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Assessing Usability and Fun of Speech Articulation Training for Children with Down Syndrome

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***Abstract*: The main objective of this study is to investigate the feasibility of Malay automatic speech recognition (ASR) engine as tool in speech rehabilitation among children with Down syndrome (DS) in Malaysia. Three children with DS were requested to use an application called *MyCard* during the evaluation session. Furthermore, with the integration of the Malay ASR engine in *MyCard*, the program was designed to enable the children with DS to practice their Malay articulation skills. The parts in *MyCard* which caused the usability and fun problems on the children were identified and required improvements in order to increase the feasibility of the application in the speech rehabilitation for children with Down syndrome. Therefore, an adaptive coding scheme called DEVAN was used to assess the feasibility of *MyCard* based on the usability and fun aspects. Based on the findings, the results suggested that the recording interface was observed to be causing trouble for the children in this study.**

***Keywords*:** Down Syndrome, Assistive Technology, Speech Rehabilitation, Malay Articulation Training, Usability Study, Evaluation Method, Usability and Fun Problems**.**

I. Introduction

Speech and language learning of children with Down Syndrome (DS) occurs at a slower rate compared to other children of the same age. Therefore, children with DS often take longer time to learn to speak; in some cases, they may not be able to speak in an intelligible manner throughout their lifetime [1]. The ability to learn to converse properly is crucial as it helps an individual to connect to each other in the society. Regardless of any abilities, every child needs to learn to be independent by socializing with their peers. Therefore, improving the speaking and language skills of DS children is essential in promoting an independent living for these children.

One way to improve speech and language development of DS children is to provide them with stimulus that can stimulate their learning desire. Information and communication technology (ICT) is able to fulfill this objective by presenting learning contents (in the form of multimedia application) via interactive plays and reliable feedback. These interactive applications can offer greater opportunity to bypass the learning difficulties among children with DS. In addition, children with DS are often less motivated in learning, thus the creative activities inside the interactive applications also help to improve the confidence and motivation for these children in learning [2]. Likewise, these interactive applications would help to improve the speech and language difficulties among children with DS.

In this study, the researchers developed a prototype known as *MyCard* for speech and language learning among children with DS. Integrated with automatic speech recognition (ASR), *MyCard* aimed to provide Malay articulation training for the children with DS. There are two reasons for constructing this prototype in this study. The first reason is derived from the fact that the best way to improve speech and language difficulties among children with DS is to encourage them to converse verbally. During the preliminary study, this assertion was validated and agreed by the speech therapist and teachers from the Kiwanis Down Syndrome Foundation (KDSF) centre – a legitimate DS centre registered in Malaysia. The second reason is due to the fact that the existing speech computerized applications are mostly developed based on European regions and the original users of these applications are not targeted for DS [3–10]. Therefore, these existing applications are not suitable to be used in the speech rehabilitation for children with DS in Malaysia.

In the previous publication [11], the researchers of this study investigated the feasibility of *MyCard* with three children with DS. The feasibility of *MyCard* was sought based on the difficulties and user experiences observed from the reactions of these children while they were interacting with the prototype. Nevertheless, the study in [11] did not address the usability and fun problems which affected the children when they were interacting with *MyCard*.

Identifying the usability and fun problems affecting user is important in any usability study as it helps to suggest the potential improvements which can be carried out on the design issues of an application. This in turn would increase the feasibility of an application as a tool in assisting children with special needs like DS. This paper aims to fill this particular gap by identifying the problems in both usability and fun aspects of *MyCard*. In addition, this paper also aims to extend the work published in [12].

Usability study can help researchers and developers in

identifying problems that is useful for future development of an application. As a result, this will directly help in improving the user satisfaction and feasibility of *MyCard* as a tool for speech rehabilitation among children with DS. This paper aims to discuss the usability and fun problems encountered by the children with DS when they were interacting with *MyCard*. The discussion starts with the background and literature review of related fields, description of research instruments, experiment procedures, analysis and discussion of the results, limitation and future work and the conclusion of the study.

