Jurnal Teknologi

Full Paper

INTERFACE DESIGN FOR YOUNG DYSLEXICS: A SURVEY ON VISUAL REPRESENTATION

Rozita Ismail[a], Azizah Jaafar[b]

[a]College of Information Technology, Universiti Tenaga Nasional (UNITEN), Kajang, Malaysia
[b]Institute of Visual Informatics, Universiti Kebangsaan Malaysia (UKM), Bangi, Malaysia

Article history
Received
3 December 2013
Received in revised form
2 July 2014
Accepted
25 November 2014

*Corresponding author
irozita@uniten.edu.my

Graphical abstract

Abstract

The use of information and communication technology in learning is an essential part of the National Curriculum in Malaysia. Dyslexic children exhibit different skills and motivations. They dislike reading and find reading to be a painful activity. This paper presents an exploration of the visual representation used by dyslexic children in learning Bahasa Melayu. Visual representations, such as the use of icons and images, in interface design are remembered easily and enhance the level of concentration and experience in learning. The experiment used an educational multimedia courseware to investigate how dyslexic children react towards the use of icons and images. This study involved 12 dyslexic children in a primary school in Malaysia. Findings from the experiment were examined to understand how children with dyslexia perceive visual representations. The findings will help designers to carefully design and choose icons and images that can easily be interpreted by these children. Well designed icons and images allow dyslexic children to recognise the meaning of those visual representations without the need of additional support.

Keywords: Dyslexia, interface design, interactive interface, visual representation

1.0 INTRODUCTION

Nowadays, information and communication technology (ICT) is becoming a critical part of children"s daily lives. ICT is changing the way our children learn and behave with their peers. ICT may also be part of the solution in providing specialised technologies that support accessibility for those with learning difficulties [1, 2]. ICT has helped those with learning difficulties to acquire essential knowledge to increase their motivation in learning and to improve their self-esteem. People with dyslexia, who are regarded by teachers and psychologists as having specific learning difficulties in reading and written language, could make full use of ICT, particularly in helping them to extend their knowledge and skills that were taught in classroom [2, 3] .The use of ICT has emerged and proved effective in teaching and assisting students with learning difficulties, such as dyslexia [4, 5]. However, without taking into consideration the difficulties faced by dyslexics in terms of interaction with the interface, the technologies may not be usable and beneficial for these specific users. As such, it will only increase the gap between children with dyslexia and non-dyslexia in using ICT for learning purposes [6].

Approximately 5 to 10 per cent of school children are affected by dyslexia [7]. Accordingly, the Ministry of Education Malaysia has developed a Special Education Unit in selected schools throughout Malaysia to facilitate the needs of this population [8]. At present, a specialised module has been designed that comprises various techniques in teaching to ensure that children with learning difficulties, such as autism, dyslexia and down syndrome will have the same chances and opportunities in acquiring knowledge as mainstream students. Various approaches in teaching have been adopted to improve the educational experience and academic performance of dyslexic children in Malaysia. Observations made in one of the government schools that has a Special Education Unit shows that a small

and special classroom has been designed to accommodate the needs of these children. A small group of eight to ten dyslexic children will be placed in the classroom. Dyslexics were generally slower than non-dyslexics in learning due to difficulty in reading acquisition. Hence, a special curriculum has been designed by The Ministry of Education to accommodate their needs in acquiring knowledge.

The objective of this study is to investigate whether children with dyslexia have problems with visual representation when interacting with computers, particularly using educational multimedia courseware. We explored the usage of icons and static and animated images that would normally be used in multimedia courseware. Obtaining a better understanding of how dyslexic children perceive and identify objects at the interface can help researchers and designers to design more effective interfaces specifically targeted to them. In addition, it can also provide insights into increased opportunities for dyslexics to seek knowledge by themselves through the use of ICT, as all information can be retrieved by just clicking their finger. The aim of this study is to find answers to the following questions:

i. Which format of icon is preferred by dyslexics when educational courseware or online material is used in the learning process? An icon without text labels or an icon supported with text labels?
ii. Which format of images is preferred by dyslexics when educational courseware or online material is used in the learning process? Static or animated images?

The findings from this study can be used as a guideline for designers to design more effective interfaces for dyslexic children.

