influenced communication intelligibility in the Thai language. Nevertheless, A-Speak still had a few drawbacks that required to be corrected to increase the productivity of this program. The findings indicated that participants gained communication skills through A-Speak as a means of communication.

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Introduction

A communication disorder is an impairment that affects individuals' speech and/or language comprehension and expression abilities.[1] Without adequate communication skills, individuals cannot clearly understand others' speech, respond appropriately in social situations, and/or adequately express their thoughts and feelings.[2] Moreover, communication skill deficits affect their living and social skills, preventing them from succeeding.[3,4] Nevertheless, the degree of these difficulties depends on the severity level of communication impairments. Individuals with profound communication impairments may have limited use and comprehension of speech due to concomitant impairments in intellectual, sensory, motor, and other areas, also known as complex communication needs. The severity might vary from being completely unable to speak to being able to speak with limited intelligibility. These might be the result of congenital disabilities (e.g., cerebral palsy, apraxia of speech, intellectual disabilities, etc.), acquired disabilities (e.g., acquired brain injuries, cerebrovascular accidents, laryngectomy, etc.), or neurological differences (e.g., autism, etc.).[1] There are several approaches to help individuals improve their communication skills, including augmentative and alternative communication (AAC).

The primary purpose of the AAC system is to help individuals with communication disorders promote their communicative competence and develop their language skills, including literacy skills.[5-7] No research currently exists that reports AAC systems impede speech development; instead, multiple studies cite that these systems may even promote speech development.[8-10] Furthermore, several studies reported that AAC reduces challenge behaviors due to the limitation of verbal communication[6, 11,12] AAC are classified into two main systems: (1) Unaided systems that communicate primarily through physical movement and do not require additional tools (e.g., manual signs, face expression, gestures, etc.); and (2) Aided systems that communicate through additional tools. Aided systems include low-tech (e.g., writing, communication boards, letter board, etc.) and high-tech systems (e.g., speech-generating devices (SGDs), iPad-based speech output technologies, Android-based speech output technologies, etc.).[1,13,14] High-tech systems offer features such as adjustable vocabulary, dynamic storage, and voice output which enhance the individuals' communication intelligibility.[15]

Many studies reported that AAC systems with speech-output technologies could improve the communication skills of people with communication difficulties.[16-19] Wansiya and Goldstein reported that most Thai speech-language pathologists in the study preferred administering speech-output technologies to individuals with severe speech impairment or complex communication needs.[20] However, the available applications, such as SymboTalk, Leeloo, Funjai, and Cboard, do not entirely support the Thai language. Thai voice output in those applications presented inaccurately pronounced intonation, which would result in unclear messages. Besides, the voice synthesis offering for the application was limited to adult-female voices, which might not be suitable for male and young users. Wickenden indicated that speech-output options (e.g., age, gender appropriate, accent, etc.) play a role in individuals' identity related to selfhood and the personhood of AAC users.[21] Pullin and Hennig also demonstrated that voice should be age- and gender-appropriate to the user to reduce confusion among communication partners due to the voice's mismatch in terms of age and gender.[22]

Therefore, this study aimed to develop an AAC application specifically for Thai individuals with complex and limited verbal communication needs. A-Speak or All-Speak has been designed as an Android-based speech output technology compatible with external input devices such as switches, keyboards, eye-tracking, speakers, etc. Therefore, A-Speak would facilitate communication competence for individuals with multiple disabilities, especially those who have a limited range of physical movement.

Materials and methods

Research design

This study employed quantitative descriptive research. The intervention consisted of three main phases. The first two phases involved operational skill training (e.g., selecting symbols and changing pages). The third phase focused on teaching communication skills through the A-Speak application. In the third phase, data collection regarding the changes in communication abilities was conducted three times on separate days. The data were gathered in recorded form.

Materials

Recorded form

The recorded form contained 2 main parts. The first part involved participants' demographic information**,** including gender, age, education level, and diagnosis. The second part involved participants' communication abilities using A-Speak application according to 12 different communication intentions. The data in the second part was collected in three separate days. The data was collected in the form of code (i.e., 0 = No communication; 1 = One occasion; 2 = More than one occasion; and 3 = Communication on all occasions) and written in the recorded form developed explicitly for this study. Three speech-language pathologists who were not involved in this study were assigned to check the content validity of the recorded form. They were asked to rate the importance of each communication function that was required to be evaluated to determine whether the A-Speak application fulfilled general communication needs for the participants (i.e., -1 = completely irrelevant; 0 = fair; and 1 = very relevant). Only 12 out of 15 communication functions that the three speech-language pathologists had a consensus that the study should consider. The recorded form is depicted in Appendix A.

