"SynMax": A Mathematics Application Tool for Down Syndrome Children

Afza Shafie[1,*], Wan Fatimah Wan Ahmad[1], Nadhrah Mohd.[1], Josefina Janier Barnachea[1], M. Faisal Taha[1], and Rahmah Lob Yusuff[2]

[1] Universiti Teknologi PETRONAS, Bandar Sri Iskandar, Tronoh, 31750 Perak, Malaysia
[2] Universiti Teknologi MARA Kampus Kuantan, 25200 Pahang, Malaysia
{afza,fatimhd,josefina,mfaisal}@petronas.com.my, rahmah128@pahang.uitm.edu.my

Abstract. Research has shown that the number skills delayed relative to reading skills for Down Syndrome (DS) children. The DS children use the same learning strategy as the normal children, but their learning stages develop more slowly. A possible solution using computer based application, which the children can interact with material that have the integration of visual information and auditory. This paper describes the design, implementation and evaluation of a computer application for learning basic numeracy skills for DS. This application consists of three modules; learning identifying numbers, matching and counting. Dual Coding theory, Schema learning theory and Rapid Application Development (RAD) is employed in the design. Initial user acceptance test of the prototype has shown positive results.

Keywords: down syndrome, numeracy, computer, learning skills.

1 Introduction

Down Syndrome (DS) is a well known genetic disorder and it is caused by a chromosome abnormality that occurs before birth. In normal cell development there are 46 chromosomes but for DS, there are 47. There is an additional number 21 chromosome, resulting in the medical diagnosis of Trisomy 21. With this extra genetic material it causes changes in the orderly development of the body, brain including the physical characteristics and delayed physical, intellectual, and language development [1]. DS children do suffer from learning problems and most are classified as mildly or moderately disabled [2]. It is the most common cause of mental retardation and malformation in a newborn. Research carried out by British Medical Journal (BMJ) has shown that number of diagnoses of DS in England and Wales has increased by 71% from 1989 to 2008, whereas that of live births decreased by 1% [3]. For Malaysia, there are about 52 cases every year.

* Corresponding author.

H. Badioze Zaman et al. (Eds.): IVIC 2013, LNCS 8237, pp. 615–626, 2013.

Despite their distinct features, there is great diversity in terms of personality, intelligence, appearance, humor, learning style, compassion, compliance and attitude. DS will have a full range of emotions, are creative, imaginative in play, and can grow up in varying degrees of support and accommodation [1]. They can be friendly and can be included in community activities and by the time they become adults, they usually have some level of independence. They must therefore benefit from the same care, attention, inclusion in the community and opportunities for education which are needed in order to develop their social and academic skills needed in life. According to [4], different types of specialized therapies, counseling, and training can help them learn the necessary skills and manage emotional issues.

Most children with DS have mild to moderate retardation (IQ 30 to 60). Persons with DS at the upper end of the IQ range might attain 4th to 6th grade reading skill. They can provide for basic self–help needs, and have varying degrees of educational achievement and social and occupational skills. They need special education, training facilities, and frequently sheltered living and work situations [5]. With the advancement of technology and the internet, people with DS must be given the opportunity to access information and communication technology (ICT) in order to be fully included in the society. Research has shown that ICT would be a useful tool for DS to differentiate the curriculum and promote inclusion as well as to promote areas of development such as number skills and social development. Computer-assisted learning offers particular benefits for children with Down syndrome and for people with learning disabilities in general such as visual presentation, self-paced learning, highly motivating graphics and sound, immediate feedback and the opportunity to be in control of their own learning. It is easy to obtain many characteristics of computer-assisted learning that would reflect the specific learning style of children with DS and computers can often sustain a child's interest for much longer periods than traditional teaching. Although detailed evidence to support this view is limited, there is a growing body of research in this field. A study conducted by [7] has indicated that children with DS started to use computer as early as 3 years old and 80% of them use computer for educational purposes. This research showed that people with DS are being exposed to computer and using computer might help them in their learning.