II. Related Studies

Children with DS differ from the normal children in various aspects such as cognitive, sensory perception and processing, language acquisition as well as gross and fine motor skill development. Furthermore, due to the stereotype of DS, they often require longer time to complete a task compared to the normal children. Thus, children with DS are more likely to have a lot of interaction problems while interacting with technologies including assistive tools. There are a few aspects that must be taken into account in proposing an interactive system for children with DS.

Usability and fun aspects could reveal the feasibility of *MyCard* as an assistive tool in promoting speech rehabilitation among children with DS. The usability aspect reflects the user-friendliness of the application. Meanwhile, the fun aspect reflects the engagement of the children when they are using the application during the speech therapy session. Identifying the problems in both usability and fun aspects helps to validate the usability design of *MyCard* in fulfilling the expectations and needs of the children with DS. Eventually, this would lead to the conclusion of the potential user interfaces (UI) features that can promote the self-paced speech rehabilitation among children with DS.

One of the challenges in this study is recruiting children with DS to participate in the evaluation study with *MyCard*. Existing studies show that recruiting participants with special needs can be challenging due to the fact that children with disabilities are often associated with nature and attitudes that are difficult to predict, impulsive decisions and actions [13], [14]. Nielsen [15] suggested that three to five participants is acceptable in a usability study among people with special needs. The increasing number of sample will not only increase the costs but also prolong the evaluation session which can be troublesome to the participants with special needs.

In addition, the evaluation method needs to be taken into consideration. Children with DS are sensitive to converse with strangers. In this case, the evaluation methods that based on surveys and questionnaires are unable to meet the objectives of this study. This is due to the fact that the children with DS might have problems to understand and answer the questionnaires or the surveys. Therefore, some technical and ethnical measures were considered in conducting the evaluation of *MyCard* with three DS children.

In this study, the usability and fun problems of *MyCard* were assessed based on the structured coding scheme called DEVAN – a tool for detailed video analysis of user test data [16–18]. The method makes use of a table format to represent interactions at multiple levels of abstract to assess the usability problems in the products targeted for adults. Barendregt and Bekker[17] later adapted the DEVAN method to assess the usability and fun problems in games among normal children.

Macedo and Trevisan's study [18] later adapted the DEVAN method to observe children with DS interaction with games, particularly in eliciting the usability and fun problems in the games. Using a statistical method (Cohen's Kappa), Macedo and Trevisan measured the DEVAN's consistency between two evaluators in detecting the usability and fun problems affecting the children with DS while these children were interacting with the game. The results showed that 64% of the problems coded by two evaluators (one without experience in usability evaluation and the other an experienced evaluator) were identical when they were using the same adapted DEVAN method. This indicates the adapted DEVAN method is suitable for experienced or inexperienced usability evaluator to identify the usability and fun problems causing on the children with DS when these children were interacting with the games.

The researchers of this study opted to adopt Macedo and Trevisan's DEVAN method to evaluate the usability and fun problems of *MyCard* for two reasons. Firstly, our study targeted children with DS and the Macedo and Trevisan's DEVAN method was devised to observe children with DS interaction with the game. Secondly, the evaluation methods like questionnaires or survey are not suitable to be administered to the children with DS because they might have problems in understanding or answering the questions. Therefore, an alternative evaluation method based on observation, like DEVAN, tends to fulfill the objectives of this study.

It is important to highlight that each usability evaluation method has its own advantages and disadvantages. Nevertheless, all these evaluation methods aim to enhance the usability design of an application. Therefore, the appropriate use of evaluation methods can significantly improve the feasibility of *MyCard* as an assistive tool for children with DS. The DEVAN method is ideal for this study because its reliability has been validated by Macedo and Trevisan.

III. Description of Research Instruments

A. DEVAN Method Coding Scheme

MyCard was developed to provide articulation training for children with DS which differs from the game being assessed in the earlier study by Macedo and Trevisan. Therefore, in order to conduct the usability and fun assessment of *MyCard*, some of the breakdown indications from the original list were removed or refined. The final version of the coding scheme used in this study is shown in **错误!未找到引用源。** and the researchers in this study used it as a guideline to observe the behaviors and actions of the children with DS when they were interacting with *MyCard*.

