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HEURISTIC EVALUATION OF LEARNING TECHNOLOGY FOR SPECIFIC DISABLED LEARNER

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ABSTRACT

A disabled learner is a special needs child who requires full attention and a specific approach, particularly one who necessitates learning in special education. These learners need a unique approach to tackle their limitations since they have lower cognitive skills than a normal learner. In the current 21st century, many types of learning technologies can assist them in the learning process. However, not all learning technologies are suited to the capacity of disabled learners. The paper aims to discuss the results of the heuristic evaluation that has been carried out using a 3M learning application among disabled learners in the classroom setting. The heuristic evaluation involved six experts in determining the flaws in designing the 3M learning application as an educational technology for disabled learners. Based on the heuristic evaluation that has been conducted, the results achieved exceeded 77.5% of the usability percentage. Hence, it shows that the 3M learning application has a good user experience level that can be used by a disabled learner to maximize and increase understanding during the learning process.

Keywords: *Disabled Learner, Educational Technology, Heuristic Evaluation, Special Education*

1. INTRODUCTION

Generally, a disabled learner refers to special needs children who have limitations in their capabilities in various aspects, especially in the learning process. A disabled learner has difficulty reading, writing, and calculating, all of which are considered basic skills in normal learning. According to Malaysian government policies, the Persons with Disabilities Act of 2008 defines that children with special needs must be provided with the necessary support to participate equally in classroom learning [1]. This inclusive education refers to a special class that is provided for a disabled learner who has various forms of disabilities, focusing on the learning needs of special needs children [2]. Different approaches and forms are used in inclusive education to help these learners focus on their learning process.

However, most people are unaware that disabled learners now have easier access to privileges that can be used during their learning process. Over the last decades, numerous learning technologies have been used to assist disabled learners in their learning process. Improving the usability of information and communication technology (ICT) applications is crucial for developers and organizations, with a focus on accessibility. The goal is to ensure that everyone can seamlessly utilize hardware and software applications without being hindered by limitations [3]. Learning technologies with a good interface design and suitable modality will reduce cognitive load function as they can improve the understanding, receiving, and processing of information for disabled learners [4]. Efficiency in learning may facilitate the transmission of knowledge and easy communication between teachers and learners [5]. In addition, disabled learners have a low capacity for cognitive functioning skills, leading them to be low achievers in the academic domain. A specific approach is required and to be implemented suitably to their capacities and capabilities to increase their achievement in academic affairs.

In Malaysia, policies are established to maintain the rights of disabled learners, such as the Malaysian National Policy for Persons with Disabilities and the National Plan of Action for Persons with Disabilities. These policies are also used to safeguard disabled learners' rights under the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) [6]. Certain policies are used to ensure they are not left behind regarding education, occupation, and life aspects.

The evolution of rapid technology nowadays may help in enhancing the efficiency of inclusive social work practice for disabled learners [7]. Year to year, the number of disabled learners has been increasing, and the state of their well-being should be cared for, especially in the education aspect.

This kind of learning technology helps disabled learners in the classroom. They may have difficulty using and accessing the technology that does not support accessibility; for example, the visual-impaired and other impaired students may have difficulties using video lectures without using video-audio descriptions and accessibility features [8]. The study's findings show that there is no longer any available disability for students to fully participate in technological endeavors. Tape books and Online Public Access Catalog (OPAC) have been used to their full potential. This study also shows that they had any of the goods for the mobility-impaired, indicating that these users are not generally benefiting from the new technology [9]. Although there are a variety of learning technologies available that may help disabled learners, not all learning technologies are really suitable for the needs and capacities of disabled learners. Hence, in this study, we proposed 3M learning application for the use of disabled learners in the classroom. We are focused on the heuristic evaluation to find the flaws and minimized the design deficiency in the 3M learning application for disabled learners. The objective of this paper is to measure the efficiency of the 3M learning application; hence, we are conducting a heuristic evaluation to minimize our proposed design flaws. The heuristic evaluation is conducted with an expert in human-computer interaction background.

2. RELATED WORK

The Ministry of Education (MOE) has established three special schools for disabled learners: Special School, Special Education Integrated Program and Inclusive Program. According to the Ministry of Education, the special needs of disabled learners are categorized into handicapped, partially or fully impaired hearing, and disability to learn [10]. Additionally, disabled learners have lower functioning skills, which is necessary for learning among ordinary learners. Communication skills are one of the examples of functional skills necessary for all learners to communicate their ideas and interact well between teachers and learners.