A-Speak AAC application

The Thai National Electronics and Computer Technology Center (NECTEC) collaborated with researchers who were speech-language pathologists, disability specialists, and AAC professionals to create the AAC application, A-Speak. The application is currently available on the Android mobile operating system. A-Speak had two main modes: (a) Graphic-symbol board and (b) keyboard.

Graphic-symbol board

This system displayed colored-graphic symbols with text identifying the meaning of the symbols in the form of grid displays. Those symbol icons were arranged in the form of a board in both schematic and taxonomic grid displays, as shown in Figure 1. The number of grids per page could be adjusted to 3x5, 5x7, 6x9, or 7x11, as shown in Figure 2. The screen display was divided into three main parts: (a) main symbolic icons (i.e., taxonomic grid displays), (b) vocabulary categories (semantic-syntactic grid displays), and (c) visual message feedback bar.

The new user might feel overwhelmed by initially learning to use A-Speak. To reduce this problem, A-Speak is programmed with the “vocabulary mask” feature. This feature allows speech-language pathologists to fade out the symbol icons, which the user does not presently require, from the main board.

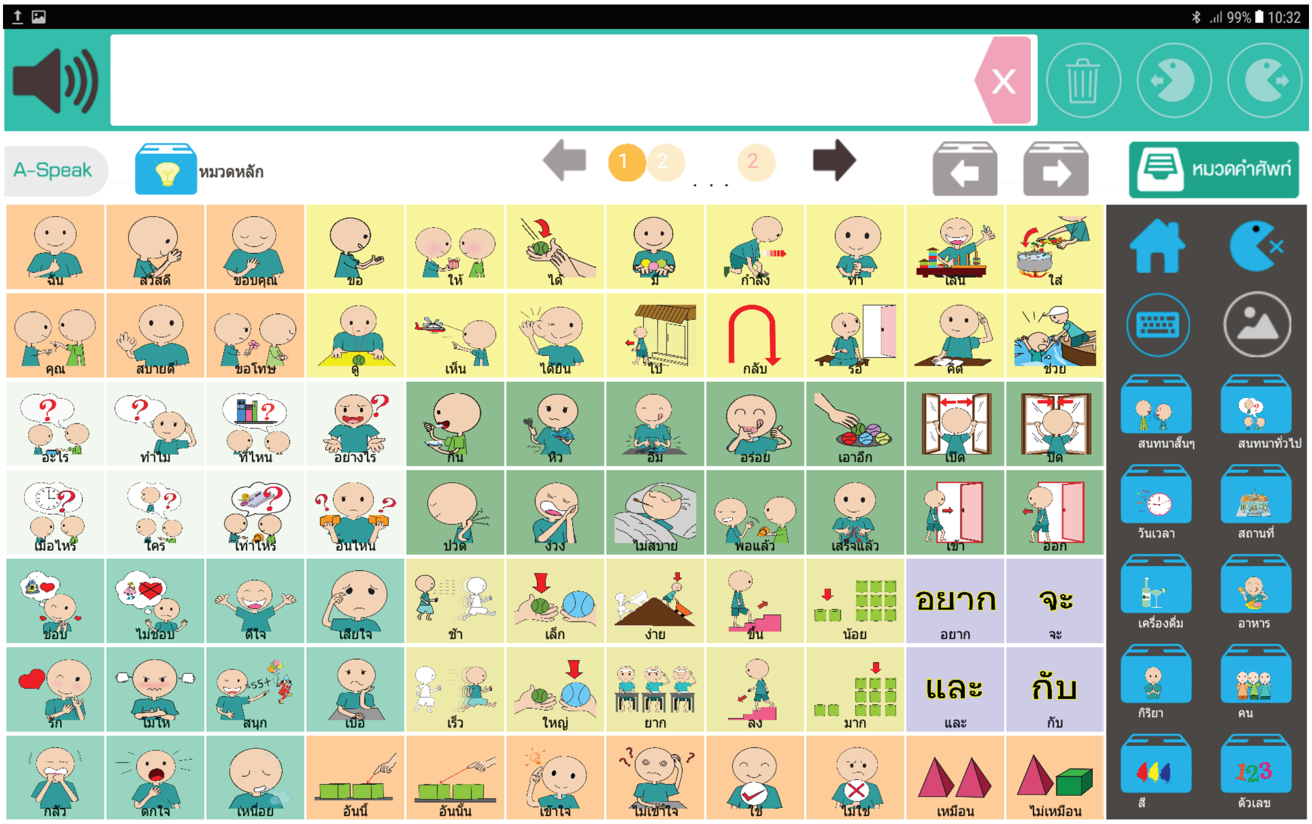

Figure 1. *The taxonomic grid displays.*

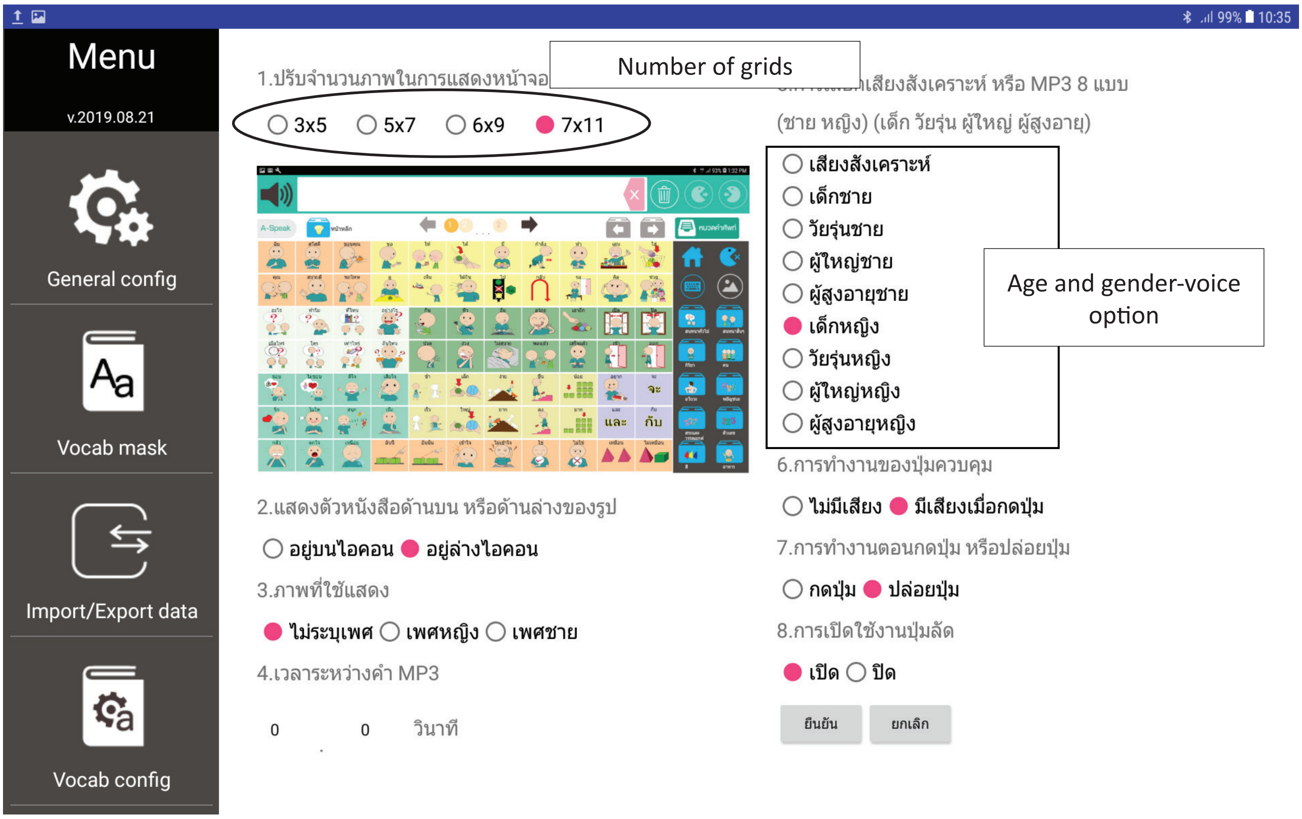

Figure 2. *The setting of grid display and voice output.*

There were more than 1,422 symbolic icons and 23 categories provided in A-Speak. Those symbol icons served as the vocabulary for basic communication functions (e.g., calling attention, protesting, requesting objects, etc.).[23]

The vocabulary was adapted from the Thai for Beginners book and Thai culture.[24] The vocabulary words and phrases in this book are arranged according to several communication functions (e.g., asking, answering, introducing oneself, etc.) in many circumstances that fulfill young individuals' and adults' basic communication needs. Therefore, this book's vocabulary words and phrases were selected to serve as the foundational concepts in A-Speak. According to the guidelines, the main page was recommended to consist of core vocabulary (i.e., words adaptable to a range of settings and can be utilized for several communication purposes) and fringe vocabulary (i.e., words unique to specific situations and settings).[25,26] 77 symbol icons were displayed on the main page. These icons comprised nouns, pronouns, verbs, adverbs, adjectives, questions, and expressions. The icons associated with the same categories had the same background color and were positioned adjacent to one another; for instance, WH-question terms (i.e., what, where, who, when, why, how much) were arranged together with the same background color (i.e., light green). The number of icons depended on the display grid size, which was evaluated and determined by speech-language pathologists.

