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Design And Development Of Let's Talk Now: A Speech Assistive Mobile App For Dysarthric Children

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ABSTRACT

Dysarthria is a neurological disorder that damages the articulation of motor speech. Medical researches has shown that young children suffering from dysarthria have no difficulty with their cognition, however since they are unable to communicate properly and smoothly with their family and friends, they have trouble speaking their thoughts. A multimedia assistive speaking intervention in the form of a mobile application named 'Let's Talk Now' which was designed and developed for the use of dysarthric children aged 3 to 7 years old. This application was meant to be an early intervention to encourage these children to communicate and enable others to understand them. It focuses on general terms of conversation for calling members of the family, simple greetings and gestures, locations, ordering food and drinks, listing events, and asking for support. This paper describes the design and development process of the speech assistive mobile application. It was designed and developed based on the ADDIE (Analysis, Design, Develop, Implement and Evaluate) Model. This paper also includes details on the evaluation of the prototype: alpha test and beta test. The purpose of designing and developing speech assistive multimedia tool for dysarthric children was to help them to be able to converse and interact with others at the early stage of recovery intervention. It is also an attempt to uphold the obligations of the Department of Social Welfare under the Ministry of Women, Family and Community Development, Ministry of Health and the Ministry of Education to provide recommendations for the care and support of the children with disabilities.

1. Introduction

Dysarthria is a neurological speech condition that that interferes with normal speech due to loss of control of articulators producing speech [1]. It is a category of congenital and traumatic neuromotor disorders that cause the physical de-formation of speech [2]. These impairments reduce or remove normal regulation of primary vocal articulators but do not impact the everyday comprehension or production of meaningful, syntactically correct language. In other words, dysarthria is a speech disorder that results in a loss of control of the muscles of the tongue, jaw, larynx or vocal cord that generates speech, nerve or muscle damage [3]. The muscles may be rigid, fully paralyzed, or the coordination between them may not have caused the speech of dysarthric patients to be poorly audible, wrongly pro-notified, or without any rhythm or speed and of very poor quality [3]. This condition can be diagnosed in young children before a child is 3 years old [4]. It is

clearly mentioned that while dysarthic children have trouble expressing their sentences, they are able to understand conversations.

Research [5] on dysarthic patients showed that, depending on the degree and location of the nervous system damage, a person with dysarthria can experience any of the following symptoms:

- Talk gently or scarcely capable of whispering
- Expression "Slurred"
- Slower speech rate
- "Rapid speech rate with a "mumbling" consistency
- Abnormal (rhythm) intonation while speaking
- Restricted motion of the tongue, lip, and jaw
- Breathability
- Changes in vocal quality ("nasal" speech or "stuffy" sounding)
- Vocal hoarseness
- Difficulty chewing and swallowing
- Drooling or impaired saliva management

People with dysarthria have a total knowledge of languages and know what they want to say, but they just have difficulty expressing it [5]. Since dysarthria cannot be fixed by surgery or medication [6], young children in particular are a major source of distress for the child and their levels of trust and self-esteem can be very detrimental. Therefore, early intervention in the form of speech and language therapy is recommended [7] [8] [9] and therapeutic approaches are also used to support computer-based assistive instruments for dysarthric patients [10] [11].

The purpose of this research is to design and develop a 'customised speech' mobile application named 'Let's Talk Now' as an early intervention to help the dysarthric children. This mobile application is suitable for the children aged 3 to 7 year-old who are facing problem to communicate and enable them to be understood by others as have trouble actually saying words. This paper will describe the content of the mobile application, design and development process, and also the pilot testing which includes the alpha testing and the beta testing of the mobile application prior to the actual implementation.