According to the Malaysian Department of Social Welfare, only 513 to 519 people from 4.86 million are registered with the department [11]. Of these figures, only 120,243 are registered with The United Nations Children's Fund [12]. The numbers illustrate a large population of disabled people in Malaysia. A necessary approach and the right learning technologies are required to assist disabled learners in their classroom environment. The strengths, capacities, and capabilities of disabled learners should be determined, as it can help them nurture their talent in academic or non-academic skills.

The Malaysia Special Education Policy aims to strengthen education for disabled learners, and ensuring that their abilities can be applied to self-sufficiency and increasing their quality of life [13]. At this stage, we can identify whether these children are having problems with their basic learning skills and provide an early intervention to address the problem. The principles of Education for All, as outlined by the United Nations Educational, Scientific and Cultural Organisation (UNESCO), aim to ensure universal acceptance of the right to education across all levels for individuals with special educational needs [14]. Specific approaches, interventions and attention should be given to this type of learner so that they are not left behind compared to a normal learner in the school environment.

2.1 Learning Technology for Disabled Learners

Advanced use of technology in education can increase many ways of teaching and learning for disabled learners [15]. The assistance of learning technologies may help improve learners' understanding of the academic subjects at hand. For disabled learners, using learning technologies may help them stir their excitement toward the learning process. Learning applications can assist teachers in planning and evaluating their own instruction as well as improving student learning. They are available daily as a result of the fast-expanding technological possibilities [16]. A report by the Kaiser Family Foundation shows that youngsters spend at least seven to a half hour daily using media, television, websites, computer games, phones, and music [17]. This proves that the emergence of technology has influenced most youngsters nowadays, as they are aware of the use of technology in their daily lives.

Learning technologies such as educational and assistive technologies, help participants overcome learning activity barriers [18]. Certain ICT applications, particularly games with highly interactive systems, pose challenges for assistive technologies, rendering them unable to provide

adequate support [19]. The development of learning technologies, for disabled learners should be approached in a way that is appropriate to the capabilities and abilities of disabled learners themselves. Individual factors describe the particularities of disabled learners' physical and psychological traits [20]. In the field of education, it is commonly acknowledged that using educational technologies in the teaching-learning process and integrating technology into education are essential [21]. Studied by [18] found that they have a digital divide that affects the participation of disabled learners in education in terms of income, language, and funding. Studied by [20], it was stated that individual and environmental factors are affecting the quality of life of a disabled learner. Studied by [21], it was stated that the compatibility of hardware and software is important in technology integration in education. Based on the findings of the overall study above, they are not discussing the compatibility of learning technologies that are available nowadays with the needs and capacity of disabled learners. Correct learning approaches assisted by using learning technologies improve the understanding of disabled learners during the learning process.

Intelligence is the ability to understand ideas, environments, experiences, and reasoning and is catered to any obstacles [22]. The intelligence aspect is one factor that correlates with the achievement score. Using multiple forms of intelligence towards disabled learners is one of the most promising approaches to assist them in the learning process. Disabled learners have lower cognition skills to cater to their limitations, and integrating multiple intelligences and suitable learning technologies will help them overcome the learning process's barriers.

2.2 Heuristic Evaluation Theory

According to Nielsen, heuristic evaluation is the involvement of evaluators to analyze and evaluate the usability problems as well as the interactions of the system according to the set of heuristic checklists [23]. Heuristic evaluation involves multiple evaluators' involvement in evaluating the design concept and interactions applied in the system. In addition, heuristic evaluation is implemented in the early stage of the design phase to solve any problems regarding usability rather than the changes made at the end of the design phase [24]. Evaluators will implement the heuristic evaluation process to evaluate the design process and identify the flaws proposed in the user interface of the developing technology.

The two most common approaches in the evaluation of usability problems are Usability Testing (UT) [25] and Heuristic Evaluation [26]. Heuristic Evaluation, which refers to the process of a heuristic-guided inspection that follows a heuristic principle to develop the best design interface to maximize user usability, is one of the best approaches [27]. Meanwhile, usability testing refers to evaluating the product with representative users to identify usability problems.

3. METHOD AND MATERIAL

This study will conduct a content validity (CV) and heuristic evaluation to determine the efficiency of the proposed prototype of low fidelity learning technologies for disabled learners. Prototypes for application evaluation can vary, ranging from rudimentary sketches on paper to intricate, immersive representations on constructed application devices [28]. The number of evaluators involved in these evaluation processes is around 3 to 5. The evaluators will evaluate the design and interaction of the interface of these 3M learning applications to determine the flaws in the proposed prototype.

