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Learning Software Application Design Model for Children with Cerebral Palsy

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***Abstract*— Most of the software applications for children with cerebral palsy (CP) do not focus on learning issues. This study describes the learning issues for children with CP and their requirements. The findings are translated into a Learning Software Application Design Model (LSADM), which could be used in developing other types of learning software application for children with CP. Guidelines for designing and developing a learning software application prototype that are compatible with the limited capabilities of children with CP are developed and presented to ensure they are able to grasp the concepts of a learning software application. The prototype is developed using a game application and a GlovePie Tool. By following this model and implementing them in the development process, can support learning and motivate learners to have interest on learning.**

Keywords — Cerebral Palsy, Learning Application Software, Disabled Children, Game Application.

I. INTRODUCTION

Cerebral palsy (CP) is one of the three most common lifelong developmental disabilities, with prevalence rates ranging from 1.5 to 3 per 1000 live births [1]. This type of disability is described as a group of disorders affecting the development of physical body movement and posture, causing activity limitation that is attributed to non-progressive disturbances. It is reported that CP is the most prevalent chronic childhood motor disability with an estimated lifetime medication cost of nearly $1 million per person in a 2003 report [2].

CP is the leading cause of childhood deformity and the second leading cause of severe mental retardation [3]. Children with CP have an increased prevalence of associated comorbidities, including intellectual disability (52%), epilepsy (45%), speech/language deficits (38%), vision impairment (28%), and hearing impairment (12%) [4].

Children with CP sometimes face additional physical and cognitive difficulties. As mentioned earlier, damage can extend to multiple areas of the brain that can result in impairing several kinds of functions. Meanwhile, abnormal muscle tone and poor motor control can pose obstacles to learning and development.

Most of the mentioned problems may lead to learning difficulties among children with CP. This requires immediate attention of application designers, so that these children may also benefit by the advancements of technology to ease their livings. This is because we do not want them to lose out in this technologies century. Negligence towards this issue may cause children with CP to face a digital divide between the normal healthy children.

One of the common problems in learning by the children with CP is the difficulty with hand control affecting the basic life necessities of holding, gripping, handwriting, cutting, pasting and cooking etc. The problems with handwriting task may include difficulty in keeping the paper steady, setting out work or completing work within a specific duration. This paper aims to study the design principles and requirements for developing a game learning application prototype on children with CP.

The structure of the paper is as follows. The next section presents the literature review. Section III describes the proposed Learning Software Application Design Model. Section IV exemplifies the model by illustrating the prototype

development. The final section discusses and concludes the paper.

II. Literature Review

Solving the learning issues among children with CP is the first step that should be addressed in order to develop a learning software application. There are a number of systematic literature review that has been done for children with CP [5, 6, 7, 8], with the number of work focuses on learning application increases from year to year. Unfortunately, most of the learning applications do not focus on children with CP.

According to findings in [5, 6, 7, 8], most of the software learning design focuses on disabled children with autism and those who are of slow learner. As for the children with CP, most of the developers focus on their rehabilitation and also their motor exercise, instead on the learning activity.

Table I outlines several learning issues among children with CP that we need to highlight and consider. From the table, children with CP usually have problem with their motor such as fine motor or coordination, gross motor skills and also motor planning difficulties. The ideas to be considered to solve this problem are, breaks down activities into small steps and use the students' interests to motivate them to participate in activities, and also tries to repeat the activity again. Although this problem is related with motor, it can be solved by allowing more time for the children to learn new skills and consider the student's interest to get their attention and focus.