Female prisoners drew all symbol icons in A-Speak from the Information Technology Foundation under the Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn. Every icon has a written text that represents its meaning attached. The written text could be set to appear either above or below the icon. Furthermore, the text and icons' background color were adjustable to support the users with vision impairments (e.g., low visual acuities, narrow visual field, etc.).

According to Beukelman and Fager, visual attention was influenced by user relevance to the age and gender of the graphic symbols.[27] Therefore, A-Speak provided graphics symbols representing both male and female characters. The user can choose the gender of the symbol to symbolize his or her gender, as shown in Figure 2. The users were also able to add new categories and pictures.

Keyboard mode

There were two alphabets: Thai and English. The Thai and English keyboards were arranged in a QWERTY platform, as shown in Figure 3. This mode also offered the writing mode, which the user might prefer.

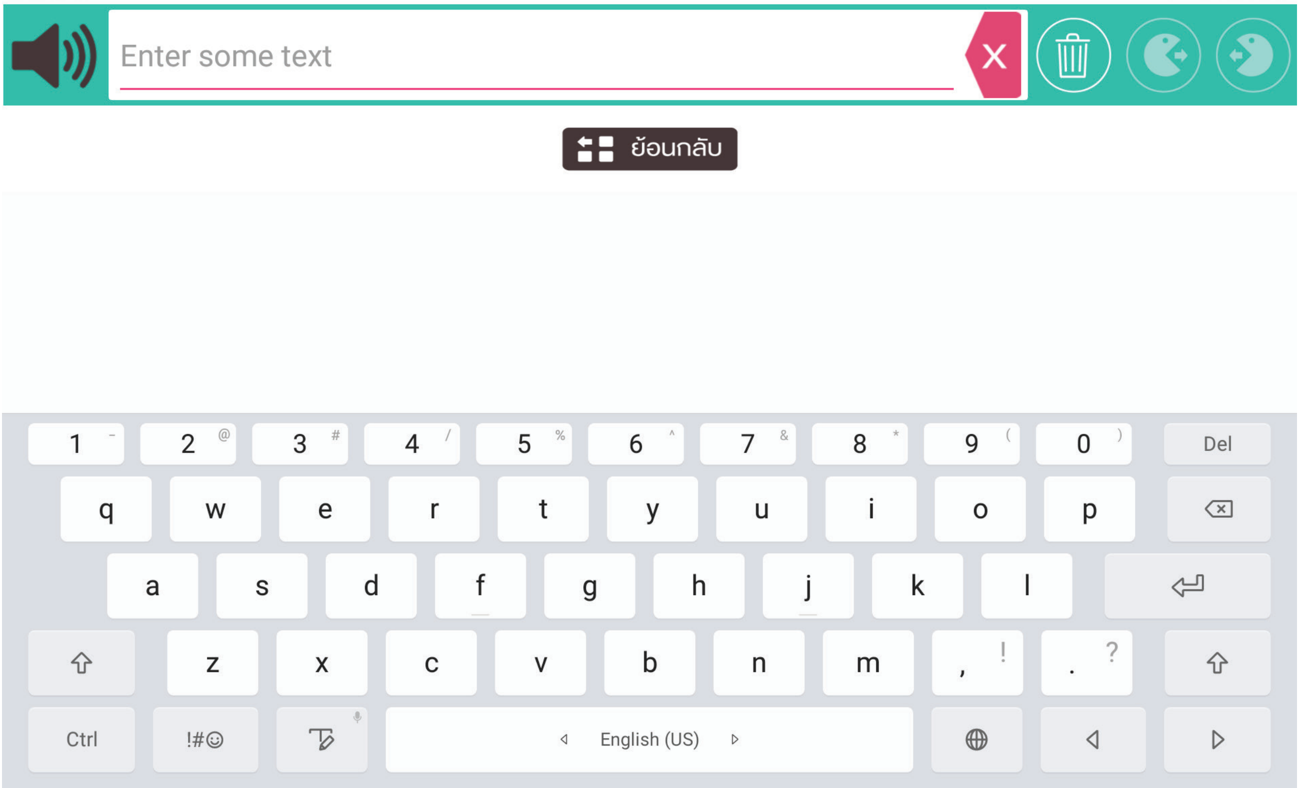

Figure 3. *Keyboard mode*

Feedback

Activation feedback

In graphic-symbol board mode, the click sound would be produced as auditory activation feedback since the icon was selected. Likewise, the click sound would be created in keyboard mode when the letter was tapped. This auditory activation feedback could be muted as needed.

Message feedback

Two types of message feedback were included in A-Speak (i.e., visual message feedback and auditory message feedback). The visual feedback messages would show the sequences of symbols as each symbol was selected in the screen display, as shown in Figure 4. In addition, the auditory message feedback (i.e., synthesized speech) would be produced word by word in the form of word echo. The user might select the voice gender of the synthetic speech output (i.e., male or female) based on his/her gender. The synthetic speech was recorded by the developer word by word. Consequently, there was no distortion of Thai voice tones in graphic-symbol board mode.