Table 1. Coding Scheme (taken and Modified from [18])

Description	Definition
Wrong Action	An action does not belong in

	the correct sequence of actions. An action is omitted from the sequence. An action within a sequence is replaced by another action. User performs a wrong action unintentionally.
Intentional Wrong Action	The user knows that the action is wrong, but still performs this action only to have fun.
Help	The user could not proceed without help from Teacher. The Teacher intervenes to prevent serious problems.
Dislike	The user indicates that he/she dislikes something. The user is not co-operating.
Puzzled	The user indicates the inability to proceed.
Impatience	The user shows impatience by moving his/her body while waiting the application to response.
Passive	The user stops interacting and does not perform the expected action
Execution Problem	The user indicates not knowing how to pronounce the word. The user makes inconsistent speech errors. The user still makes speech errors after receiving assistances from the Teacher. The user suddenly stops in the middle when he or she is pronouncing.
Perception Problem	The user indicates the inability to listen or see something clearly, not understanding how to proceed.
Random Actions	The user performs random actions.
Bored	The user indicates being boring by sighing, yawning or acting sleepy.

B. MyCard

MyCard is a card-based game learning application developed to provide articulation training for the children with DS [11]. It utilized the speech automatic speech recognition (ASR) to access the speech pronunciation skills of DS children. Figure 1 shows the description of each interface from the application.

Usually, it is difficult to determine whether certain aspects of *MyCard* caused usability or fun problems. For example, it is hard to determine whether the problem occurs when the child is watching the animation and at the same time displaying the behavior that could signal usability problem, like staring on the screen or being passive. Therefore, some actions are predicted by the researchers and these actions would serve as guidelines for detecting the usability and fun problems of *MyCard*. 错误!未找到引用源。lists the expected actions that the children would perform when he or she is interacting with *MyCard*.

Table 2. Isolated Words List

Word	**Syllable Structure**
Adik (brother)	V-CVC
Emak (mother)	V-CVC
Suka (like)	CV-CV
Makan (eat)	CV-CVC
Sakit (pain)	CV-CVC
Buah (fruit)	CV-VC
Askar (army)	VC-CVC

C – Consonant, V – Vowels

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Screen	Description
	Menu Interface – User selects the word he or she likes to practice in this screen. Audio – No audio displays in this scene.
	Animation Interface – The screen displays the animation and pronunciation of the word selected. The color of text will change as the animation is playing to highlight the pronunciation of the syllable. Audio – The pronunciation of the word, e.g. "A-dik".
	Recording Interface – The scene contains three icons programmed to provide different function. This screen allows the user to record his or her voice by clicking the microphone icon. The mouth icon will playback the animation and pronunciation of the word selected. The tick/cross icon will analyze the pronunciation of the user after the user had made the pronunciation during the recording. Audio – No audio displays in this scene.
	Recording Interface – After the microphone was clicked, the listen sign will start to play and the agent will put her hand behind the ear. The ear of the agent will also start to animate for five seconds. Audio - No audio display in this scene.
	Feedback Interface – This scene displays the score of the user. One star indicates low score; whereas, five stars indicate high score. Auditory feedback like 'uh-oh' and applauding are used to reflect low and high score respectively. Audio – Applauding for high score (4 to 5 stars), and warning sound ('uh-oh') for low score (1 star).

Figure 1. *MyCard*

I. Procedure

Three children with DS, aged between 6 and 12 years old (mean = 10 years old), were recruited for the usability study of *MyCard*. None of the children had any previous experiences using *MyCard*. The small sample of participants recruited in this study is due to the fact that one of the features in *MyCard* was to provide speech assessment for user and the children with DS must have some basic sound imitation skills in order for them to interact with *MyCard*. This had imposed a technical problem when recruiting the children with DS for the usability study as many of these children did not meet this eligibility due to severe speech difficulties.

The usability study was conducted as individual session at the private room of KDSF centres, and the children were accompanied by their teachers. The teachers were allowed to provide assistance but they were advised to keep their interaction with their child as minimal as possible. Before the study took place, the researchers demonstrated the methods to use *MyCard* and later each child was given the opportunity to explore the application with certain degree of assistance. Each session was videotaped and the researchers obtained three videos of approximated 60 to 90 minutes for the evaluation of *MyCard*.

