Learning through Playing for Children with Cerebral Palsy

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Graphical abstract

Abstract

Guidelines for designing and developing a learning prototype that are compatible with the limited capabilities of children with Cerebral Palsy (CP) are established in the form of a model, known as Learning Software User Interface Design Model (LSUIDM), to ensure children with CP are able to grasp the concepts of a learning software application prototype. In this paper, the LSUIDM is applied in developing a learning software application for children with CP. We present a user study on evaluating a children education game for CP children at Pemulihan dalam Komuniti in Johor Bahru. The findings from the user study shows that the game, which was built, based on the LSUIDM can be applied in the learning process for children with CP and most notably, the children are engaged and excited using the software. This paper highlights the lessons learned from the user study, which should be significant especially in improving the application. The results of the study show that the application is proven to be interactive, useful and efficient as the users used it.

Keywords: Cerebral Palsy, learning application software, disabled children, game application

Abstrak

Garis panduan untuk mereka bentuk dan membangunkan prototaip pembelajaran yang bersesuaian dengan keupayaan terhad kanak-kanak Cerebral Palsy (CP) diwujudkan dalam bentuk model, yang dikenali sebagai Model Reka bentuk Antara Muka Pengguna Perisian Pembelajaran (LSUIDM), untuk memastikan kanak-kanak dengan CP dapat memahami konsep aplikasi prototaip perisian pembelajaran. Dalam kajian ini, LSUIDM yang digunakan dalam membangunkan aplikasi perisian pembelajaran untuk kanak-kanak dengan CP. Di sini, kami membentangkan satu kajian pengguna untuk menilai permainan pendidikan kanak-kanak untuk kanak-kanak CP di Pemulihan dalam Komuniti di Johor Bahru. Penemuan daripada kajian pengguna menunjukkan bahawa permainan yang dibina berdasarkan LSUIDM yang boleh digunakan dalam proses pembelajaran untuk kanak-kanak dengan CP dan paling ketara, kanak-kanak terlibat dan teruja dengan menggunakan perisian. Kertas kerja ini menekankan pengajaran yang diperoleh daripada kajian pengguna, yang sepatutnya menjadi penting terutama dalam meningkatkan aplikasi. Keputusan kajian rintis pengguna menunjukkan bahawa aplikasi ini terbukti interaktif, berguna dan berkesan apabila pengguna menggunakannya.

Kata kunci: Palsi Serebrum, Perisian Aplikasi Pembelajaran, Kanak – Kanak Kurang Upaya, Aplikasi Permainan

1.0 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]. CP describes a group of disorders affecting the development of physical body movement and posture, causing activity limitation that is attributed to non-progressive disturbances. 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. 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 [5].

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 evaluate a children education game for children at *Pemulihan dalam Komuniti* (PDK) in Johor Bahru. The game was built based on the Learning Software User Interface Design Model (LSUIDM), which concentrates in the development of a learning software application for children with CP [6]. As LSUIDM considers the requirements of learning for children with CP and consists of a number of suitable components that suit the objective, we use LSUIDM in this study to demonstrate its usage and implementation.

2.0 BACKGROUND AND RELATED WORK

From the Systematic Literature Review that has been performed earlier [5], the number of work focuses on learning application increases from year to year but most of the learning application do not focus on children with CP. According to the findings, most of the software learning design focuses on other types of disabled children, such as autism and slow learner. The developers only focus to train the children with CP for their rehabilitation and also their motor exercise, but not on assisting the children on learning.

At PDK Tanjung Puteri, they use the conventional puzzle game as part of the training for the CP children. The puzzle game has knobs on each puzzle to allow children with CP to hold and grip and place the puzzle on the correct position. According to the trainer, children with CP take up a lot of time to hold and grip the puzzle and to finish the entire puzzle. This type of game aims to train their rehabilitation and also to fulfil their time at the PDK. This game is used to avoid children with CP from getting bored and to stay in focus. Figure 1 shows a puzzle game used at the PDK.