2. Related Work

Research suggests that if a child has been found to have speech disorder such as dysarthria, parents or caregivers should not wait and quickly implement an early intervention using Speech Assistive Technology as the developmental language delays do not disappear with age [12]. These conditions may then evolve into lifelong disabilities with severe long-term consequences if not corrected, such as school challenges (reading, writing and spelling), language-related difficulties, behavioral abnormalities and emotional issues [5]. It is therefore important that this disorder be treated early, especially in young children. Early intervention programs are documented to improve child development using simple and user-friendly speech assistive technology [13]. The effectiveness of improving child growth, however, depends on the early intervention strategies they are provided as children [10] and it is asserted that families must also be active in the evaluation and intervention process (Judge, 2002).

Children with speech disorder such as dysarthria use alternate communication modes such as manual signs and visual signals under normal situations, which are a substitute for spoken words [14]. However most of the existing speech assistive technologies (MSAT) focused on multimedia provide elements of speech recognition [15] or text input. It is unlikely for these programs to support young children who still have trouble pronouncing clearly and do not know alphabets. In addition, for adults

with dysarthria, the latest MSAT systems/application are complex and modelled [4]. In addition, the new MSAT is meant to be operated by an adult and instruments that promote the rehabilitation of patients with speech disability [16] and does not help children interact at the initial level. It requires supervision of the therapist and caregivers in order to facilitate intervention for these children, and it is not for early intervention. In one of the study, [4], the authors argued that children will have to be subjected to the intervention individually at an early stage for a better recovery.

3. 'Let's Talk Now' Mobile App

The mobile app Let's Talk Now has been designed and created as an early intervention interactive assistive tool to support dysarthric children aged 3 to 7 years who face communication difficulties and to enable caregivers who interact with them to understand them. The reason why this age group were chosen is because early intervention services to young children in this age group who have or are at risk for developmental delays have been shown to positively impact outcomes across developmental domains, including health, language and communication, cognitive development and social/emotional development (NECTAC, 2011). Researches done with young children aged between 2 -5 years old stated that the use of assistive technologies and best practices of Universal Design for Learning provide a viable pathway for needed customization and personalization for young children with disabilities [17] [18] [19].

This app focuses on general terms of communication that are used on a regular basis, such as calling family members, greetings and gestures, mentioning locations, ordering food and drinks, mentioning activities and asking for help. It is designed and develop with redundant multimedia elements, namely narration (that help them to communicate), text (to indicate the purpose of the buttons), and graphics (to indicate the purpose of the button). The prototype was designed in such a way that it is suitable, user-friendly and attractive for young children. It can be used via tablet and mobile as it is portable and intended to be used on the go.

3.1 Design and development process of 'Let's Talk Now' Mobile App

The 'Let's Talk Now' mobile app was designed and developed based on the ADDIE (Analysis, Design, Develop, Implement and Evaluate) Model. In the first phase which is the analysis phase, the literature research on the theories, models, processes and methods of speech assistive multimedia and dysarthria was carried out. Information related to the dysarthric children's speech issues and requirement was also studied and investigated. Once the information had been gathered, a critical analysis was conducted on the existing models and mobile applications which will lead to the specific identification of the components that forms the design of 'Let's Talk Now' mobile app for the dysarthria children.

In the design phase, the findings from phase 1 was integrated into the speech assistive mobile application design. The information which were essential to aid the development of the mobile, such as special education syllabus, storyboarding sheets and production files was developed. Figure 1 illustrates one of the storyboard used as the low fidelity design of this mobile app. Upon completion of the information gathering, the development process in the third phase begins.