TABLE I. LIST OF LEARNING ISSUES AMONG CHILDREN WITH CP

Type of Learning issue	Description	Effect
Fine motor / coordination [9,10]	Difficulty with hand control may affect student's abilities with handwriting.	Unable to keep the paper steady, set out work or complete work within a specific time.
Gross motor skills [9,11]	Difficulty with movement and postural control that may affect their ability when sitting or moving around the classroom.	Children may tire easily if it takes too much effort.
Motor planning difficulties [9,12]	Have problems to know what they want to do and have difficulty planning in their minds how to go about it.	They will rush into activities without carefully planning the stages required in order to complete them.
A short attention span [9,13]	Some children may be more easily confused.	Children may get bored easily and not focus on the subject.
Perceptual difficulties [9,13]	Difficulties with interpreting information from their senses	Difficulties with reading, spelling and number work.
Communication/ language difficulties [9,13]	Difficulties with understanding spoken and written language such as following instructions, understanding concepts and reading	Their action or work maybe adopt by looking and following their peers.

Children with CP also have problem with their mental disabilities such as a short attention span, perceptual difficulties, and also communication and language difficulties. The ideas to consider solving this problem are, use the listening game and also use simplify instructions [9, 13]. We can also consider adding music in their learning classes [9, 15]. Other than that, we can use the students' interests to get them to focus and give attention to their learning subjects [9, 13].

III. The Proposed Learning Software Application Design Model

This section describes the proposed learning software application model to overcome the learning issues for children with CP. Figure 1 shows the proposed learning software application design model (LSADM). The model consists of five activities. Each of the activity is described in detail in the following sub sections.

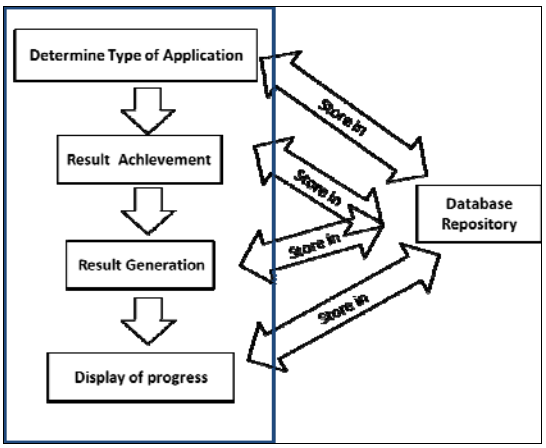

Fig 1. Learning software application design model

A. Type of Application Determination

The first step to develop a learning software application for children with CP is to determine the type of application. There are four types of application that can attract children with CP attentions, which are game, video, education and entertainment [14].

The proposed learning software application for children with CP may include a game to entertain children with CP, which studies have shown that people with CP benefit from video game-playing [14]. The game application in learning

software application will make the learning process more interesting and fun. The benefit of this application will make the children with CP more interested with the learning process. Based on the literature review and observation at *Pemulihan Dalam Komuniti* (PDK), these learning software applications may also contain music and brain games element. Research has shown that music therapy helps with alertness because the beat of the music helps a child build connections within the brain that help them concentrate and focus. This helps the child respond to external stimuli quickly and appropriately. It can also ease muscle tension, which is something that can significantly benefit a young person who has CP. The rhythmic nature of music also helps children with CP organize their gait; they can time their movements to the beat of the music. This, in turn, allows therapy to take place in a way that is fun for a child [15].

Researchers have also proved that playing puzzles and other brain games goes beyond mere rest and relaxation. These games actually help in delaying the memory-related diseases like Alzheimer's disease and dementia. Solving puzzles and playing brain games can actually help maintain the mental faculties of an individual. Puzzles and other brain games help maintain an active mind. It also helps children with CP to become more productive because their mind is trained for analytical and problem-solving skills [16].

According to a study published online in the Archives of Physical Medicine and Rehabilitation, children with CP may benefit from playing active video games (AVG), such as Nintendo's Wii. The researchers found that not only did children enjoy playing AVGs, the games can also help children attain moderate levels of physical activity and could potentially be used in rehabilitation therapy [17].

Other than that, literacy curriculum video is the type of educational application that can be used for children with CP. This curriculum is specifically designed for learners who have difficulty using speech to communicate. For this curriculum, it focuses on Reading Comprehension to enhance their reading skill and the literacy curriculum develop in video type which the instructor as a host of the video.