Figure 1 Puzzle game as a conventional game

For the progress report, the trainer uses the manual record to record the children progress. In this progress record, the trainer will fill in the record every week for track a month performance. The trainer needs to check whether the student can do it on their own, can do it but need other's help, or cannot do it for every activity that have been assigned for them.

Figure 2 shows their learning process in classroom. The children seat together at one table and the trainer will assist them to do the activity. The trainer will approach them to do the activity until they can complete the task.

Figure 2 Children with CP in class activity

There are many other existing games for children with CP which already in use around the globe, such as Computer Assisted Music Therapy [11]. This system lets the music composition and creation activities, and games of follow sound-and-colour that developed with Augmented Reality techniques. Users are allowed to create the melodies, and use them as a new music composition to simulate sounds of various musical instruments.

Other than that, there is an Entertainment and Social Interaction Applications [8]. The application targets to provide easy access to different entertainment mediums like, reading book, listening to music, watching videos, and accessing social network sites like Facebook and Gmail. People with CP lack motor control that causes full or partial malfunctioning of body parts responsible for generating speech and limb movements [8]. Their proposed framework is integrated with an easily accessible auto scanning mechanisms that helps people with motor disorders to access computer applications.

Table 1 lists several learning issues among children with CP that need to be highlighted and considered I this study. 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 that can be considered in order to solve this problem are, (i) to break down activities into small steps and use the students' interests to motivate them to participate in activities, and (ii) to repeat the activity again. Although this problem is related with motor, it can be considered in the learning process by allowing more time for the students to learn new skills and consider the student's interest to get their attention and focus.

Children with CP also have problem with their mental disabilities such as short attention span, perceptual difficulties, and also communication and language difficulties. The ideas that can be considered in solving this problem are, (i) use the listening game and (ii) use simple instructions [11, 12]. We can also consider adding music in their learning classes [11, 12]. Other than that, we can use the students' interests to get them to focus and give attention to their learning subjects [11, 12].

Children with CP regularly have problem with learning process. They have difficulty processing certain types of information because they have learning disability at average or below average level of intelligence. In addition, many children with CP are limited in their ability to communicate can cause them to having a learning disability. Because of this, children with CP are sometimes deemed to have much less intellectual ability than they actually do, as if they are unable to speak, teachers may not be able to tell whether or not the child get the point of the lesson. Due to this, many children with CP are unessentially placed into special education programs, many of which focus much of the time in school on different therapies, to the detriment of academic progress [11].

According to [11], to teach the children with CP, the teachers need to make sure that the classroom is easy to get around and free of obstacles. The children with CP may need to miss class time for doctor visits or to see the school nurse to take medication. Other than that, the teacher need to give special consideration regarding missed instruction, assignments, and testing. In some cases, arranging for verbal responses in assignments and testing can be a good way to measure learning.

Educators, parents, doctors, therapists, and the students with CP should work together to develop and maintain the best treatment and education plans. Be prepared for possible medical emergencies by planning ahead with parents in case the students with CP need advanced assistance.

Table 1 List of Learning Issues among Children with CP

Type of Learning issue	Description	Effect	Type of Game
Fine motor / coordination [11, 13]	Difficulty with hand control may affect a student's abilities with handwriting and anymore.	Unable to keep the paper steady, set out work or complete work within a specific time.	Typing and scratch game.
Gross motor skills [11, 13]	Difficulty with movement and postural control that may affect their ability when sitting or moving around the classroom.	Student may tire easily if it takes too much effort.	Role-playing game.

Type of Learning issue	Description	Effect	Type of Game
Motor planning difficulties [11, 13]	Have problems to know what they want to do but 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.	Educational game.
A short attention span [11, 12]	Some students may be more easily confused and / or unable to focus for as long as their peers.	Student may get bored easily and not focuses in study anymore.	Educational game.
Perceptual difficulties [11, 12]	Difficulties with interpreting information from their senses	Difficulties with reading, spelling and number work.	Puzzle game.
Communication/ language difficulties [11, 12]	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.	Singing game.