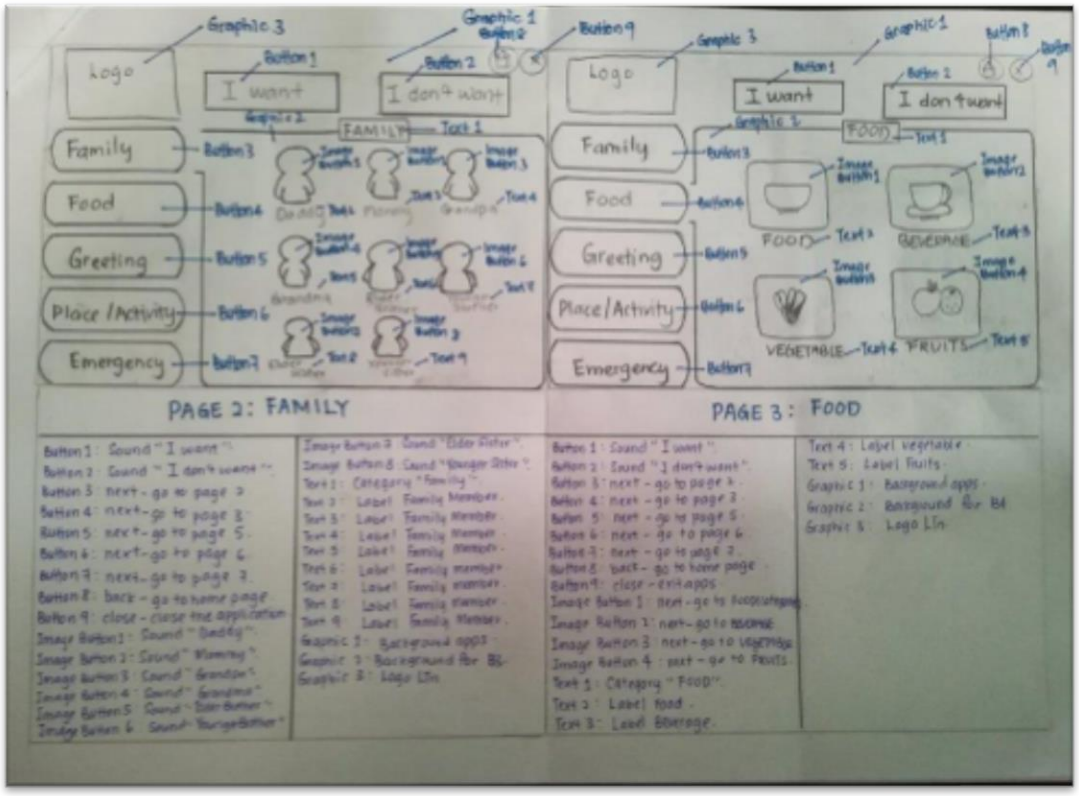


Fig. 1. Example of the storyboard used for the design of 'Let's Talk Now' mobile app

The third phase which is the development phase enables the required elements of the mobile application to be developed and assembled to form a prototype. The development process of this mobile app involves various software such as Adobe Animate CC, Adobe Audacity, Adobe Photoshop, Adobe Audition and Adobe Illustrator. The characters and the graphics were drawn individually and the narration were recorded prior to the development of the prototype. Once the development process was done, the prototype was pilot tested which involve two evaluations: alpha test and beta test. In the alpha test, the application was evaluated by content experts, language experts, and user interface expert. This is to confirm that the prototype was working as intended. After the alpha test, the prototype was revised and went through a second phase of evaluation, which is the beta test that evaluated the usability (usefulness, ease of learning and satisfaction) elements before being employed to the potential users.

Implementation phase required the prototype to be used in real environment. For this purpose, two wellness center that acts as a therapy hub for dysarthria children were chosen. The prototype was then employed to the children assisted by the therapist and their parents after instruction on how to use the prototype were given. In the final phase which is evaluation phase, we investigated the effectiveness of the developed 'Let's Talk Now' prototype as an early intervention to assist the dysarthric children to communicate independently. The mobile application that has been developed in the earlier phase was evaluated using three techniques: questionnaire survey, interviews, and observation. The questionnaire survey and interview process was conducted on the parents, teachers and therapists while the observation process was conducted on the dysarthic children to investigate the effectiveness of the prototype on assisting them to communicate. The findings of this phase provide recommendations to promote improvement on the prototype.