The reading comprehension strategies include comprehension monitoring and summarization, graphic and semantic organizers, and cooperative learning. In comprehension monitoring and summarization strategies children with CP are taught to stop at regular intervals while reading a text and determine whether or not they understand the text. The children with CP will summarize the main idea of each part of the text and for example, answering two questions such as who is this part about and what happened.

B. Result Achievement

The results achievement in the chosen application is based on how the children with CP use the learning software application and their learning progress.

For each application, the target is to help children with CP in the learning process. So for each application, the outcome is different. For a video game application such as Active Video Game (AVG), the result would be obtained from children with CP by observing them in a specific duration of time that are fixed by the trainers at PDK to see the result. For instance, the children need to spend a 6-week period to complete a set of a game program, as it takes time to see the improvement of learning for the children with CP.

C. Result Generation

For this activity, the learning software application will generate result based on the types of learning software application chosen. The children will have a table "Achievement" that stores their grade scored when they finished the tasks on the learning software application.

D. Progress Display

Display Progress activity is closely related to Generate Result. It is to provide the report of the children with CPs' achievement. This report can be used as a report card that can show student achievement to their parent. This report can also be used to show the student's performance in school. Parent and teacher can also use this report to encourage the student to do the task and give more support to them.

The results are represented as a bar chart with the percentage (%) score of each application and combine the result together to see the children with CP achievement. Fig. 3 illustrates an example of a result progress report.

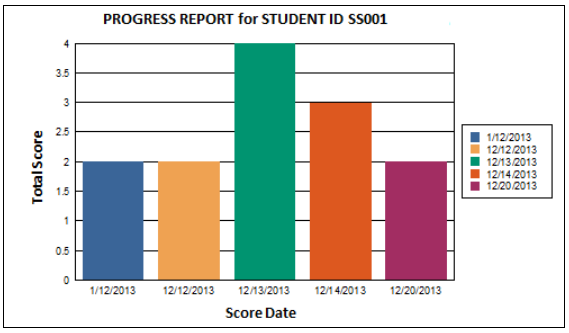

Fig 3. An example for a result progress report

E. Database Repository

The learning software application will use SQL Management Studio 2008 to store the reference to all data such as words and numbers. The database should have a unique identification number (primary key) for each child with CP. The table "Users" stores the children with CP personal information (Unique identification number, name, birth date, language, repeated time, language) and the table "Achievement" that store their grade scored when they finish the task. The entire database about the users, task and achievement is done through the Microsoft Excel that store when the children with CP complete the task. The achievements accounted by the users are stored in the database with a unique relation with the user identification number. The achievement is saved into the children accounts when they finish the task completely.

IV. Prototype Implementation

This section describes the techniques and methods used during the development of the prototype. This prototype uses GlovePIE tool that can control the keyboard using a microphone. The tool is preferred as it caters both languages; Malay and English, as the children with CP may speak using

the language they prefer. The voice or speech will be detected by a microphone.

The following sub-sections describe the development and implementation of a prototype based on the proposed learning software application model for children with CP as a proof of concept.

A. How the model can be applied?

The proposed model is to be used for designing a learning software application for children with CP. Based on the proposed model in Fig. 1, there are five activities that need to be performed in developing a learning software application for children with CP:

1. Determine the type of application.
2. Get result Achievement.
3. Generate result.
4. Display progress report.
5. Store data and information

The first four activities must interact with the repository, at the same time. The following sections will discuss each activity individually.

In order to gain attention of the children with CP, the application should have the elements that can get the children to pay attention and focus on the learning process. To exemplify the usage of the model, we will be developing a prototype application based on the suggested elements as shown in Table II.