3.0 GAME DEVELOPMENT

This section describes the techniques and methods used during the development of the prototype. Figure 3 below illustrates the LSUIDM, which is followed and adhered to in the developing the game. LSUIDM offers guidelines for designing and developing a learning prototype that are compatible with the limited capabilities of children with CP.

The following subsections describe the proposed learning software user interface model to overcome the learning issues for children with CP. This design model refer to [13] work. The identified conceptual components in this study are more similar to Ghosh *et al*. [13], which is the target user are the same; student and trainer. Although Ghosh *et al*. (2003) work focus on course administration system, some module can be used in this study. The difference of this study to theirs is our students' results achievements are stored in the database to keep track and see the children with CP performance. The model consists of the

following: (i) determine type of application, (ii) result achievement, (iii) result generation, (iv) display progress and (v) repository. Figure 3 illustrates the proposed Learning Software User Interface Design Model (LSUIDM).
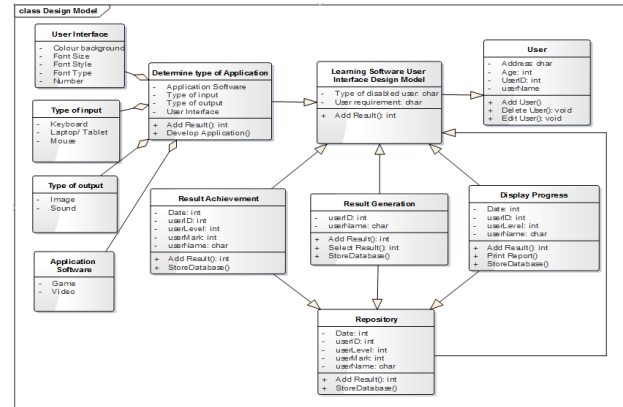

Figure 3 Learning Software User Interface Design Model (LSUIDM)

The following sub-sections describe the development and implementation of the game based on the Learning Software User Interface Design Model (LSUIDM) for children with CP [6] as a proof of concept.

3.1 Requirement and Installation

This prototype uses GlovePIE [13] as a tool to control the keyboard. GlovePIE stands for Glove Programmable Input Emulator. The GlovePIE needs to be installed in the computer. 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. Currently it supports emulating all kinds of input, using all kinds of devices. Figure 4 is an example of the GlovePIE interface.

This GlovePIE tool 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.
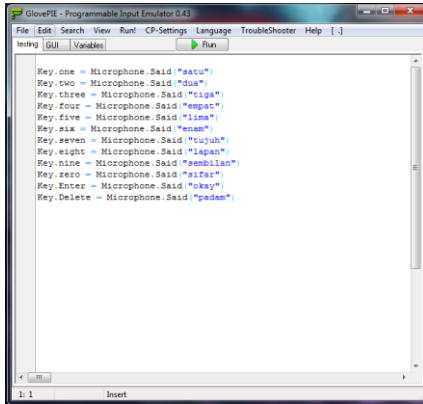
Figure 4 The GlovePIE tool interface

Figure 5 Count the Sheep – Math Game

3.2 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 [14]. 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.

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. By clicking 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. Figure 5, Figure 6 and Figure 7 shows the interface for Count the Sheep.