Figure 2 illustrates the design and development process of 'Let's Talk Now' mobile app.

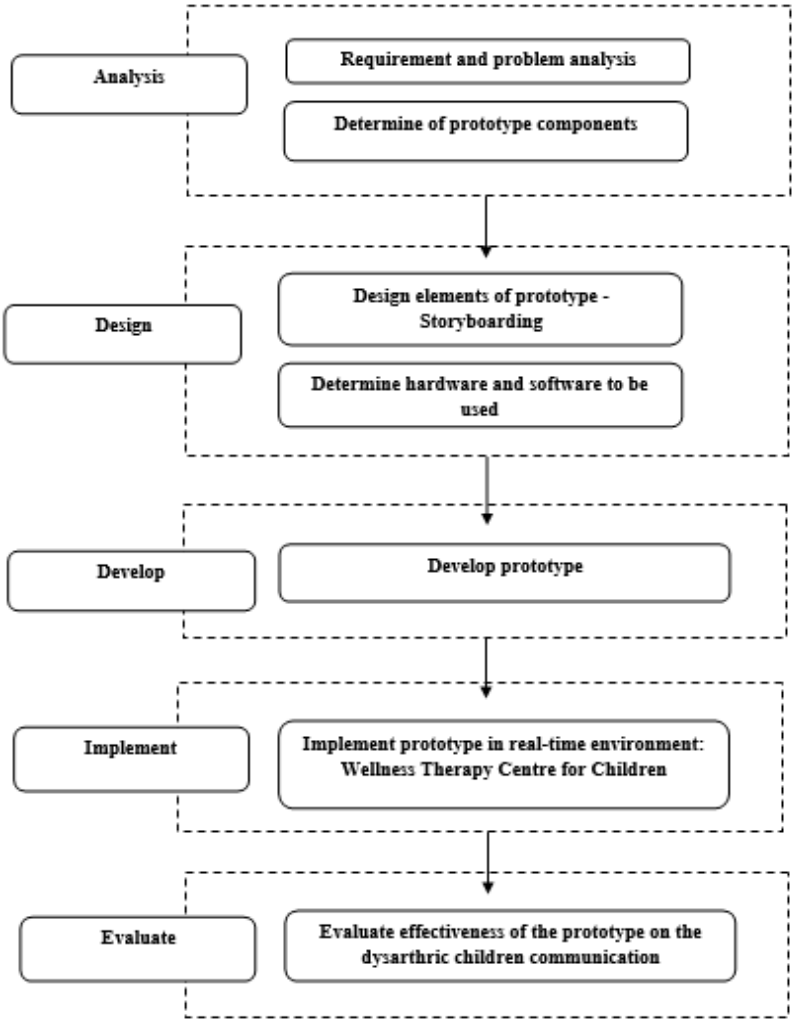


Fig. 2. The design and development process of 'Let's Talk Now' mobile app

3.2 Content of 'Let's Talk Now' mobile app

The lesson content for the 'Let's Talk Now' mobile app was developed based on the Special Children Curriculum syllabus that was provided by the Special Children Care Centre in Malaysia. The mobile app was developed using software such as Adobe Animate, Audacity, Adobe Photoshop and Adobe Illustrator. The user interface of the mobile app 'Let's Talk Now' was developed using fitting colors, fonts and graphics suitable for children between the ages of 3 and 7. The application features such as the menu, buttons, labels, wording, and format interface are also considered to be compatible. As each menu represents words relevant to the feature, it has six menus and is used with multimedia elements such as text, narration, background music, graphics and animation. In order to represent the dysarthric children and encourage them to interact, this application has narratives using the voice of a small child as its speech and language components.