TABLE II. SUGGESTED ELEMENTS FOR A LEARNING SOFTWARE APPLICATION

Type of application	Input device	Example of Type of application
i. Music i. Brain Game	i. Mouse ii. Headphone with microphone	i. Math Game ii. Music Therapy

B. Requirement and Installation

This prototype uses GlovePIE [18] as a tool to control the keyboard. The GlovePIE need to be first installed in the computer. GlovePIE stands for Glove Programmable Input Emulator. It does not have to be used with the VR Gloves, as it was originally started as a system for emulating Joystick and Keyboard Input. Now it supports emulating all kinds of input, using all kinds of devices. Fig. 4 is an example of the GlovePIE interface.

C. Implementation of Learning Software Application Design Model

Step 1: Determine Type of Application

Learning software application for children with CP may use a brain game such as Puzzle Games, Sudoku Puzzles, Word Games and Math Games to improve their brain abilities. The most common way to develop brain is to solve puzzles and play logic games, like chess [16]. There are other ways to develop human brain. Brain games such as application based on puzzle game can be developed or designed according to their limitations.

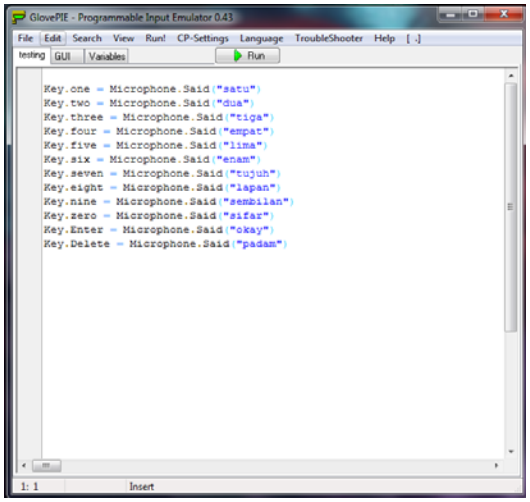

Fig 4. The GlovePIE tool interface

In this learning software application, we use open source math game "Count the Sheep" as a brain game. In this game children with CP need to count the correct number of sheep without being fooled by the disguised wolves. A number of sheep will appear at the start of each level, and he/she will have a few seconds to observe them. After that, he/she needs to report the exact number of sheep on the grassland, and he/she can click the corresponding number on the screen or use his/her keyboard to give his/her answer. Click the Submit button to check the result, and he/she can proceed to the next level if his/her answer is correct. As he/she advances in the game, the number of sheep will increase, and more disguised wolves will join the game. Fig. 5 until Fig. 7 shows the interface for Count the Sheep.

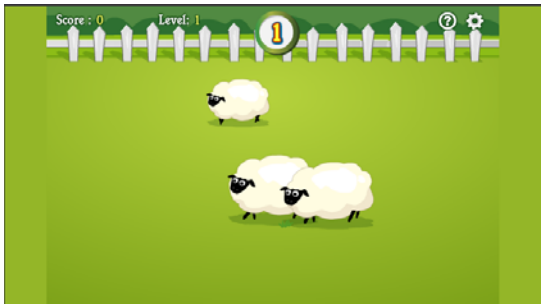

Fig 5. Count the Sheep – Math Game

Fig. 6. The Math Game total score.

Fig. 7. The interface for correct answer

The prototype uses a microphone which is attached to a headphone to enter the answers. Microphone is suitable for children with CP because they can manipulate the microphone by voice and speech to answer the question on screen. Fig. 8 shows an example of a headphone that used in the game prototype.