The prototype uses 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. While Figure 8 shows the coding part for the learning game application prototype. Figure 9 shows the children learn using the headphone mouse.
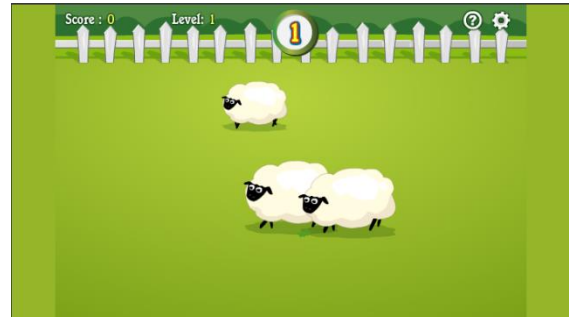

Figure 6 The Math Game total score

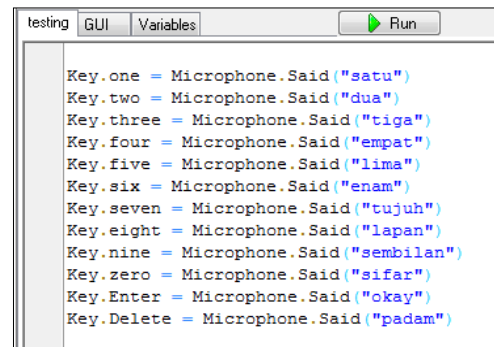**Figure 7** The interface for correct answer

Figure 8 Coding part for learning game application

Figure 9 The children learn using the headphone mouse.

Step 2: Obtained Results

The results obtained in this study are based on how the children with CP use the learning software application and their learning progress process. It is also based on the result the children with CP obtain from the type of application software such as game, education, and entertainment. The result obtained after children with CP play the application game four times a week to see their performance and achievement.

The trainer will assist the children with CP to play the Count the Sheep application game. In this game, the children with CP need to count the correct number of sheep's without being fooled by the disguised wolves. A number of sheep will appear at the start of each level, and the children with CP will have a few seconds to observe them.

After that, the children with CP needs to report the exact number of sheep on the grassland, and he/she can click the corresponding number on the screen or use the children with CP keyboard to give the answer. By clicking the Submit button to check the result, and the children with CP can proceed to the next level if the children with CP answer is correct.

As the children with CP advances in the game, the number of sheep will increase, and more disguised wolves will join the game. After they finished playing the game, the trainer will store the children with CP achievement result such as mark, level, score, and date in the application repository.

In educational application such as literacy curriculum video, the result obtained during at the end of the learning session. It will be obtained at the end of the learning session because the children with CP will have to answer correctly questions at the end of the video. In this application, it focuses on reading comprehension to enhance their reading skill and literacy curriculum develop in video type which the instructor as a host of the video.

At the end of the literacy curriculum, it will provide questions or exercises that must be answered by the children with CP. If the children with CP can focus and give attention in this learning session, and answer the question correctly, it means the literacy curriculum can give interest to them to keep on track for this learning session.

Step 3: Result Generation

For this module, the learning application design model will generate results based on the three learning application models, which are video game application, educational application and also entertainment application. Generate result which is part of the management section, is to provide the access to the results visualization of the users once the profile management option is selected. The results are represented as a bar chart with the percentage score of the each application and combine the result together to see the children with CP achievement. Figure 10 illustrates an example of result report graft.
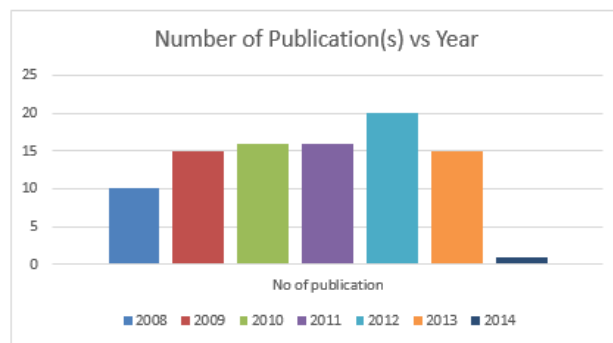
Figure 10 An example for results report graft

The trainer will need to fill in the detail of the students score in the application repository. Progress button will display the progress interface. The trainer will select the student name that they want to see how their progress is and then click OK button.