Users must have a storage capacity of 301 MB in order to install this application, and the operating framework appropriate for this application is Android version 6.0 or above. The mobile app is available in two languages, English and Mandarin, and can be used without connecting to the internet. As the purpose of this application is as an early intervention to encourage dysarthric children to interact and allow their caregivers to understand them, the mobile application was not developed with any evaluation exercises. This mobile application was developed based on family centered approach, by integrating the elements of i) early intervention, ii) assistive technologies for

children, iii) communication, and iv) multimedia elements. The mobile app 'Let's Speak Now is intended to be an early intervention that is accessible and sufficient to enable dysarthric children to communicate independently at the initial level. Figure 3 illustrates the interfaces of the 'Let's Talk Now' mobile app.



Fig. 3. The interface of 'Let's Talk Now' mobile app (English Version)

In the digital market, there are two similar apps for assisting the special children' s namely *Talking Pictures: Autism, CP* and *Speak CePal for Autism and CP*. These applications are however, created for the iOS operating system and do not appeal to users of An-droid. In addition, these applications are intended to promote contact with non-speaking children diagnosed with autism, mental retardation, and cerebral palsy, and do not expressly meet the criteria of dysarthic children. The Talking Pictures: Autism, CP software has images with sound depending on the setting; the expression that is set for that image will be spoken by either an alarm sound or speech synthesizer; however, it does not have its own narration. The Talk CePal app for Autism and CP also has restricted choices that are equivalent to the former.

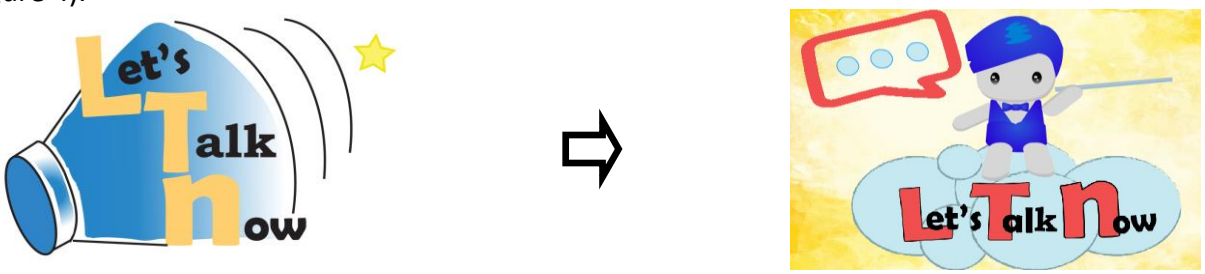
4. Pilot Testing: Evaluation of 'Let's Talk Now' Mobile App

In the development process, two types of pilot testing were conducted namely alpha test and beta test. In the alpha test, the application was evaluated by content experts, language experts, and user interface expert. This is to confirm that the prototype was working as intended. After conducting the alpha test, the prototype was revised and went through a second phase of evaluation, which is the beta test before the prototype was implemented to the potential users.

The alpha test was conducted to evaluate the prototype in the aspects of design, content, and usability. This is to identify the strengths and weaknesses of the prototype and revise it accordingly. The researchers used experts review method as an approach to conduct the alpha test on the 'Let's Talk Now' prototype. It required the content experts and user interface expert to use his/her knowledge and experience to identify problems and recommend solutions to improve the usability of the prototype. In this testing, the researchers employed interview method to collect data. The interview questions were prepared. It contains four sections - demographic, design, content, and usability.

Findings from the alpha testing indicated that there were some improvements need to be done on the prototype. Figures 4 until Figure 7 indicate some of the changes:

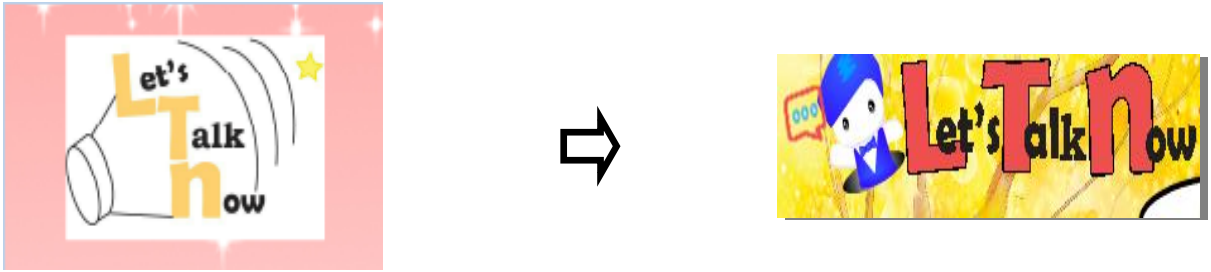
1. Icon: Icon was changed from speaker to character that similar to the interface of the prototype (Figure 4).



Before After

Fig. 4. Changes of the icon

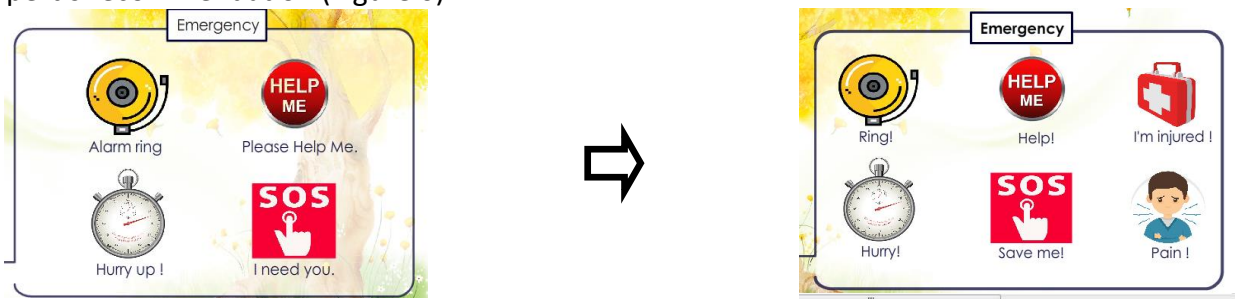
2. **Logo**: Logo of the application was changed from a simple to an attractive one (Figure 5).



Before After

Fig.5. Changes of the logo

3. **Emergency Page**: Two more buttons were added to *Emergency* section based on the content expert's recommendation (Figure 6).



Before After

Fig. 6. Changes in the *Emergency* page

4. **Scrolling**: Initially, all buttons in every section are displayed using tab. Based on the user interface expert's recommendation, scroll panel replaced the tab (Figure 7).

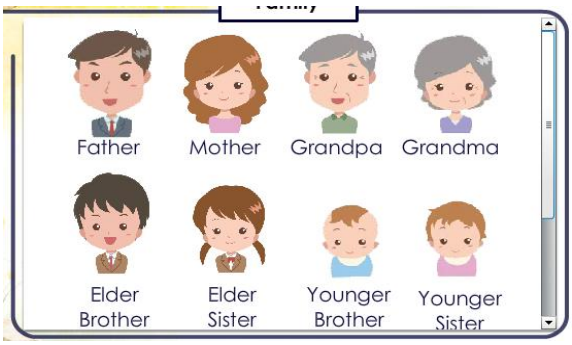
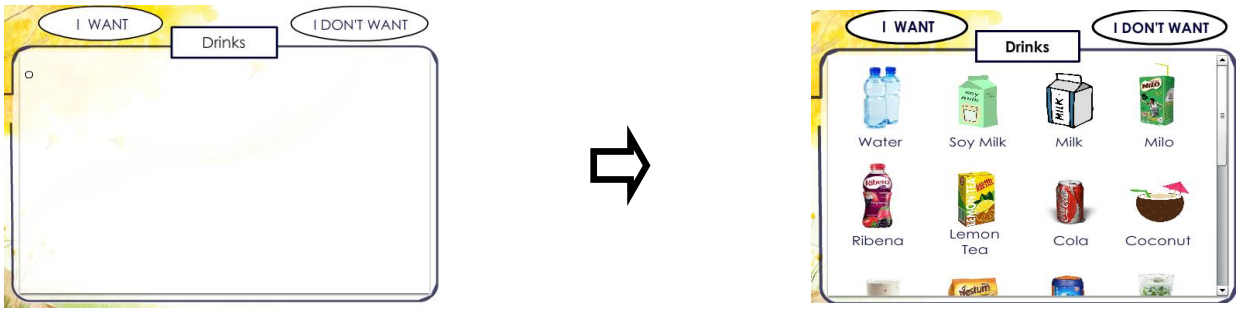