A-Speak operated with the external input devices (e.g., single switch, eye-tracking, etc.). In this study, a single switch was used in scanning mode with participants who lacked motor control and could not directly select the icons on the screen. The type of scanning pattern used in this study was group-item scanning with automatic scanning as a selection control technique. The cursor automatically ran from top to bottom rows (i.e., group selection) and left to right sides (i.e., icon selection). The first pressing the switch would choose the group, and then pressing the switch again would select the icon within that group. To create a phrase or sentence, the users repeated the selection process. For further information, including instruction video, about A-Speak, go to https://aspeak.kid-bright.org

Figure 4. *Visual feedback messages.*

Mechanical switches

Two switch models (Big Buddy and Specs) were used in this study. The Big Buddy Button from AbleNet (i.e., IT Outsourcing Company) had a 4.5-inch diameter and was wired to the apparatus (i.e., tablet). The Specs switch from Ablenet had a 1.375-inch diameter and was wired to the tablet. Both models provided activate feedback, including auditory click and tactile.

Tablet

For this project, A-Speak application was installed in Samsung Galaxy Tab A (2016) (SM-P585Y).

Participants

Out of all individuals in Pakkret Home for Children with Disabilities, only 15 individuals between 11 and 24 met the inclusion criteria and participated in this study. The inclusion criteria included: (a) Their primary language was Thai; (b) Their vision and hearing were normal; (c) They were considered to have complex communication needs; (d) They had never used hi-tech AAC; (e) Their receptive language development was equal to or above 4 years of age. Thai Speech and Language Assessment: Pediatric Standardized Test (0-4 years) was employed to evaluate participants 'receptive language development, and (f) They could remain in a sitting position.[28] The exclusion criteria included their speech and language development, which were within normal limits. Individuals who failed to attain the Phase 1 mastery level within two months would be withdrawn from the study. All participants had intellectual disabilities and cerebral palsy at different levels. Three of the fifteen participants had limited upper-body movement. Therefore, those three participants required training to use a scanning mode as an operating technique. The participants' demographic information is displayed in Table 1.

Table 1. The demographic data of the participants. (N=15)

Characteristics	N	%
Gender		
Male	5	33.33
Female	10	66.67
Age, Mean (SD)	17.4 (4.34)	
Type of cerebral palsy		
Spastic	13	86.67
Ataxic	2	13.33
Highest education level		
Grade 10	2	13.33
Grade 11	3	20
Grade 12	10	66.67

Training Procedures

The training procedures consisted of three main phases: Phase 1: Train to select icons; Phase 2: Shift to different categories; and Phase 3: Use A-Speak to communicate. Two researchers were responsible for training throughout all phases, while one engineer was in charge of setting up the switch with the tablets for participants. The researchers visited the Pakkret Home for Children with Disabilities once a month to provide the intervention for participants and train their caregivers to operate A-Speak to be able to assist participants (e.g., configuring the display, adding new icons, modeling participants to communicate through A-Speak, interacting with participants by using A-Speak, etc.). After the training session, the caregivers were assigned to encourage participants to use A-Speak to communicate with caregivers in their daily routines.

Phase 1: 12 individuals with precise finger control were taught to tab the tablet's screen with their fingers to select the desired icons. On the other hand, three participants who had trouble using their fingers effectively were instructed to utilize the scanning mode via the single switch. The single switch was used to activate A-Speak, and the participants were trained to have sufficient capacity (i.e., the switch was activated accurately when the cursor stopped at the target item). The type of scanning pattern used was group-item scanning with automatic scanning as a selection control technique. The cursor automatically ran from top to bottom rows (i.e., group selection) and left to right sides (i.e., icon selection). The first press of the switch would choose the group, and then pressing the switch again would select the icon within that group. To create a phrase or sentence, the users repeated the selection process. The participants were assessed motor skills by a physiotherapist, who was working in Pakkret Home for Children with Disabilities, to select individual discrete-motor control. They each pressed the switch with different parts of their, including the right temple, right shoulder blade (i.e., scapula), and left elbow. Two used the Big Buddy Button, and another used the Specs Switch. The participants were required to master the skill before proceeding to Phase 2. Those who utilized a switch needed two training sessions and spent between 30 and 40 minutes per session to be proficient at selecting icons. The participants who could use a finger to select the icons required one training session and spent between 15 and 20 minutes each.