For each application, the target is to help children with CP in their learning process. Therefore, for each application the outcome is different. For video game application, such as the Active Video Game (AVG), the result is obtained from children with CP by observing them in specific duration that is fixed by the PDK to see the result. For the AVG application, the learning software application need all the participants of children with CP to complete the study had 100% attendance for the entire six weeks period to see result of this type of application because this application takes time to see the improvement of children with CP learning process.

Step 4: Display Progress

Students have a table named Achievement that store their grade score when they finished the task of learning application model. The Storage and Management block/module should perform to provide report of the children with CP achievement.

This report can be used as a report card that can show student achievement and performance in school to their parents. Parents and teachers can also use this report to encourage the student to do the task and give more support to them.

Step 5: Repository

The learning application model will use the SQL Management Server database to store the reference to all data such as word and number. The database should have unique identification number (primary key) for each child with CP. The table Users stores the children with CP information details and the table Achievement will store their grade scores when they finish the task. All the database about the users, task and achievement is done through the SQL Management Server database, that store in real time when the children with CP complete the task. The achievements accounted by the users are saved in the database with a unique relation with the user identification number. The achievement will be stored into children with CP account when they finish the task completely.

4.0 USER STUDY

4.1 Participants

The participants of the study are both students (children with CP) and trainers at the *Pemulihan Dalam Komuniti* PDK Tanjung Puteri, Johor Bahru. The participants use the application four times in different days to see how they can evaluate the application accurately. After the fourth use of the application, the trainer answered some question about the evaluation of the application. A total of 10 participants, consisting of 5 males and 5 females all of them are male children with CP where their ages are between 7 and 12 years, came from diverse cultural, ethnic and social backgrounds. This study also includes 5 trainers as a participant.

4.2 Material

Users interact and communicate with the application via the program interface. In addition, between the users and the computer, the interface can also be used for fetching and sending information. Figure 11 shows the home interface of the system.
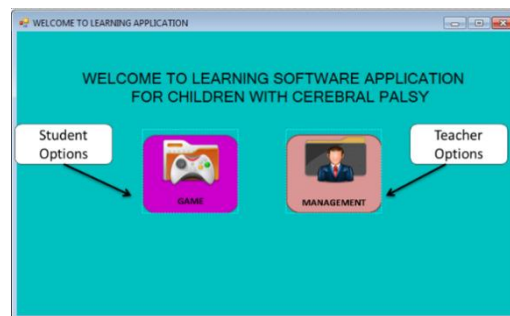

Figure 11 The home interface of the system.

The home interface is designed to allow user to start using this application. There are two options for the user; either to login as a student or a trainer. These are reflected by the two image buttons in the home interface. These buttons will allow the user to select either playing the game (usually for the children with CP) or monitoring the management process (trainer).

4.3 Procedure

The study took four days in a class room at PDK Tanjung Puteri, Johor Bharu. This is the first category of the survey and observation which give us a clear view about how our participants deal with the learning application design model prototype in their learning process.

For the user perspective, because there are two types of users, which are children with CP and the trainer, we observed the children with CP performance when they use the application whether they show or act when they like the application or not. For the trainer, we conduct a survey and questionnaire.

There are two parts to the questionnaire. One is about the model itself i.e. the LSUIDM, second is on the acceptance of the application prototype. For the first part, questions are focused on the components of the model, which are, the types of input and output used in the learning application, the involvement of the trainers in supporting the application by having control in the Management subsection, and the way the results are being generated and displayed.

In the second part, we have four questions that need to be answered by the trainers regarding to whole learning application prototype which include the login time, ease of use, usability and overall performance. The login time for the prototype gives an idea on how long the users will take to login, how the response time from the application to the user activity, can the user make any corrections or go back for some operations during their verification process and if the overall performance and usability features has been achieved in the prototype design to give the complete idea about overall application performance. Each question carries five answers (likert scale) starting from completely dissatisfied,

dissatisfied, not sure, satisfied and completely satisfied.