Fig. 7. Scrolling panel

5. **Tab**: Tab labels were bold to make it obvious and outstanding (Figure 8).



Before After

Fig. 8. Changes in the Tab label (bold)

The beta test was conducted to potential users who are dysarthric children, assisted by therapist and their parents. The testing only investigated the user acceptance of the 'Let's Talk Now' mobile app from the perspective of 30 respondents who are the main caregivers to the dysarthric children. These caregivers include the therapists, parents, and the teachers of dysarthric children. The researchers did not investigate the dysarthric children because the questionnaire is quite difficult for them to express their approval or opposition as they are still young special children and are very unable to interact with strangers.

Prior to the testing, the caregivers were given a brief instruction on how to use the prototype. This beta testing involved 30 respondents namely the therapists, parents, and teachers. For this purpose, a validated questionnaire that was adapted from the USE questionnaire [20] with the Likert scale of 1 (Strongly Disagree) to 5 (Strongly Agree) was employed as an instrument. The instrument contains 13 items on usefulness (USE), ease of learning (EOL), and satisfaction (S). Data collected were then analyzed to ensure that there were no errors and the prototype manage to deliver its intended purpose. Table 1 represents the demographical findings of the beta testing.

Table 1
Demographical findings

Section	Details	Item	Findings
Demographic	Gender	Male	11(36.7%)
		Female	19 (63.3%)
	Age	18 - 24	4 (13.3%)
		25 - 30	13 (43.3%)
		30 and above	13 (43.3%)
	Role	Parent	10 (33.3%)
		Teacher	6 (20.0%)
		Therapist	14 (46.7%)

Descriptive statistical analysis was used to analyze the data obtained in the beta testing. Table 2 illustrates the findings from the questionnaire.

Table 2
Questionnaire findings

Construct	Item	Neutral	Agree	Strongly Agree	Mean
Usefulness (USE)	USE1	4 (13.3%)	16 (53.3%)	10 (33.3%)	4.20
	USE2	1 (3.3%)	20 (66.7%)	9 (30.0%)	4.27
	USE3	4 (13.3%)	14 (46.7%)	12 (40.0%)	4.27
	USE4	3 (10.0%)	15 (50.0%)	12 (40.0%)	4.30
Ease of Learning (EOL)	EOL1	-	13 (43.3%)	17 (56.7%)	4.57
	EOL2	2 (6.7%)	14 (46.7%)	14 (46.7%)	4.40
	EOL3	-	10 (33.3%)	20 (66.7%)	4.67
	EOL4	3 (10.0%).	15 (50.0%)	12 (40.0%)	4.30
Satisfaction (S)	S1	2 (6.7%)	16 (53.3%)	12 (40.0%)	4.33
	S2	7 (23.3%)	11 (36.7%)	12 (40.0%)	4.17
	S3	1 (3.3%)	14 (46.7%)	15 (50.0%)	4.47
	S4	3 (10.0%)	17 (56.7%)	10 (33.3%)	4.23
	S5	2 (6.7%)	16 (53.3%)	12 (40.0%)	4.33