II. Analysis of the test session

The analysis of the study commenced with the priority to transcribe the video and the logging behaviors as well as actions observed during the evaluation session. The behaviors and actions were transcribed into a multicolumn table; one for each participant. It is noted that some similar usability and fun problems reoccurred when the children were interacting with *MyCard* throughout the video recording session. Therefore, instead of transcribing the video in full length, only the first 20 minutes of these videos were transcribed.

The interval for video transcribing must be determined first before the commencement of the video transcribing process. If the interval was too short, some actions or behaviors of the children would not be observed. However, if the interval was too long, some actions or behaviors of the participants would be overlooked. In this study, the interval used for video transcribing process is between two to four seconds. The reasons behind this are: 1) if transcribing the video based on one second, the video segment only contains single action of user which is "meaningless" because human-computer interaction is a bidirectional process; and 2) children with DS often have different interaction problems which may delay their responses when they are interacting with the interactive system. Based on the pilot study, it seemed that four seconds is ideal for the delay among the children in this study.

Once the videos were transcribed inside a multi-column table, it is followed by the location of the breakdown indications. The procedure begins with analyzing the multi-column table and 'one-by-one' locating the behaviors based on the breakdown indications from **错误!未找到引用源。** the actions anticipated from **错误!未找到引用源。** This leads to the creation of interaction table as shown Figure 2.

The left-most column represents the time stamp when an action (second column) performed by the child when he or she was interacting with the application. The third column is the contextual information and *MyCard* status when the action was performed by the child. The right-most column is the breakdown indication coded for the actions or behaviors observed on column two or three. For instance, the passive behavior was coded in the right column when the participant was observed staring on the screen without performing any action (00:02:30).

Time Stamp	Log	Context	Breakdown Indications
00:02:30	Looking on the screen	[Trial 1 – *Adik* Animation starts]	Passive
00:02:55	Turn to facilitator and smile	Animation stops	
00:02:58	Looking on the screen ("Tak dengar")		Perception Problem
00:03:00	Looking on the screen	Recording starts	Passive
00:03:04	Assistance - repeating		Help
00:03:07	Smile ("Take dengar")		Puzzled
00:03:10	Assistance – repeating	Recording starts	Help
00:03:12	Repeat the word		
00:03:15	Assistance – instructing		Help
00:03:18	("Huh")		Puzzled
00:03:24	("Tak dengar")		Puzzled
00:03:30	Looking on the screen	Recording starts	Puzzled

Figure 2. Interaction Table

Once the coding was completed, the occurrence of each indication observed from each participant was keyed in separately in the Microsoft Excel document. The goal is to determine which aspects (animation, recording, and feedback) are more likely to cause the usability and fun problems among the children. Therefore, each indication was organized according to Animation, Recording, and Feedback aspects of *MyCard*.

III. Results

The overall score of usability and fun problems was completed by counting all the breakdown indications observed from each participant (Figure 3). The result shows that Participant 1 (P1) and Participant 2 (P2) have indicated more usability and fun problems compared to Participant 3 (P3). Most of the usability and fun problems among P1 and P2 were observed during the voice recording process. This indicates that the recording scene appeared to be causing problems for P1 and P2.

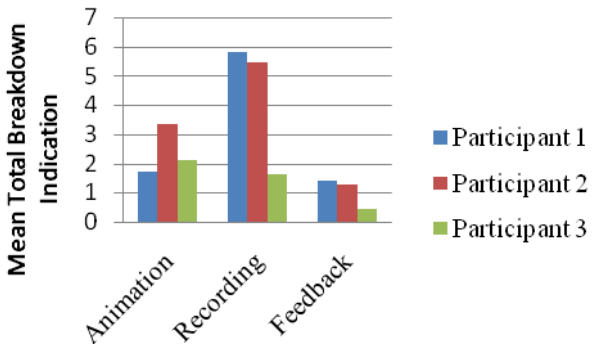

Figure 3. Total mean usability and fun problem

Figure 4 shows the overall total occurrence of each indication found in the animation, recording and feedback scenes of *MyCard*. The results show that the recording scene being the most difficult task for the children as the number of assistance provided by the teachers to the children was high. This happened mainly due to the fact that the children could not spontaneously repeat the word. The breakdown indications like Puzzled and Passive were also found frequently occurred during recording interface. The points of indications were investigated in order to determine the usability and fun problems affecting the children when they were interacting with *MyCard*.