5.0 RESULTS AND DISCUSSION

Here we report the questionnaire results on the graphical password system as a whole system and the usability features on it.

5.1 Observation Evaluation

We observed the children with CP when they used learning application design model is the way to evaluate the prototype. Observations of children interactions and engagements with materials and other children within the classroom is a valuable means of assessing student learning. The trainer finds out under what conditions success is most likely, what individual students do when they encounter difficulty, how interaction with others affects their learning and concentration, and what students need to learn next. Observations may be informal or highly structured, and incidental or scheduled over different periods of time in different learning contexts.

We include the evaluation about the LSUIDM as part of qualitative evaluation, as the questions were subtly asked. The trainers were happy to be part of the application besides the students, i.e. as the user who records the progress, maintain the information on the system. They also were keen on the type of input and output being used in the prototype, but suggested to consider music therapy as the backgroundmusic to attract student and keep them playing the game. As part of the output, the trainers further suggested to differentiate each character in the game with multiple colors and shape.

From the observation result, we seen that children with CP like to play the game and feel excited to play it. At the beginning, the children with CP feel shy but when we try to interact with them and introduced them with the game, they feel comfortable and they try to touch the computer and play the game. Although the children with CP have difficulty to control movement but they manage to click one button less then three minute and the student only take less then 15 minutes to complete one game task with assisted by the trainer while the trainer happy because the children with CP can fulfil their time with education game.

Other than that, the trainers also give some feedback and opinion to improve the game. We also look at the problems faced by the children with CP when they prefer to be the one who nonverbal than verbal but they try to speak the word by followed the trainer voice and try to answer the questions in the game by using voice.

5.2 Questionnaire Results

The trainers need to answer the questionnaire after they assisted the children with CP play the game. Before that, we explained the questionnaire to the trainer to make sure they understand how to answers the questionnaire. To answers the questionnaire, the trainer need to observe the children with CP behaviors towards the prototype whether they like it or not. Other than that, the trainers also can give opinion and feedback about this prototype while they answers the questionnaire. Quantitative use to quantify data and generalize results from a sample to the population of interest.

The trainers were presented with the acceptance level questionnaire at the end of each evaluation. The questionnaire form can be viewed in Appendix B. Overall, the quantitative results show that the participants appreciated the proposed method. After collecting the data from trainer, we start analyzing the questionnaire answers by using Microsoft Excel software and the results will be explained in the following section and it will supported by the percentage graphs.

5.3 Evaluation Towards the Whole System of the Learning Application Prototype

In this category, the evaluation of the whole application of the learning application prototype is also important in our questionnaire, to see the feedback of our participants about the learning application prototype from all views to see how they feel about the prototype and whether they are satisfied or not with it. We have four questions that need to be answered by the trainer regarding the whole learning application prototype which include the login necessity, ease of use, usability and overall performance.

After analyzing the questions regarding the whole evaluation of the prototype we found that 100% of the users agreewith the prototype.From our observation, the trainer feeling grateful and delighted when we present our prototype because until now the trainer only provide the manual puzzle game for children with CP playing just only for fulfill their time when the children with CP at the PDK. Besides that, after we train the trainer on how to play the prototype, the trainer feel happy to train the children with CP on how to play the prototype.

5.4 Ease to Play the Game

From this category, the main goal of the observation checklist is started by evaluating the game of the learning application prototype feedback. In this category the evaluations of the ease of play the game in the learning application is important in our observation to see the reaction from the children with CP when they play and complete playing the game in the learning application prototype.

From the observation checklist, we can see that children with CP behavior such as ability to finish the play, ability to speak, ability to touch the number keypad, ability to count the sheep, and willingness to follow the instruction. Figure 12 shows the table of the observation checklist for children with CP when they play the game.