2.0 UNDERSTANDING DYLSEXIA

Dyslexia is the most common learning difficulty in children and it is estimated that around 10 to 17.5 per cent of people across countries are dyslexic [9]. It is very important to identify if a child is dyslexic in the early stages, before the child begins to develop low self-esteem due to his or her low academic achievement. The Dyslexia Association Malaysia defined dyslexia as the following, „Dyslexia is not a disease it occurs in children with normal vision and has nothing to do with the hearing, sight or brain damage. It happens because the brain lacks a function to translate the image seen or heard into something meaningful" (Puan Sariah Amirin, President Dyslexia Association Malaysia). Those with dyslexia may exhibit any or several signs of dyslexia at any time in their life [10]. As they grow up, every dyslexic may exhibit different signs of dyslexia. However, the main problem is the difficulty dyslexics experience with reading, listening to instructions, writing and spelling [3, 11, 12].

Most dyslexics have problems connecting the words that they see with the sounds of the words (phonological difficulties). Some researchers found that children with dyslexia think and learn differently [3, 13]. In addition, dyslexics are very creative and they often devise their own compensatory strategies to overcome their weaknesses. Unfortunately, sometimes these strategies become less effective over time, as they take time and effort. Hence, continuous support and motivation from parents and teachers are certainly important to help dyslexics succeed academically and in life in general [14, 15].

It is also the case that the usual method in teaching non-dyslexic children needs to be enhanced and adjusted to cater for the needs of those who have dyslexia. Parents and teachers have to explore and creatively use specific teaching methods that may need some individual adjustment to suit the dyslexic"s capabilities. It is important for teachers and educators to recognise the specific learning needs of dyslexics to ensure that they are not abandoned or left out of mainstream education [15, 16]. Early identification of dyslexic symptoms among children is important to assist them with obtaining the appropriate teaching intervention. The majority of researchers have focused on the use of phonological techniques in helping the dyslexic child learn how to read [3, 9, 17].

3.0 INTERFACE DESIGN

Educational materials and computer applications such as game based learning are widely used in today"s teaching and learning process [18]. Children are exposed to the computer, the internet and multimedia courseware to enhance their learning experience and to increase their understanding of particular a subject or syllabus. Considering that ICT has potentially provided broad access to education for children with learning difficulties, such as dyslexia, designers need to design suitable interfaces for this population. Suitable interface design is important, as children with dyslexia may have their own preferences and behaviours in interface design, which could influence the effectiveness of the function of the educational material.

Discovering a user-interface design that dyslexic children find usable and accessible to their way of learning is an important matter. As a computer interface is the interaction between the children and the computer application, it should be made as usable as possible to help them engage their attention towards acquiring knowledge. Interface design that is not user-friendly and looks dull can lead to dyslexic children becoming easily frustrated and not motivated in accomplishing the intended tasks. It is important for the designer to recognise the strengths and weaknesses of dyslexic children to assist them to develop a usable interface design that is intuitive and easy to use.

Dyslexic children find reading to be a painful activity, as they need to focus attention on the text

based presentation. Due to their difficulty with reading, visual representations, such as icons and images, are best used to supplement the text based presentation [19]. Graphic images help users to recognise functions more easily [20]. However, in order to facilitate the use of icons and images into interface design, it is first necessary to investigate the features of icons and images that are well suited and can be understood by dyslexic children. The British Dyslexia Association has come up with the Dyslexia Style Guide that contains guidelines for dyslexic readers [21]. Unfortunately, little research on the design of icons and visual representations could be found. Previously, we had conducted a study to identify technology acceptance among dyslexic school children towards the use of educational multimedia courseware, as one of the effective teaching tools in the classroom [22]. We have discovered several difficulties faced by dyslexic children in interacting with a computer interface. This study further investigates the usage of icons and images.

4.0 METHOD

A small-scale experiment was conducted to understand the elements of visual representation for the interface of a multimedia courseware that supports dyslexic children in the learning process. In order to know whether the dyslexic children were satisfied with the icons and images and could easily recognise them, we prepared a few basic questions asking whether they could explain what the meaning of the icons and images was. This was similar to intuitiveness testing, where the dyslexic children were required to identify and explain what they knew by looking and manipulating the icons and images that appeared on the screen [23]. It is hoped that the findings from this study will reveal important aspects of icons and images that represent certain functions or activities that specifically suit dyslexic children.