Fig 8. An example of headphone mouse

The prototype has been accomplished using the GlovePIE and the "Count the Sheep" game as an education game for children with CP. Fig. 9 shows the coding part for the learning game application prototype.

```
testing | GUI | Variables | Run

Key.one = Microphone.Said("satu")
Key.two = Microphone.Said("dua")
Key.three = Microphone.Said("tiga")
Key.four = Microphone.Said("empat")
Key.five = Microphone.Said("lima")
Key.six = Microphone.Said("enam")
Key.seven = Microphone.Said("tujuh")
Key.eight = Microphone.Said("lapan")
Key.nine = Microphone.Said("sembilan")
Key.zero = Microphone.Said("sifar")
Key.Enter = Microphone.Said("okay")
Key.Delete = Microphone.Said("padam")
```
Fig. 9. Coding part for learning game application

V. Discussion

The learning software application prototype was developed based on the proposed design model for Children with Cerebral Palsy. In this learning software application, we use open source math game "Count the Sheep" as a brain game. This prototype uses GlovePIE as a tool to control the keyboard. Trainers record the result that obtained on how the children with CP use the learning software application. The learning software application will generate result. The application will provide the report of the children with CPs' achievement. Fig. 9 shows the system design for the learning software application prototype.

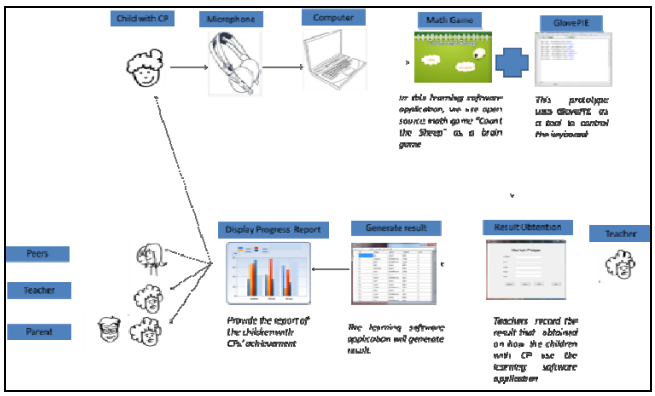

Fig 9. System design for the learning software application prototype

The evaluation of this study uses an empirical evaluation model for validation as this type of evaluation will be able to measure the user satisfaction with the proposed model. This phase could also get the feedback from the users about their satisfaction when using the proposed model.

The suitable empirical evaluation is user experience because we want to investigate how the children with CP feel when using the application prototype. Observation was selected for gathering user experience from non-verbal expressions because the children with CP may not be capable to express their word verbally. The interviews and observations also conducted among the teachers to get their user experience from their point of view.

The evaluation will be conducted with the children with CP community (PDK). PDK or Community-based rehabilitation (CBR) focuses on enhancing the quality of life for people with disabilities and their families, meeting basic needs and ensuring inclusion and participation. PDK "One Stop Centre" as a "Focal Point" because it is a program that uses an integrated approach to community in every region and state. Through PDK "One Stop Centre", services for the disabled will be available at one place to facilitate them and the local community to get information, advice and current needs as well as appropriate training [19]. The next stage is to allow the children with CP to use and test the proposed design model and also get their comments and feedback. Fig. 10 shows actual performance for the learning software application prototype.

VI. Conclusion

Applying the design principles and guidelines are very important for developing a learning software application for children with CP. By observing both the user interface design principles and the learning issues of the children with CP have derived to a learning software application design model. By following this model and implementing them in the development process, it can be helpful for the children with CP to increase their learning process and also improve their brain

abilities. A simple game application and usable interaction design will definitely support learning and motivate learners to have interest on learning.

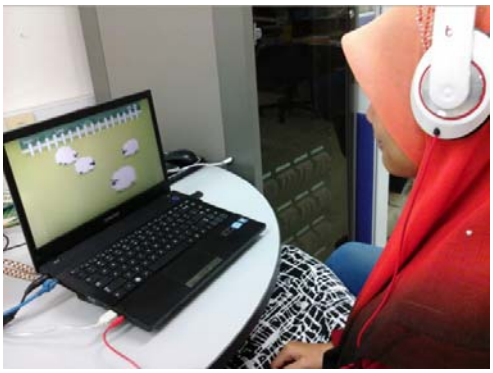

Fig 10. Actual performance for the learning software application prototype

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