Phase 2 involved training the participants to shift between different categories. The participants needed to switch between categories to generate a desired phrase or sentence. All participants were encouraged to answer questions or make requests in a word or sentence. Initially, the process was trained by navigating from the main page to a different category. Switching between multiple categories was taught afterward. The participants were supported in acquiring this capacity before moving to Phase 3. Like Phase 1, the participants acquire adequate proficiency in this skill before continuing to the next phase. The participants who used a switch required one training session and spent between 30 and 40 minutes per session to acquire adequate skills to switch between pages. Those who could use a finger to operate required one training session and spent between 10 and 15 minutes each.

Phase 3 was about training participants to operate A-Speak independently and motivating them to use A-Speak as a communication tool in their daily. To encourage individuals to use A-Speak for communication, the researchers verbally asked different kinds of questions (e.g., open-ended questions, yes/no questions, etc.) and developed circumstances for participants to communicate through various communication functions (e.g., requesting objects, telling stories, imitating conversation, denying, expressing feeling, etc.) while they were engaged in activities. The complexity of questions varies depending on participants' language proficiency, interests, and circumstances in a particular instant. As a result, the question lists that each participant received were unique. Participants who used switches and those who did not use a switch needed to attend three training sessions; each session lasted 60 minutes for participants and 60 minutes for caregivers. (a total of two hours per session).

Data collection and analysis

According to Phase 3, the researchers created the circumstances to encourage participants to communicate 12 communication functions, including requesting objects, requesting actions, denying, answering yes/no questions, answering WH-questions, naming, asking questions, storytelling, explaining, telling emotions, greeting, and initiating conversation.

Two researchers with more than 18 years of experience as speech-language pathologists administered the data collection process. To reduce bias, the researchers rotated the participants throughout three sessions. In two sessions (sessions 1 and 3), each researcher was assigned to conduct an intervention with the same participants as the primary therapist, and in just one session (session 2), with a different participant. Both researchers individually collected the participants' performance in their record form during the intervention process without discussion. After every intervention session, the data in the researchers' record form were discussed to verify the agreement of each participant's outcomes.

The data was collected based on observation and recorded in the form of code (e.g., 0, 1, 2, and 3) according to communication performance in three sessions. This study used descriptive statistical analysis reporting frequency (e.g., number, and percentage). The significance of mean differences between the three intervention sessions was examined using the Friedman and Wilcoxon tests. The mean differences of 13 different communication functions were analyzed independently.

Results

The Friedman test indicated that the mean differences between the three sessions were significant for 10 out of 12 communication functions, including requesting objects (X^2=10.129, p=0.006), requesting actions (X^2=12.057, p=0.002), denying (X^2=14.205, p=0.001), answering yes/no questions (X^2=9.579, p=0.008), answering WH-questions, naming (X^2=18.865, p<0.001), asking (X^2=8.4, p=0.015), explaining (X^2=20.6, p < .001), telling emotions (X^2=12.067, p=0.002), and greeting (X^2= 13.231, p=0.001). The communication function of answering WH-questions was analyzed separately in two domains: (a) The questions did not require descriptive answers (i.e., what, where, when, and who questions; and (b) The questions required descriptive answers (i.e., why and how questions). Only WH-questions showed statistical significance, including what, where, when, and who questions (X^2=8.588, p=0.014). Some communication functions consisted of 14 participants since some did not wholly participate in three intervention sessions. Table 2 presents the overall data of statistical differences as determined by the Friedman test.

Table 2. The Friedman test analyzed mean differences between the three intervention sessions and statistical significance.

Measurement	Mean			N	Chi-Square	df	*p* value
	S1	S2	S3				
Requesting objects	1.60	1.97	2.43	15	10.129	2	0.006
Requesting actions	1.46	2.04	2.50	14	12.057	2	0.002
Denying	1.32	2.25	2.43	14	14.205	2	0.001
Answering yes/no questions	1.68	1.96	2.36	14	9.579	2	0.008
Answering what, where, when, and who questions	1.71	1.96	2.32	14	8.588	2	0.014
Answering why and how questions	0.64	2.04	2.32	14	5.871	2	0.053
Naming	1.43	1.90	2.67	15	18.865	2	0.000
Asking	1.57	2.07	2.37	15	8.400	2	0.015
Storytelling	1.87	1.97	2.17	15	2.800	2	0.247
Explaining	1.40	1.87	2.73	15	20.600	2	0.000
Telling emotions	1.63	1.87	2.5	15	12.067	2	0.002
Greeting	1.6	1.93	2.47	15	13.231	2	0.001
Initiating conversation	1.68	2.07	2.25	14	5.360	2	0.069