Researchers in special education are to some extent informed of the potential of computer technology in helping individuals with DS. They claimed that computer technology can help people with DS increase confidence and motivation through creative activities and Web browsing. This can achieved if educational software programs are age appropriate and are able to reach educational goals for individuals with DS. For example, study conducted by [6] showed that virtual reality using Wii gaming technology is potentially effective intervention to enhance sensory motor functions in children with DS. They claimed that repetitive training and the observation, practice, and representation on the screen of task-specific can facilitate brain plasticity of children that engaged the mirror neuron system or long-term effects [7] and [8].

Mandy Wood, a psychologist, has indentified the advantages of computer assisted learning for children with Down syndrome such as visual learning style, non-verbal mode of response, being in control, opportunities for practice and immediate rewards,

errorless learning, self-paced learning, improving motivation, clutter free working environment and fear of failure. For instance, in the case of improving motivation, a child's attention span may be increased as the learning experience is enhanced with pictures, sounds and animations. One study using interactive commercial software suggested that attention span could be increased from less than 3 minutes to more than 15 minutes in children mild to moderate learning difficulties. Also, the child is able to proceed as quickly or as slowly as he/she wishes as the computer will 'wait' for the child to respond without prompting them before he/she has had time to fully process the information and construct his/her response [9] and [10].

A study conducted by [11], suggested that technological tool must be incorporated in the teaching and learning process. It was emphasized that teaching the elementary concepts in Mathematics represents a long term process with individual's with DS where mastering could take years. For this reason, the system has to be rich in the variety of media and tasks presented, because it is necessary to avoid the repetition of activities. In addition, chronological and cognitive ages of the children must be considered hence the presentation should be in stages, i.e., from childhood to adulthood.

Since children with DS experience cognitive delays that cause them to have slower physical and mental development, it is crucial to ensure that the mismatch between learning and teaching methods are minimized. A possible solution using computer based application, which the children can interact with material that have the integration of visual information and auditory. A study is conducted to identify the suitable learning theory (s) to be adapted in designing the application, develop the application and conduct a user acceptance test for the developed application.

This paper describes the design, implementation and evaluation of a computer application for learning basic numeracy skills for DS. This application consists of three modules; learning identifying numbers, matching and counting. The application was developed in collaboration with the Ipoh Kiwanis Down Syndrome Foundation Centre. The center was established on September, 2006 by Kiwanis Club of Bandaraya Ipoh for Down Syndrome children ages 2 months old to 6 years old. Currently the centre has nineteen (19) Down Syndrome (DS) children between 1—13 years old.

2 SynMax

A study exploring the extent to which computer-assisted teaching facilities assisted children with DS in learning basic mathematical concepts and skills was conducted by [12]. The results showed that the group of children with DS that was taught using multimedia teaching method showed a higher performance than the paper and pencil assisted teaching group on a variety of tasks and measures. This result suggests a clear relation between teaching method and mathematical learning in DS children. Since children with DS have the same educational goals as those of other learners but have a slower learning pace, computer software can be carefully programmed to meet individual needs and teaching activities can be achieved in very small stages [7] and [13], providing the opportunity for Artificial Intelligent (AI) be incorporated in the

design to allow for personalized teaching. The AI agent will act as the agent for transition between progression (moving forward), regression (moving backward) and permanency (no change in phase).

Study by Gonzalez proposed the following to be considered in designing education programs for children with learning difficulties:

- Operations, instructions, and verbal content must be structured in levels
- The content must also be in a simple format for early learners to access
- Feedback sequences must be incorporated which can explain the causes of error to the learner
- Learner must be guided towards getting the correct answer.
- Reinforcement techniques need to be incorporated

They went on to suggest that mathematics software for DS need to incorporate activities related with their experiences from their environment, their lexical deficits and to avoid repetition of presentation.