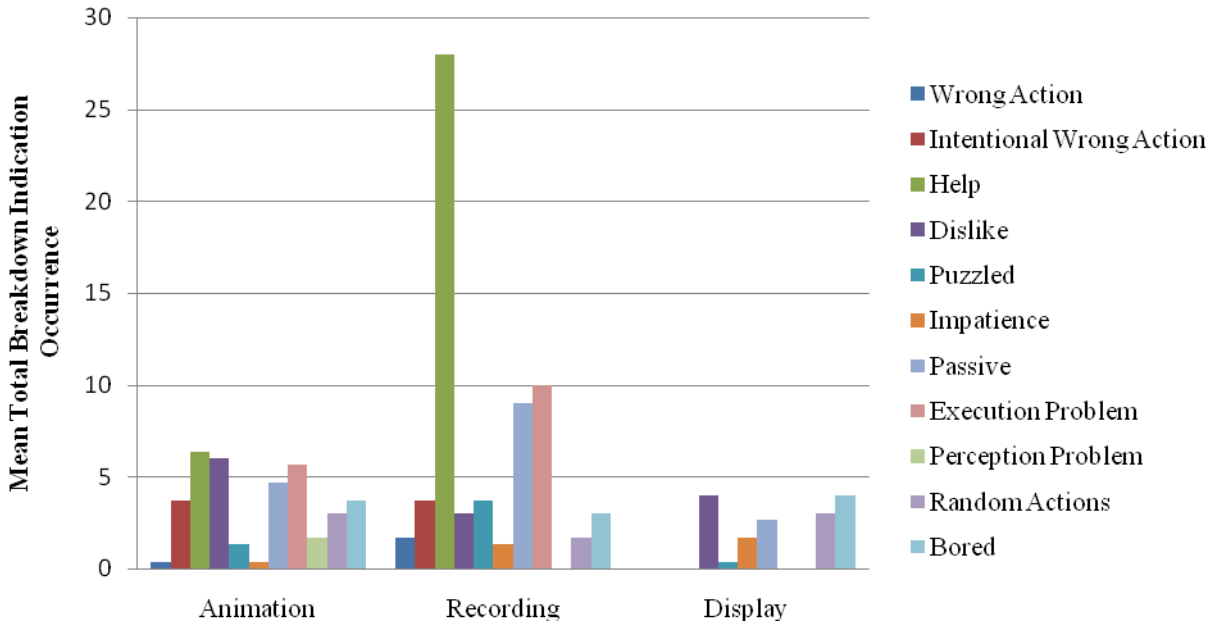

Figure 4. Usability and fun problems of *MyCard*

A. *Animation Interface*

Analyzing the breakdown indications in the animation interface was most confusing. For example, coding the *passive* or *puzzled* indication was confusing in this interface. In the video analysis, the children did not necessary imitate the animation displayed – except P1 who always imitate the animation. This behavior could indicate that the child concentrated while watching the animation but the child is uncertain on what he or she needs to do, or the child is uncertain on the pronunciation of the word. Therefore, the researchers discovered that it was difficult to determine whether the children had usability and fun problems during the animation interface in this study.

The children also indicated dislike when they were interacting with the animation interface. This happened when they could not pronounce the word precisely. This behavior also showed when the teachers selected the word that was not the first choice of the children. For instance, the teachers selected the word Makan for the child to practice when the child requested the word Emak.

The articulation skills of the children also hindered the researchers to identify the usability and fun problems in the animation interface. In many occasions, the children imitated the word while the animation was playing but they often made various and inconsistent pronunciation errors. As a result the teachers offered their assistance to correct the pronunciation of their children during the animation interface. This problem is associated with the children's articulation skill which is not relevant to the usability and fun problems of the *MyCard*.

Nevertheless, there is an interesting finding in the animation interface. Based on the researcher's observations, all the children who participated in this study showed positive reactions when they watched the lip-sync animation (Figure 5); these children were attracted by this animation and they were spontaneously repeated the word when they watched this animation. This demonstrates that the animation could stimulate these children to express verbally, and it could potentially promote speech and language learning among these children.