Note*: S1: session 1, S2: session 2, S3: session 3, *p<0.05.*

Wilcoxon test was used as a post-hoc test. **Requesting objects**. The mean difference between Sessions 1 (M=1.6) and 3 (M=2.43) was significant, Z=2.549, p=0.011. **Requesting actions**. The mean differences demonstrated in both Session 1 (M=1.46) compared to Session 2 (M=2.04), Z=2.333, p=0.02, and Session 1 compared to Session 3 (M=2.5), Z=2.724, p=0.006, were significant. **Denying.** There was statistical significance in the mean differences between Sessions 1 (M=1.32) and 2 (M=2.25), as well as in Sessions 1 and 3 (M=2.43), the statistical significance illustrated, Z=2.887, p=0.004, and Z=2.804, p=0.005, respectively. **Answering yes/no questions**. The mean differences between Sessions 2 (M=1.96) and 3 (M=2.36), Z=2.251, p=0.024, as well as between Sessions 1 (M=1.68) and 3, Z=2.07, p=0.038, were statistically significant. **Answering what, where, when, and who questions.** The outcomes of Session 1 (M=1.71) compared to Session 3 (M=2.32) showed a statistical difference, Z=2.06, p=0.039. **Naming.** The means among all comparisons were significantly different: Session 1 (M=1.43) compared to Session 2 (M=1.9), Z=2.236, p=0.025; Session 1 compared to Session 3 (M=2.67), Z=3.134, p=0.002; and Session 2 compared to Session 3, Z=2.558, p=0.011. **Asking.** The significant differences were presented between

Sessions 1 (*M*=1.57) and 2 (*M*=2.07), *Z*=2.121, *p*=0.034, as well as between Sessions 1 and 3 (*M*=2.37), *Z*=2.565, *p*=0.01. **Explaining.** The means among all comparisons were significantly different: Session 1 (*M*=1.4) compared to Session 2 (*M*=1.87), *Z*=2.449, *p*=0.014; Session 1 compared to Session 3 (*M*=2.73), *Z*=3.095, *p*=0.002; and Session 2 compared to Session 3, *Z*=2.842, *p*=0.004. **Telling emotions**. There were significant differences between Sessions 1 (*M*=1.63) and 3 (*M*=1.87), *Z*=2.762, *p*=0.006, as well as Sessions 2 (*M*=2.5) and 3, *Z*=2.165, *p*=0.03. **Greeting.** The means among all comparisons were significantly different: Session 1 (*M*=1.6) compared to Session 2 (*M*=1.93), *Z*=2, *p*=0.046; Session 1 compared to Session 3 (*M*=2.47), *Z*=2.598, *p*=0.009; and Session 2 compared to Session 3, *Z*=2.333, *p*=0.02. The total data of statistical differences as determined by the Wilcoxon test is illustrated in Table 3.

The satisfaction of using A-Speak was not directly surveyed. Two participants used keyboard mode to express their gratitude. At the same time, A-Speak helped them explain the brief stories they had experienced and let their caregivers understand how they truly felt.

Table 3. Statistical significance of mean differences between the three comparisons of the three intervention sessions as analyzed by the Wilcoxon test.

Measurement	S1 compared to S2		S1 compared to S3		S2 compared to S3	
	z	*p* value	z	*p* value	z	*p* value
Requesting objects	1.890	0.059	2.549	0.011	1.681	0.093
Requesting actions	2.333	0.020	2.724	0.006	1.628	0.103
Denying	2.887	0.004	2.804	0.005	0.750	0.453
Answering yes/no questions	1.732	0.083	2.251	0.024	2.070	0.038
Answering what, where, when, and who questions	1.732	0.083	2.060	0.039	1.841	0.066
Naming	2.236	0.025	3.134	0.002	2.558	0.011
Asking	2.121	0.034	2.565	0.010	1.557	0.120
Explaining	2.449	0.014	3.095	0.002	2.842	0.004
Telling emotions	1.134	0.257	2.762	0.006	2.165	0.030
Greeting	2.000	0.046	2.598	0.009	2.333	0.020

***Note**: S1: session 1, S2: session 2, S3: session 3, *p<0.05.*

Discussion

Several AAC applications are attributed to facilitating the communication competencies of individuals with complex communication needs. Unfortunately, those applications have considerable limitations on speech-output features. Therefore, this study aims to develop AAC applications specifically for Thai individuals. The application was A-Speak or All-Speak. Two main communication options were available in A-Speak, including a graphic-symbol board and keyboard.

A-Speak was mainly similar to Funjai; Funjai is also a Thai AAC application that consists of colored-graphic symbols as a primary operating system with voice output. Both applications could add extra pictures saved on the device to serve as symbols. However, there were significant differences between these two AAC applications. Funjai could be installed on various operating systems, including Huawei, iOS, and Android; however, only Android was supported for A-Speak. There were additional differences in the voice output systems employed in these applications. Funjai's text-to-speech technique was utilized in its voice output, which was limited to female voices. This resulted in intonation distortion on transliterated words such as hamburger, French fried, and carrot. Another distinction was that Funjai did not offer keyboard mode as a backup communication option.