SynMax is mathematics computer application software that is developed to assist DS to learn the number concepts. The acquisition of number concept will help the learner to know numerical series and the order of numbers. The initial stage of the development involves only single numbers from 1 to 10. The problems and learning environment is designed to be as close as possible to the experiences of the learners. Three modules were considered; identifying numbers, matching and learn.

The development of SynMax has also taken into consideration of some learning theories such as behaviorism, cognitivism and constructivism together with the Dual Coding theory (Clark & Paivo, 1991). Dual-coding theory postulates that both visual and verbal information is used to represent information The ability to code a stimulus two different ways increases the chance of remembering an item compared to if the stimulus was only coded one way. For instance, there will be both written and verbal instructions to assist the children in using the application.

Schema theory **is** about concepts: objects and the relationships they have with other objects, situations, events, sequences of events. The focus of the application is on numbers from 1 to 10. These are the numbers that had been taught by the teachers. The design of the prototype is based on the methodology as shown in Fig. 1.

Rapid Application Development (RAD) was considered in the development of the prototype. The tools used in the development of the prototype are Adobe Flash CS5.5, Action Script 2.0, Photo editing and Sound Recorder. Suggestions from staff of Ipoh Kiwanis Down Syndrome Foundation (DSF), Center are (a) use bright colors in the presentation; (b) font size must be big enough for the DS to recognize; (c) use of familiar objects to represent numbers. The application was developed to accommodate Bahasa Melayu and English Language users. The objective of SynMax is to teach children with DS to recognize number from 1 to 10 There are mainly 3 activities which are “Learning ”, “Counting” and “Matching” and users can choose whether to do the activities starting from 1 until 5 or 1 to 10. Phases involved in the RAD are; Requirement Planning, User Design, Construction and Cutover. The brief description for the phases is as follows:

- Requirement Planning

In this phase, interview and survey had been done. An interview with the staff of Kiwanis Down Syndrome Foundation Center (KDSFC) , Ipoh were done to get

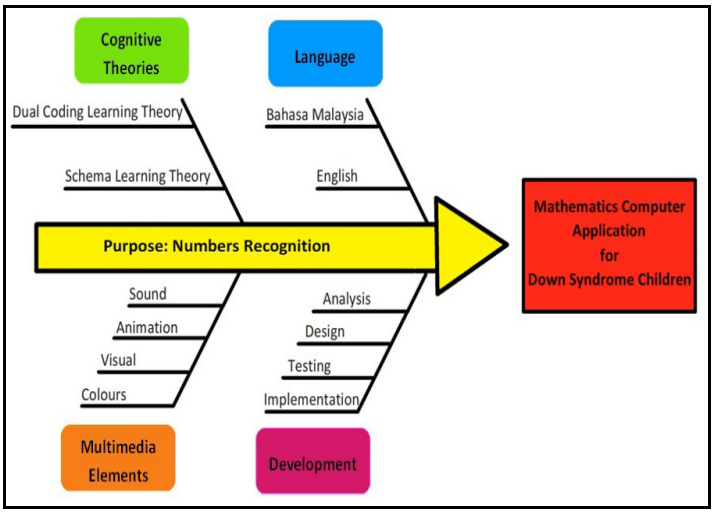

Fig. 1. Methodology for the development of SynMax

feedback regarding what should be included in the mathematics application tool to specify area or requirement needed by the DS children in learning mathematics. Also, a survey using a set questionnaire was done to gather data from parents and teacher at KDSC

- User Design

During this time, the instructors of the DS children will give some opinion on how the application should work to ensure that it will successfully assist DS children in learning mathematics. Instructors and developer will work closely to create prototypes that capture systems requirements and that become the basis for the physical design of the system being developed. The outcome is the preliminary draft of the interface.

- Construction

Here is where the development of the application will take place. The outcomes from this activity are finalized number skill conceptual framework and the application.