Figure 5. Lip-sync animation

B. *Recording Interface*

Most of the usability and fun problems occurred when the children were interacting with recording interface of *MyCard*. In the video analysis, it was observed that the children could not repeat the word when *MyCard* did not provide an audio display during the recording of this interface. These children indicated the *execution problems* when they could not repeat the word. For instance, the children remained passive by staring or pointing to the screen to indicate they could not pronounce the word.

The closed observation revealed that the microphone icon and listen-sign animation (Figure 6) failed to work on the children who participated in this study. Both microphone icon and the listen-sign animation were used to invoke the recording feature of *MyCard* so that it could record the pronunciation of the children. It was observed that the children failed to recognize the functionality of these two components which resulted that these children remained passive until further assistance was provided by their teachers. This indicates the microphone icon and listen-sign animation

are less intuitive to these children.

Figure 6. Microphone and Listen-sign animation

Assessing the both mouth and tick-cross icons (Figure 7) were difficult in this study. This is because the children who participated in this study did not utilize the mouth and tick-cross icons when they were interacting with *MyCard*. In the video analysis, it was observed the children who participated in this study were assisted by their teachers when they could not proceed. As a result, these children do not have the initiative to interact with the mouth and tick-cross icon during the session.

Figure 7. Mouth and tick-cross icon

Based on the findings in recording interface, the researchers recognized that both microphone icon and listen-sign animation was a design flaw in *MyCard*. It was believed that both microphone icon and listen-sign animation failed to work on the children in this study due to fact that these two components did not provide any audio display. As a result, these two components appeared less intuitive to the children. Some refinements are needed to be carried out on the microphone and listen-sign animation, and this will be revisited in the discussion section.

C. Feedback Interface

The children showed less usability and fun problems during the feedback interface. In the video analysis, the children often could not pronounce the word precisely during the recording interface which caused the participants to have low scores. Consequently, the children responses indicated *dislike* or *passive* behaviors when they could not obtained high scores. This indicates the feedback (Figure 8) was intuitive to the children who participated in this study.

Figure 8. Rewarding Animation

Based on findings in feedback interface, the design principle of this interface is suitable for children with DS who participated in this study. All the children that participated in this study showed proper responses in relation to the high or low score displayed by *MyCard*; they would look excited when they obtained a high score or they would look disappointed when they obtained a low score. This indicates the feedback displayed by *MyCard* was intuitive to these children.

IV. Discussion

Based on the adapted DEVAN coding scheme, we found that the recording interface caused most usability and fun problems in *MyCard* for the children with DS. This happened mainly due to the fact that the children were confused with the task required during the recording interface. In the development of an application for children with special needs, the interface should be user-friendly in order to encourage the children to use it in a simple and efficient way. In contrast, the interface which is not user-friendly would cause confusion among the children and will hinder their interaction with the application.

The main drawback of the recording interface is that this interface did not provide an audio display. In the video analysis, it was observed that the children could not associate the displayed 'listen sign' after the microphone icon was clicked on the screen. It was also confusing because there was no sound when the listen-sign animation was played. As a result, the children stopped interacting with *MyCard* during the recording interface.

In addition, the children who participated in this study displayed problems to pronounce the isolated Malay words – they made various and inconsistent pronunciation errors. This problem is associated with the children's articulation skills, which is not relevant to the usability and fun problems. However, enhancing *MyCard* to support this problem would lead to the increase of the satisfaction among these children. This in turn would increase the feasibility of *MyCard* as a tool in promoting self-paced speech rehabilitation for children with DS.

The combination of visual and audio display seemed to have an impact on the way the children interact with *MyCard*. For example, in the animation and the feedback interface, it was observed that the children were more likely to get attracted by the audio and visual feedback when the feedback was displayed together. This indicates that both audio and visual display can stimulate the desirability of the children to interact with *MyCard*. Hence, instead of using the visual feedback alone, audio feedback should be added on the microphone icon and listen-sign animation in order to increase its intuitiveness to the children with DS.

Grounded on these results, the recording interface of *MyCard* needs to be improved in order to increase its feasibility as an assistive tool in promoting the self-paced speech rehabilitation among children with DS. A practical way to improve the recording interface is by adding an audio feedback on this interface. For instance, repeating the word's pronunciation when the listen-sign is playing would help to stimulate the children to imitate the word.