4.1 Participants

Twelve children between 8 to 12 years of age were studied. All of the children had been identified as having learning difficulties, after taking a series of tests under the Literacy and Numeracy Screening (LINUS) program, provided by The Ministry of Education Malaysia. They had also undertaken the Dyslexia Screening Test (Senarai Semak Disleksia) [8]. All of the children had normal vision and ten out of twelve of the children are boys. All of the children were identified by their teachers as having mild symptoms of dyslexia and their academic performance was declining compared to their non-dyslexic classmates of the same age. School and parental consent was obtained for all the children who participated in the study.

4.2 Materials

In order to obtain the opinions of the dyslexic children, we selected an educational multimedia courseware that contained icons and static and animated images, which were used to represent functions and tasks that would normally exist in children"s educational courseware. All developers have different ways of designing icons, but the reason we chose this courseware was because the features of the icons and images were palpable and easy for dyslexic children to interpret their meaning. At the same time, we endeavored to select suitable icons and images that directly represented their function. As such, we allowed them to draw and design their own icons and images that they believed were suitable to see how creative they were at expressing their ideas.

In this study, we focused on the use of icons without text labels, icons with text labels and static and animated images. All these icons represented certain functions once the user clicked on them. Static and animated images are used to help dyslexic children to understand the subject better.

Table 1 Icon without text label

Icon	Description	Function
	Home	To bring user to the main menu
	Exit	To exit from the courseware
	Next	To go forward
	Previous	To go back to the previous screen
	Erase	To erase activity done by users

Table 2 Icon with text label

Icon	Description	Function
	Repeat	To repeat the particular activity
	Help	To offer information and assistance about something related to the material
	Audio	For user listen to the audio instruction instead of reading the text
	Write	Allow user to write but using mouse
	Check	To check for the correct answers
	Enter	To enter to a module

Table 3 Static and animated images

Icon	Description
	User can see the image of yoyo going up and down
	User can see the image of cow's tail moving
	User can see the flame of fire

4.3 Procedures

The experiment was carried out in a computer lab, with two dyslexic children being tested and observed concurrently. Before starting the experiment, we presented participants with a brief explanation on the tasks that they were required to carry out within the stipulated time. We let them explore the courseware by themselves. The researcher sat behind them to observe the activity and at the same time record all the conversations with each dyslexic. All distractions were monitored to ensure that the dyslexics gave their full attention to the tasks that needed to be accomplished. The participants were asked a set of questions as they were exploring the courseware. The researcher needed to find the most appropriate way to ask these questions, in order to extract the answers and opinions from the dyslexics. Dyslexics may not cooperate if they are too tired or are not in a good mood. As such, it was necessary from time to time, for the researcher to support and motivate them to complete the required tasks. We made sure that the tasks that the dyslexics were required to perform utilised the icons and images that we wanted to investigate.

We also used a webcam in order to record the dyslexic children's reaction and behaviour while interacting with the courseware. Time given to complete the task was approximately 35 to 45 minutes, depending on the children"s ability.

5.0 FINDINGS

Based on the testing and observations, we identified few notable findings. Most of the dyslexic children in our study have been using computers as early as five years of age. When we asked the question, „Have you used a computer and do you like to use it?" most children stated that they use a computer for playing games and also to do homework that requires them to search for certain information on the internet. Two dyslexics also mentioned that they have their own computer at home and they use it to complete their homework. One girl also mentioned that she sometimes uses her father"s iPad to play games and to access Facebook. These examples clearly show that children nowadays are increasingly using computers for playing games, searching information and for social communication. This also indicates that additional ICT based materials should be designed to support more effective learning experiences for dyslexic children. The design should take into consideration the children"s abilities, interests and developmental needs. Using computer and educational multimedia courseware has been proven to offer a motivating, safe and engaging experience for not only dyslexic children, but for all children as well.

Generally, the dyslexic children liked the idea of learning with multimedia courseware, as they thought it was entertaining. Next, we elaborate on the findings that focused on how the dyslexic children thought about the icons and images used in the courseware.