- Cutover

Cutover is the delivery of the application to its end users. Cutover involves implementation, testing and training users. The outcome from this activity is that the new application will be implemented

2.1 The Prototype

The main page of the application allows the user to choose whether they want to do the activities in English or Malay Language by clicking either one of the buttons, This

is then followed by the e level page. At this page users can choose to do the activities from number 1 to 5 or from number 1 to 10. User is then directed to the 3 modules which are the “Learning” Module, “Match” Module and “Count” Module. A series of animation, text, images and are incorporated in the application but is kept at minimum. The screenshots of the application are shown in Fig. 2, 3 and 4. The prototype was developed for numbers from 1 to 5 only.

Fig. 2. Screenshot of the main page

Fig. 3. Screenshot of the level

Fig. 4. Screenshot of the main page

The screenshots for the modules are shown in Fig. 5, 6 and 7. In the "learn identification" Module, the user will be introduced to numbers. The digits will appear one by one and in sequence together with the pronunciation. The objective of the module is to introduce the numbers and for the user to recognize the digit. Each of the digits is repeated three times.

Fig. 5. Screenshot of the Learn Module

The user is required to match the number that appears on the board with that in the given shape in the "Match" .Module. User will have to draw a line to match the items.

Besides numeracy skill, the module will help with the development of fine motor skills. Finally, the Count modules require the user to pop the number of balloons as shown on the screen.

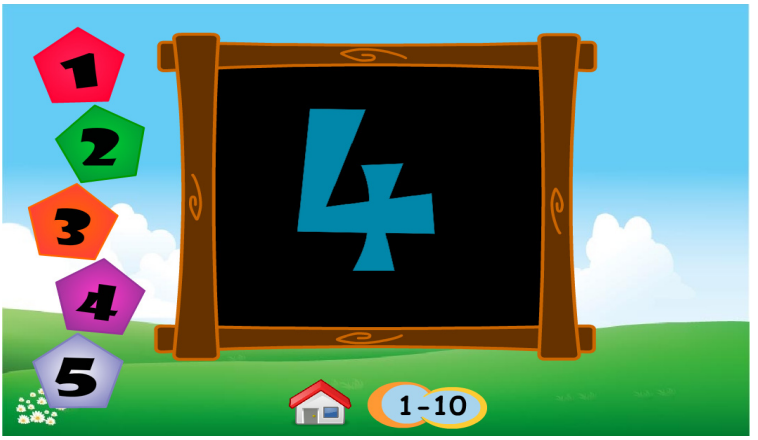

Fig. 6. Screenshot of the Match Module

Fig. 7. Screenshot of the Count Module

3 Methodology

Due to limited number of DS students at the center, a one stage sampling method was used. This prototype was tested with three (3) children aged between 8 – 13 years of age. One of them had followed the intervention programme that was held by the center in his early years there. The main requirement that the children had to fulfill is their ability to respond to instructions that are given by their teachers. The teacher is

present throughout the evaluation session. The evaluation was carried out for 45 minutes for each student.

Two observation checklists8 items were prepared for the survey. The teacher and parents will answer the survey in order for the researchers to have a basic understanding about the DS children by observing the activities performed by them at the center and at home. The checklist is composed of 34 items. These items include observable learning skills (cognitive, affective , psychomotor) and occurrence of observable behavioral problems of the DS child.

Another instrument is the user acceptance test to be filled up by the teacher by rating the DS child according to his performance in using the SYNMAX-the mathematics application tool. It is composed of 8 items were each item need to be answered by either 'YES" or "NO" using different levels from 0 "NO" (not done at all) to 4, "YES" (well done). The aim of the evaluation is to test users acceptance to the application and also to find out whether users can connect or recall their prior knowledge with the information in the application. Only three (3) children with DS aged between 8-13 participated in the testing process.

4 Results and Discussion

4.1 Survey Findings

The questionnaires serve the purpose of having a basic understanding about the children by observing the activities performed by them during class session at the center and at home. Nineteen (19) DS children aged between 1 to 13 years old were observed and the respondents of the questionnaire consist of 10 mothers and 1 teacher from KDSC. In the questionnaire, mean is used to determine the occurrence of activities performed by the children during the session and behavior of the children at the center and at home. The results are given in Table 1 and Table 2.