Both Symbotalk and A-Speak included colored-graphic symbols with voice output. They were also able to adjust the number of grids according to the user's level of proficiency. However, SymboTalk showed intonation distortion in Thai voice output. This could be the outcome of SymboTalk's use of voice synthesis through text-to-speech generation. On the other hand, the voice synthesis of A-Speak was created by word-by-word recording, which eliminated intonation distortion in Thai voice output. To add more graphic symbols to SymboTalk, the application automatically connects to graphic-symbol resources with an internet connection. Nevertheless, this feature was not available in A-Speak.

This limitation was similar to Leeloo. Graphic symbols were specifically created and attached to Leeloo, so the number of symbols was limited. However, if users wanted to add more symbols, they could download them by registering for the premium version. Likewise, graphic symbols were mainly developed and contributed to A-Speak. However, if users want to add more symbols, they can download them online or take pictures and set them to A-Speak.

Cboard and SymboTalk were comparable. These applications instantly linked to online symbol resources and allowed users to install those symbols on their boards. Nevertheless, the Thai voice output from these two applications was limited regarding intonation distortion and the lack of diversity in voice age and gender. A-Speak, on the other hand, offered a more incredible selection of voice choices for age and gender that matched the characters of users.

In addition to those features, A-Speak provided a list of folders organized vocabulary into different categories on the display's right side. This feature facilitated users to shift to another category quicker. A-Speak also offered literate individuals the option to use the keyboard mode. A-Speak's symbols have been deliberately designed to correspond with Thai culture. Nevertheless, A-Speak was currently compatible only with Android.

The results of A-Speak training showed that participants' communication efficacy had improved using graphic-symbol mode, even though there were few communication functions that the participants did not attain within the training period. The communication functions that the participants showed improvement during the A-Speak intervention included requesting objects, requesting actions, denying, answering yes/no questions, answering WH-questions, naming, asking, explaining, telling emotions, and greeting. However, the participants did not significantly attain communication functions of telling stories and initiating conversation within the three intervention sessions. The findings also showed that explanation abilities were the communication function that improved the most. On the other hand, storytelling abilities were the communication function that exhibited a minor development. Requesting activities, refusing, naming, asking, and greeting were likely the communication functions the participants found the simplest to learn, as the participants showed a noticeable improvement. The results agreed with the language development milestones in children, such as denying, which starts at 16 months of age, while responding to WH-questions, which begins at 2; 5 years of age.

Conversely, narrative storytelling begins to show at the age of four.[29,30] The explanation for these would be related to children's cognitive development, as they start to think intuitively at a later age.[31] However, this study measured communication efficiency in terms of communication functions only and recorded the outcomes in code numbers without collecting the details of language components (i.e., form of language, content of language, and use of language). Besides this limitation, since this project focused on graphic-symbol mode, participants' communication efficacy in keyboard mode was not investigated. Finally, the researchers had training sessions with the participants once a month, and there were only three training sessions, which were too short to explore the result.

Nevertheless, the main objective of this study was to develop the Thai AAC application and tentatively investigate the effectiveness of the application on individuals with complex communication needs. The future research would focus on further developing the A-Speak application to minimize its existing constraints, such as a limitation about inserting additional symbols, and evaluate the proficiency of the application with individuals with complex communication needs. The evaluation would extend the number of training sessions and use multiple baseline designs as a research design. Moreover, the satisfaction of A-Speak users and communication partners with the quality of voice output was also considered to be investigated in future research.

Conclusion

A-Speak is an AAC application developed especially for Thai individuals with complex communication needs. Although several AAC applications that included Thai-speech output were available, those applications had some drawbacks that possibly reduced the intelligibility and competence of communication. With the training, all participants improved their abilities to communicate in various communication functions while using A-Speak.

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Conflict of interest

The authors declare that there is no conflict of interest.

Ethics approval

The Ethical Committee of the Ramathibodi Hospital approved the participants in this study. Since all participants had disabilities and could not provide informed consent themselves, informed consent was obtained from their caregivers.

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Appendix A

Part 1: Demographic information

Participant code______________________ Age____________________ Gender_______________________

Education level________________________________ Type of cerebral palsy_________________________

Caregiver name____

Part 2: Communication functions

No.	Communication functions	1st session	2nd session	3rd session
1	Requesting objects			
2	Requesting actions			
3	Denying			
4	Answering yes/no questions			
5	Answering WH-questions			
6	Naming			
7	Asking			
8	Storytelling			
9	Explaining			
10	Telling emotions			
11	Greeting			
12	Initiating conversation			

Scoring rubric

0 = No communication
1 = One occasion
2 = More than one occasion
3 = Communication on all occasions