In addition, another way to improve the usability and fun problems of the recording interface is by adding a real-time visual feedback when the children are pronouncing the word [19]. For instance, when the children start to pronounce a word, a visual effect is displayed in real-time from the scene. As the feedback is displayed in the real time situation, it tends to capture the interest of the children when he or she is articulating with *MyCard*. Therefore, using real-time visual feedback displays would help to improve the usability and fun problems particularly for children with DS in this study.

In order to solve the problem of various and inconsistent

pronunciation errors among children with DS, *MyCard* should provide the notifications of speech errors for the children with DS. *MyCard* would be more beneficial to the children with DS if it could highlight the pronunciation errors made by these children during the feedback interface. Highlighting the pronunciation errors that the child made would increase the awareness of the child thus causing the child to be alert and improve his/her pronunciation in the next attempt.

V. Limitations and Future Work

One major limitation of this study is the limited sample size of children with DS. As mentioned earlier, recruiting suitable participants is often challenging in any HCI research, especially when it involves with children with special needs. In this study, the primary qualification of the recruitment of participants for this study is the children must have some basic imitation or articulation skills in order for them to interact with *MyCard*. Nevertheless, majority of the children with DS from the KDSF centres do not meet this qualification because their speech and language skills are severely delayed. Furthermore, due to privacy reasons which includes stigma issues, majority of the parents are not willing to expose the identity of their child to the public. Further studies with larger sample size are required to validate the usability and fun problems of *MyCard* and to allow new discoveries on the feasibility of *MyCard* as an assistive tool in promoting self-paced speech rehabilitation among children with DS.

This study also overlooked at the difficulties of the isolated Malay words when developing the Malay ASR engine for *MyCard*. It was believed that the isolated Malay words selected for this study are ideal for the children with DS to practice. However, based on the observations, the children in this study showed the opposite results in which they could not articulate these word correctly. Therefore, future studies should start with basic phonemes such as alphabets for the development of Malay ASR engine. This would allow more children with DS who are eligible to participate in the evaluation with *MyCard* as well as helping to increase the validity of the findings.

A longitude study that spans a period of several weeks should be carried out in order to obtain more reliable findings. The duration of the test session often takes 60 to 90 minutes to complete. This implies that the teachers at the KDSF centres have to allocate the timeslot for the test session during their speech therapy lessons. Inevitably, it shortens their therapy session with their children and it would influence their teaching timetable for the children in the centre. Therefore, a longitude study could not be implemented in this study. Nevertheless, conducting a longitude study would help to assess the effects of *MyCard* over a longer period of time on self-paced speech rehabilitation progress among children with DS. This would provide more reliable results on the usability and fun problems of *MyCard* and its feasibility as an assistive tool in promoting self-paced speech rehabilitation among children with DS.

Due to the scope of this study, only DEVAN method were used to assess the usability and fun problems of *MyCard*. It is important to highlight that no single usability method could identify all the usability problems of an application. Therefore, DEVAN method could overlook some usability and fun problems of *MyCard*. Using other evaluation methods could complement the findings of DEVAN method which could yield more reliable results on the usability and fun problems of *MyCard*. There are numerous other evaluation methods based on the usability testing or inspection methods which are worth to be examined. Further studies are required to investigate the efficacy of these methods in eliciting the usability problems of *MyCard*.

VI. Conclusion

This paper examined the usability and fun problems of *MyCard* using the DEVAN coding scheme adapted from Macedo and Trevisan [18]. Ideally, usability testing with representative user, like DS in this study, will reveal as many aspects of *MyCard* as possible which caused problems. In this study, we have identified that the recording interface which is the most difficult interface for the children when they were interacting with *MyCard*. After identifying the existing problems in this study, the problems solved in the *MyCard* should lead to the increase in satisfaction among children with DS. This in turn would increases the feasibility of *MyCard* as an assistive tool that promotes self-paced speech rehabilitation for children with DS. Finally, we believe that the findings from this study provide some insights for future development of similar applications and for other related studies which are not limited to the area of speech rehabilitation and interaction design for the children with special needs.

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