Table 1. Response from the Teachers

Category	Age		
	7 - 9	**4 - 6**	**1 - 3**
Cognitive	1.45	2.61	1.74
Affective	2	3.02	2.54
Psychomotor	1.9	2.43	1.7
Behavioral Problem	2.0	1.75	1.29

Table 2. Parents' Resonses

Category	Age		
	7 - 9	**4 - 6**	**1 - 3**
Cognitive	2.65	1.68	2.03
Affective	2.66	2.82	2.56
Psychomotor	2.4	2.67	2.27
Behavioral Problem	2.7	1.88	1.67

From the results in Table 1 and Table 2, it showed the children show their anxiety (nervous) with repetitive behavior, they tend to withdraw from peers or family members and they have many intellectual challenges. Therefore, it is necessary for the teacher to find strategies so that they will progressively move up and never assume that the child is not capable of doing things. They could be helped using the right tools that are appropriate for their learning capabilities. It is hoped that the application that is being developed will help them in learning Mathematics more effectively.

In addition, some of the inputs gathered from interviewing the staff are; the children's attention span increases when they use the computer, DS kids like colours, sound and direct manipulation of objects while learning and the preferred language is either English or Bahasa Malaysia.

4.2 User Acceptance Test for Prototype

These user interfaces was developed using Adobe Flash CS5.5. The application tool "SynMAX" was developed to accommodate Bahasa Melayu and English Language users. The main idea is to teach children with DS to recognize number from 1 to 10. There are mainly 3 activities which are "Learning", "Counting" and "Matching" and users can choose whether to do the activities starting from 1 until 5 or 1 to 10.

The user acceptance results are shown in Fig. 8.

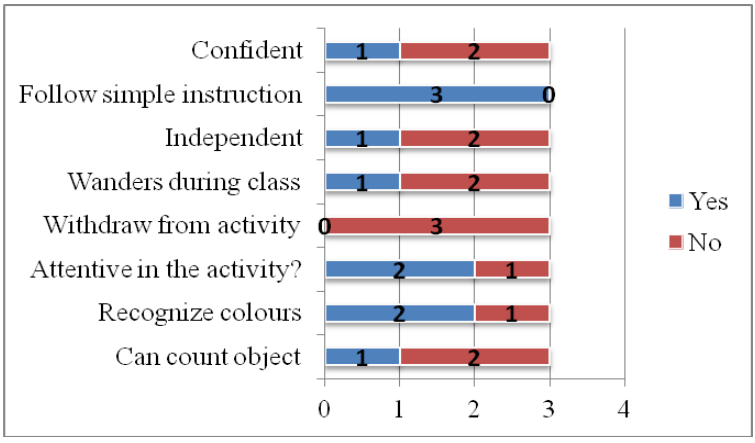

Fig. 8. The User Acceptance Results

On the whole, the results indicate that the students seem to be able to accept the application The results has shown that the students are able to follow the instructions given in the application even though the teacher sometimes need to repeat the instructions to them. It is also positive to note that they do not withdraw from the activity and were attentive to the animation and the images on the screen. These seem to imply that the students are receptive towards using computers as a learning tool, consistent with the results of some of the studies that had been carried out. However, only one of them managed to complete the "Learn" module. It is also interesting to

observe that this is the student that had been exposed to the intervention plan. Even though there was a child that always wanders during the activity, he will continue to do the activity once instructed by the teacher and was eager to use the computer.

Some of the positive feedback that was given by the instructors are;

- The colours, font size and animations are suitable for the students.
- The level of content is satisfactory
- The activities are suitable for the students.
- DS children learn better when the information are given in small amount.