5.1 Icons

This section examines the use of icons in educational multimedia courseware. We were interested to know how the participants performed an activity when it had icons that need to be clicked on. The dyslexic children were asked to answer two important questions. Firstly, „Do you know what this picture is?" And secondly, „What do you think it is used for?" We observed that most of the participants understood the use of the icon and its function if the design of the icon could be mapped with its function. But there were also icons whose functions were not obvious to some of the children. Children with dyslexia may find these icons hard to guess, due to a limited understanding of concepts and how they relate to each other. We observed that when they were not sure about the function of the icon, they would just click on the icon to see the result. This outcome happened when we asked them why they clicked on the icon (icons without text labels, refer to Table 1). Only a few of them had the courage to ask the researcher about the function of the icon if it was not familiar to them.

1) Icons Without Text Labels

For the purpose of this study, we specifically made a few icons stand out when the user placed the mouse cursor over them. Some icons were also made to change colour when the user pointed to it using their mouse. This was a way to make sure that the user was aware in relation to which icon that they wanted to click on. Furthermore, it differentiated between items that were able to be clicked on and those items which did not have a function behind it. Young dyslexic children may have problems in recognising icons that they see. They may take sometimes to interpret the meaning of icons that appears in the courseware.

For the "Home" icon, most of the participants could interpret its meaning. When we asked about this icon, eight out of the twelve children answered that this icon will bring them to the first screen. When we asked them, „How did they know the meaning of the "Home" icon," one of them stated that „I have seen this icon before . . . although the picture is not exactly like the one that I see here, but I know that this is a house and that means it will go back to the main page. Another dyslexic commented, "This is home and if I click on it I will see the first screen."

While the other four dyslexics answered that either they were not sure with the function of the "Home" icon or they simply did not respond to the question when asked. One of them said, "I am not sure what happens if I click on it" and another dyslexic said, "When I first saw this, I knew it was a picture of a house, I have no problem understanding what it will do, I just click on it if I am not sure of the function and it will tell me later." We were advised that this participant was bright, however she always found it hard to recall the lessons that she had been taught. According to her teacher, she needed a lot of revision, drilling and testing to make sure she remembered what she had been taught to her.

For the "Next" and "Previous" icons, it was found that most of the participants could directly interpret the meaning of their function. According to the children, they had seen these icons when they browsed the internet and when they played online games. As such, we concluded that the representation of these icons is simple and distinctive.

For the "Exit" icon, ten out of the twelve dyslexics answered correctly that the icon was for exiting from the courseware. One of them stated, "I have seen this often when I need to do my assignment using Microsoft Word, if I accidently click on it, it will close my file." While another dyslexic mentioned that "Usually it appears in the top right corner of my computer screen with a red colour." The other two dyslexic children were not sure of its function. One of them guessed by saying "this is the cross symbol if I make mistakes." The other dyslexic child asked, "Does this icon mean the wrong answer?"

For the "Erase" icon, only two participants interpreted it as an eraser to delete whatever they had done in the activity window panel. The rest were not sure until they clicked on the icon and tried it out for themselves. One of them stated, "I have never seen this icon before." Another dyslexic stated, "When I place my mouse cursor on it, then I can only see the text change its colour and I guess I can click on it." This clearly shows that for this icon, it is important to have pictures that can represent the function to make it more understandable for dyslexic children.

2) Icons with Text Labels

We also designed two types of icons which were supported with text to explain their functions. One type was where the text or label appeared once the mouse cursor pointed on it. The other type was where the text was placed next to the image of a particular icon.

For the "Repeat", "Help", "Audio" and "Write" icons, the text appeared just below the icon to depict the function (refer to Table 2), once the dyslexic pointed to the icons with their cursor. For the "Check" and "Enter" icons, the text was designed to appear next to the image of the icons.

Most of the participants had no problem recognizing the icons because of the supported text that appeared together with the icon. One of the dyslexic children said, "If I do not put the mouse cursor over the icon, I don't understand what it is for, but if I place the cursor over it the text appears and it helps me." While his friend added, "Some icons stand out and I am still not sure what they mean, but when I see the text under the icon it helps me to understand its function." Another dyslexic mentioned, "I like icons with text underneath, it gives me an idea about what it does.

5.2 Static and Animated Images

In this study we asked participants to explain what they understood when they saw the images that appeared in one of the activity (refer to Table 3). We started by asking them what they thought about the static images and whether they understood them. We made sure that the task and activities that the children needed to perform showed the static images first before the animated images appeared. The purpose of this activity was to ascertain which type of image dyslexic children preferred and whether they understood the message that related to it.