Category	Ability to finish the play	Ability to speak	Ability to touch the number keypad	Ability to count the sheep	Willingness to follow the instruction
Student Name					
Children 1	YES	YES	NO	NO	NO
Children 2	YES	NO	YES	NO	YES
Children 3	YES	YES	YES	YES	YES
Children 4	YES	YES	YES	YES	YES
Children 5	YES	YES	YES	YES	NO
Children 6	YES	NO	YES	YES	NO

**Figure 12** The observation checklist for children with CP when they play the game

5.5 Ease to Memorize Feature

This category is the evaluation of the ease to memorize feature of the learning application prototype which is important in the usability features in our questionnaire to see the feedback of our participants about the memorization process of the learning application prototype. We have a question regarding to the ease to memorize of the feature in the learning prototype and each question has ease memorize question.

5.6 Ease to Learn Feature

To see the feedback of our participants about the learnability feature of the learning application prototype we used this category to evaluation the ease to learn feature of the learning application prototype which is one of the usability features in our questionnaire.

Regarding to the ease to learn the learning application prototype there are three questions with five answers in this category which includes the ease to learn, simple learning application and improving the learning application prototype understanding. By analyzing the results of the questionnaire we can see that the trainers choose a somewhat easy answer and the participants satisfied with the learnability feature of the application.The percentage of each question to each user obtained from analyzing the results of the questionnaire and take the average of the answer percentage and we illustrate the average in the following Figure 13.
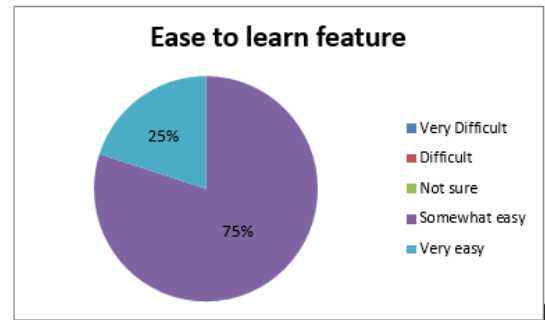
Figure 13 Ease to learn feature

5.7 Design and Screen Layout Application

Regarding the design and the screen layout of the learning application prototype, there are two questions given with five possible range of answers (Likert scale). The results show that all of them show positive remarks with the proposed design and screen layout, with 25% agree and 75% strongly agree. Figure 14 shows that the application screen and layout is very good and most of users agree about that point.
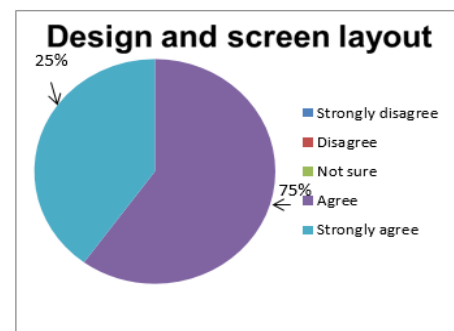
Figure 14 Design and screen layout

6.0 CONCLUSION

This study evaluates the proposed design model in developing learning application for children with CP. From the observation, the children with CP are happy and having fun when they are using the game. From the user study on the game itself shows the student willingly to play the game and complete the game. Applying the LSDAM design principles and guidelines are very important for developing a learning software application for children with cerebral palsy.

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 users 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.

There are some contributions on this study after completing the development process which are:

i This study propose a design model in developing learning application for children with CP and to evaluate the proposed design model in developing learning application for children with CP.

ii This study try to facilitate and develop the learning application design model for them to solve their learning difficulty issue.

iii The design principles and guidelines are very important for developing a learning software application for children with cerebral palsy.

iv This model and implementing them in the development process, it can be helpful for users to increase their learning process and also improve their brain abilities.

Part of the future work are to develop applications that can combine the education and rehabilitation for children with CP (multi-application) to help them learn and rehabilitation at the same time and enhance the model by integrating it with another existing software application for other type of CP such.

Acknowledgement

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