While the recommendations for improvements include:

- Replace the existing background music with nursery rhymes or songs that the students are familiar with. This will provide a familiar environment to them.
- Include a "teacher kind of figure" in each of the modules, and this figure be used to show the examples.
- Repeat the activities for at least a few times but with different scenarios and animation.
- More animation and interactivity added in this application since DS are very fond of interactivity in their learning. Interactivity will allow them to explore the knowledge by themselves and it can expand their attention span that will assist them in learning.
- Consideration to integrate application with handheld devices such as smart phones and tablets to allow simultaneous development of motor skills.

5 Conclusion

The paper has discussed on the design and development of an initial prototype of a mathematics software , SYNMAX for Down Syndrome children. This design, based on dual coding learning theory, schema learning theory, is the first initiative of development of a learning tool for DS children in Malaysia aimed at enhancing their numeracy skills. Positive feedback and suggestions for improvement of the prototype have been obtained from the user acceptance evaluation. Enhancement of the prototype is currently being carried out. The application is currently extended to mobile applications in keeping up with the advancement of technology.

Acknowledgments. The research is funded by the Ministry of Higher Education (MOHE) under Fundamental Research Grant Scheme (FRGS Fasa 1/2012). The authors would also like to acknowledge the staff and students of Kiwanis Down Syndrome Foundation (DSF), Ipoh Center, Perak.

References

1. Public Awareness Language Guidelines National Down Syndrome Congress, `http://www.ndscenter.org/resources/packages4.php` (accessed Date: October 7, 2010)

2. Trix, Victoria, Teaching tips for children with Down Syndrome. JEN (2008), http://www.brighthub.com/education/special/articles/29680.aspx (2009) (accessed Date: October 7, 2010)
3. Morris, J.K., Alberman, E.: Trends in Down's syndrome live births and antenatal diagnoses in England and Wales from 1989 to 2008: analysis of data from the National Down Syndrome Cytogenetic register. BMJ2009-339-b3794do:10.1136/bmj.b3794 (2009)
4. Sexton, M.J., Dolan, S.M., Smith, D.: Common therapies, counseling and training for young people with Down Syndrome. Health & Fitness (2009), http://wrondiagnosis.pubs.righthealth.com/topic/People%20Down%syndrome?as=clink&ac+1437&afc=21686466&p=&dqp.cache.mode+PMBypass#xzz11jtmHk8 (accessed on October 8, 2010)
5. Leshin, L.H.: Down Syndrome, Trisomy 21. Encyclopedia Index, http://www.drhull.com/EncyMaster/D/Down_syndrome.html (accessed on: November 18, 2010)
6. Wuang, Y.P., Chinag, C.S., Su, C.Y., Wang, C.C.: Research in Development Diasabilities (2010), doi:10.1016/j.ridd.2010.10.002
7. Feng, J., Lazar, J.: Computer Usage by Children with Down Syndrome: Challenges and Future Research ACM Transactions on Accessible Computing 2 (3), Article 13, 13– 44 (2010)
8. Bird, G., Buckley, S.: Down Syndrome News and Update, 1 (4), 159–174 (2000)
9. Wood, M.: Down Syndrome News and Update 1 (4), 2–10 (2004)
10. Black, B.: Down Syndrome News and Update 2 (6), 66–68 (2006)
11. Bruno, A., Gonzales, L., Moreno, L., Noda, M., Aguilar, R., Munoz, V.: Teaching Mathematics to Children with Down's Syndrome. Universidad de La Laguna, Tenerife, Spain (2003)
12. Ortega–Tudela, J.M., Gomez– Ariza, C.J.: Computer-assisted teaching and mathematical learning in Down Syndrome children. Journal of Computer Assisted Learning 22, 298–307 (2006)
13. Garcia, J., Ipina, K.L., Irigoyen, E., Elorriaga, J., Garay, N., Zulueta, E., Rubio, J., Vaquero, C., Penagarikano, M., Lopez, J.M., Ezeiza, A., Ipina, J.M.L. (2006), http://www.iadat.org/iadat-e2006/abstracts_web/IADAT-e2006_32.pdf
14. Clark, J.M., Paivo, A.: Dual coding theory and education. Educational Psychology Review 3(3), 149–170 (1971)