Only four out of the twelve dyslexic children gave the correct answers in relation to the static images that were shown in the courseware. The remaining children were not so sure about message the static image was portraying. Four of them gave wrong answers, which showed that they failed to relate the images with its function. Another four dyslexics took a long time to explain what they thought the images meant. One of the dyslexic stated, „I don"t know . . . this picture is not clear." In contrast, we found that the animated images were correctly recognised by all twelve of the dyslexic children and that they were able to explain to us what they were expected to. They mentioned that the animated images „came alive" and that they easily understood the message that relates to the images. One of the dyslexics said, „Now I am sure that this image explains the text that appears once I click on the activity." He was referring to the animated image that illustrated the word that he had chosen. Another two dyslexics mentioned that the animated images gave them a better idea as to what the tasks were all about.

These findings reveal the importance of how icons and images could be presented to enable increased usability for dyslexic children. As dyslexic children have limited ability in reading, the use of visual representations such as icons and images are strongly recommended to facilitate the connection between objects and the situation [24]. Although every designer will design their own icons and images based on their creativity, designers need to know the types of icons and images that can stimulate and capture a dyslexic"s imagination to encourage him or her to engage in the learning process through ICT.

6.0 CONCLUSION

Although this study has some limitations, namely we only dealt with a limited number of icons and images, we still learnt some valuable lessons. This study provides valuable insights regarding the use of icons and images from a dyslexic child"s point of view. Considering that dyslexic children have different ways

of thinking, they might prefer icons and images that can demonstrate functions, as well as capture their imagination. A correct design of icons and images can optimise the way dyslexic children interact with an interface. The following are that most influential factors found during the study:

- Choose pictures for icons and images whose meaning can be easily interpreted by dyslexic children.
- Use familiar pictures for icons to help dyslexic children correctly interpret the icon"s function.
- For an icon that is ambiguous, adding text helps dyslexics to understand its function.
- User experience plays an important role in recognising the meaning of icons and images.

Familiarity of an icon is an important factor, as it helps dyslexic children to recall and recognise the icon"s functions and meaning. Adding text to accompany an icon can help dyslexics to understand the meaning more promptly. This view was mentioned by other researchers, specifically that children"s sensibilities are limited and that by adding text to the icon helps children (in our case dyslexic children) to recognise intuitively the icon"s function [25]. It also appears that dyslexic children can understand animated images better, as these images can describe the situation much more clearly. This finding corroborates the views of past research that suggested that animated icons as a feature in child computer interface is important [26].

Acknowledgement

We would like to thank the teachers of Sekolah Kebangsaan Jalan Enam Bandar Baru Bangi for their help with the dyslexic children. We would also like to especially thank all the children who were directly and indirectly involved in this study, for without them this study would have not been possible.

References

[1] Nurul Hidayah, M. Z., J. Azizah and A. R. Farizah Hanis. SGameFlow Framework: How to Experience Enjoyment in Serious Game (SG) for Motor Impaired Users (MIU). *2012 International Conference on Computer and Information Science (ICCIS)*. Kuala Lumpur. 12-14 June 2012. 1020-1024.

[2] Torgesen, J. K., R. K. Wagner, C. A. Rashotte, J. Herron and P. Lindamood. 2009. Computer-Assissted Instruction to Prevent Early Reading Difficulties in Students at Risk for Dyslexia: Outcomes from Two Instructional Approaches. *Annals of Dyslexia*. 60(1): 40-56.

[3] Snowling, M.J. 2004. The Science of Dyslexia: A Review of Contemporary Approaches. In Turner and Rack (eds). *The Study of Dyslexia*. New York: Kluwer Academic Publishers.

[4] Seo, Y. J. and H. Woo. 2010. The Identification, Implementation and Evaluation of Critical User Interface Design Features of Computer-Assisted Instruction Programs in Mathematics for Students with Learning Disabilities. *Computers and Education*. 55(1): 363-377.

[5] Kast, M., G.M. Baschera, M. Gross, L. Jancke and M. Meyer. 2011. Computer-based Learning of Spelling Skills in Children With and Without Dyslexia. *Annals of Dyslexia*. 61(2): 177-200.