The first construct is the usefulness aspect. The high mean scores which is closer to 4.00 indicated that the mobile app is useful in meeting the dysarthric children's need and are able to help the children to communicate more effectively. As for the ease of learning construct, the mean score for the items suggests that the dysarthric children are able to easily remembers how to use the mobile app and learn to use the mobile app quickly. For the satisfaction construct, mean scores are also closer to 4.00 indicating that the caregivers feel that their children need to have the mobile app and that they are satisfied with the outcome of the mobile app. The feedback of the respondents also stated that the mobile app is works the way it supposed to. All the mean scores which are more than 4.00 ($4.00< x< 5.00$) suggested that all the respondents who are the caregivers of the children strongly agreed that the mobile app prototype 'Let's Talk Now' satisfy all the usability construct as it is helpful, simple to understand, and the design and function of the mobile application is stated to be user friendly and satisfying. However, the caregivers also gave some suggestions verbally that was included and applied in the revised version of the prototype.

The findings of this study reveal a significant level of satisfaction among respondents, who were caregivers of children, regarding the usability of the mobile app prototype 'Let's Talk Now.' Notably, mean scores falling within the range of 4.00 to 5.00 strongly suggest unanimous agreement among respondents that the prototype excels in meeting key usability constructs. Specifically, respondents expressed a high degree of contentment with the app's perceived helpfulness, ease of comprehension, and the overall user-friendliness of its design and functionality. These favorable mean scores indicate a consensus among caregivers that the 'Let's Talk Now' mobile app prototype has successfully addressed their usability needs.

However, it is important to note that the study did not conclude with the mere collection of numerical ratings. Respondents, in addition to providing quantitative assessments, also offered verbal feedback. This qualitative aspect of the study enriched our understanding of user perceptions. The user interface experts provided specific suggestions and insights during the course of the survey, and these verbal contributions were carefully considered during the subsequent development phase.

The incorporation of these expert suggestions into the revised version of the prototype underscores the value of user feedback in iterative design processes. The development team recognized the importance of not only quantifying user satisfaction but also actively engaging with users to refine the application. By integrating the experts and respondents' suggestions into the revised prototype, the team demonstrated a commitment to creating an application that truly aligns with user needs and expectations. This approach ensures that 'Let's Talk Now' evolves to meet the dynamic demands of its user base and, consequently, maintains its high level of usability and user satisfaction. Furthermore, it highlights the iterative nature of the development process, emphasizing the continuous effort to enhance the application's usability in response to real-world user input.

4. Conclusions

Dysarthria is a motor speech disorder, and if a young child is affected by this disorder, the child will face a lot of difficulty speaking, especially at the early stage. While many speech-based assistive devices and strategies have been developed for users with dysarthria, it is not easily designed to be employed and used by small young children without adult assistance. Little has been achieved in the early stage of the recovery experiment to support children who have this communication disorder. It is suggested that at the initial stage, speech-assistive ma-terials should be introduced in a child-friendly, personalized family-centered approach. Therefore, there are a few suggestions that there should be an early intervention that will assist these dysarthric children to interact independently and allow others, especially for the caregivers initially, to understand them.

'Let's Talk Now' mobile app was designed and developed with multimedia elements such as narration, tect, graphics, and animation for the use of dysarthric children aged 3 to 7 years old. It serves as an early intervention tool to help these young children to communicate. It was designed and developed using the ADDIE model and it is available in dual language. This mobile app concept is intended to lead to early intervention of dysarthric children as a multimedia-based speech assistive technology that will help them engage with their caregivers at an early stage and ease their effort to connect with normal individuals. This prototype is also intended to assist in other potential studies for young children who have speech impairment disorder to design speech assistive multimedia. This prototype not only recognizes the developing capacities of children with disabilities, in particular children with dysarthria, but also supports the call by Malaysia and UNESCAP (United Nations Economic and Social Commission for Asia and the Pacific) to adapt the Incheon 'Make the Right True' strategy for people with disabilities, which includes early intervention expansion strategies for them.

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