[6] Cook, M.A. 2008. *Using the Web and ICT to Enable Persons with Disabilities*. Berlin: Springer-Verlag.

[7] Lee, L. W. 2008. Development and Validation of A Reading-Related Assessment Battery in Malay for the Purpose of Dyslexia Assessment. *Annals of Dyslexia*. 58(1): 37-57.

[8] Gomez, C. 2004. The International Book of Dyslexia: A Guide to Practice and Resoures. In I. Smythe, J. Everatt and R. Salter (eds.). John Wiley and Sons, Inc.

[9] Elliot, D. L., J. K. Davidson and J. Lewin. 2007. *Literature Review of Current Approaches to the Provision of Education for Children with Dyslexia*. HM Inspectorate of Education.

[10] Massey, J. 2008. *Meeting the Needs of Students with Dyslexia*. First Edition. Network Continuum Education.

[11] Schmidt, A. and M. Schneider. 2007. Adaptive Reading Assistance for Dyslexic Students: Closing the Loop. 1-3.

[12] Fletcher, J. M. 2009. Dyslexia: The Evolution of a Scientific Concept. *Journal of International Neuropsychological Society*. 15(4):501-508.

[13] Humphrey, N. and P.M. Mullins. 2004. Self-Concept and Self-Esteem in Developmental Dyslexia: Implications for Theory and Practice. *Journal of Research in Special Educational Needs*. 2(2): 1-11.

[14] Huitt, K. L. 1999. Teaching Dyslexic Students. 1-16.

[15] Long, L., S. MacBlain and M. MacBlain. 2007. Supporting Students with Dyslexia at the Secondary Level: An Emotional Model of Literacy. *Journal of Adolescent and Adult Literacy*. 51(2): 124-134.

[16] Hornstra, L., E. Denessen, J. Bakker, L. V. D. Bergh and M. Voeten. Teacher Attitudes Toward Dyslexia: Effects on Teacher Expectations and the Academic Achievement of Students with Dyslexia. *Journal of Learning Disabilities*. 43(6): 515-529.

[17] Savage, R. 2004. Motor Skills, Automaticity and Developmental Dyslexia: A Review of the Research Literature. *An Interdisciplinary Journal*. 17: 301-324.

[18] Nurul Hidayah, M. Z., J. Azizah and A.R. Farizah Hanis. Eye Tracking in Educational Games Environment: Evaluating User Interface Design through Eye Tracking Patterns. *Visual Informatics: Sustaining Research and Innovations*. 7067: 64-73.

[19] Zakaria, Z. 2006. The Application of Visual Art Activities in the Teaching and Learning of the Malay Language to Dyslexic Primary School Children. *World Conference on Arts Education Building Creative Capacities for the 21st Century*. Lisbon. 6-9 March 2006. 1-18.

[20] Gatsou, C., A. Politis and D. Zevgolis. 2012. The Importance of Mobile Interface Icons on User Interaction. *International Journal of Computer Science and Applications*. 9(3): 99-107.

[21] Evett, L. and D. Brown. 2005. Text Formats and Web Design for Visually Impaired and Dyslexic Reader-Clear Text for All. *Interacting with Computers*. 17(4): 453-472.

[22] Rozita, I. and J. Azizah. 2011. Interactive Screen-based Design for Dyslexic Children. *Proceedings of IEEE International Conference on User Science and Engineering (i-USEr)*. Shah Alam. 29 Nov.-1 Dec. 2011. 168-171.

[23] Ferreira, J., J. Noble and R. Biddle. 2006. A Case for Iconic Icons. *Seventh Australasian User Interface Conference (AUIC 2006)*. Hobart, Tasmania, Australia. 16-19 Jan. 2006. 97-100.

[24] Nikolopoulou, K. 2007. Early Childhood Educational Software: Specific Features and Issues of Localization. *Early Childhood Education Journal*. 35(2). 173-179.

[25] Jo, M. and J. Han. 2006. Metaphor and Typeface based on Children's Sensibilities for e-Learning. *Information Processing Systems*. 2(3): 178-182.

[26] Jones, T. 1993. Recognition of Animated Icons by Elementary-Aged Children. *Association for Learning Technology Journal*. 1(1): 40-46.