The background evaluators involved in these evaluations are teachers and experts in Human-Computer Interaction. The evaluator will evaluate the design using the heuristic evaluation checklist by Nielsen [29]. A purposive sampling method is used to select the expert sample. Purposive sampling is used when a study needs to acquire knowledge from people with specific experiences. The heuristic evaluation aims to determine the flaws in the proposed low-fidelity prototype of learning technologies for disabled learners.

3.1 Method of a Study

Before the heuristic evaluation is done, the content validity will be assessed on the questionnaire checklist to determine how well the instrument is relevant and suits the item that wants to be measured. The content validity process was done by validating and getting an expert's opinion on the questionnaire checklist used in the study. Content validity index values equal to or higher than 0.74 were considered excellent [30]. Meanwhile, values between 0.60 and 0.74 were good, and values between 0.40 and 0.59 were considered fair.

After the content validity is done, the heuristic evaluation will be carried out to get feedback on the flaws of the proposed low-fidelity prototype. This heuristic evaluation process will involve an expert

with a human-computer interaction background. Here are the details of the heuristic evaluation process.

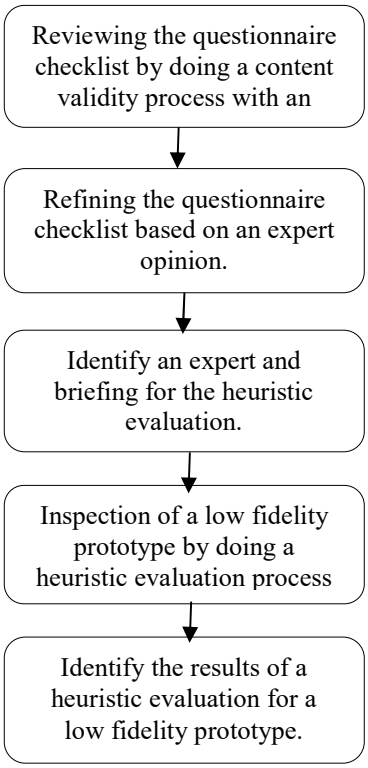

Figure 1. Method study procedure of these study

Figure 1 shows the method study procedure that will be carried out in these studies. Below are the details of the heuristic evaluation process:

- An expert will do the review process for a questionnaire checklist through a content validity process.
- In this reviewing process, the questionnaire checklist will be refined by retaining and deleting the items based on the content validity index value based on expert opinion.
- Next, identifying an expert with a human-computer interaction background will be carried on in these stages.
- After that, a low-fidelity prototype will be inspected using a heuristic evaluation process.
- Finally, the identification results for a heuristic evaluation for a low-fidelity prototype were determined at this stage.

Usability evaluation involves usability experts engaging with a system of interest to detect usability problems [31]. The result of this evaluation will help the designer overcome any problems and flaws in the design of the low-fidelity prototype. This will help to maximize the usability and efficiency of these low-fidelity prototypes for disabled learners.

These evaluations will use a quantitative analysis with an evaluator to determine the efficiency of the proposed low-fidelity prototype. The purpose of this heuristic evaluation is to determine and inspect software usability. Table 1 shows the heuristic evaluation checklist used in this study. It consists of ten heuristic usability elements used in this study and reviewed by an expert [32]. The results obtained will help to increase the efficient usage of disabled learners using these low-fidelity prototypes in the classroom environment.

Table 1: Heuristic evaluation checklist

Item	No	Review Checklist
Visibility of System Status (A)	1	Does every display begin with a title or header that describes screen contents?
	2	Does every display begin with a title or header that describes screen contents?
	3	Is each page labelled in multipage data entry screens to show its relation to others?
	4	Do menu instructions, prompts, and error messages appear in the same place(s) on each menu?
	5	Is the current status of an icon indicated?
	6	Is there feedback when function keys are pressed?
Match Between Systems and The Real World (B)	7	Are icons concrete and familiar?
	8	Do menu choices fit logically into categories that have readily understood meanings?
User Control and Freedom (C)	9	Can users cancel out of operations in progress?
	10	If the system has multiple menu levels, is there a mechanism allowing users to return to previous menus?
	11	Are menus broad (many items on a menu) rather than deep (many menu levels)?
	12	If the system allows users to reverse their actions, is

		there a retracing mechanism allowing multiple undos?
	13	If users can return to a previous menu, can they change their earlier menu choice?
	14	Can users move forward and backwards between fields or dialogue box options?
	15	Can users easily reverse their actions?
Consistency and Standards (D)	16	Are icons labelled?
	17	Does each window have a title?
	18	Does the menu structure match the task structure?
	19	If "exit" is a menu choice, does it always appear at the bottom of the list?
	20	Are menu titles either centered or left-justified?
	21	Are field labels consistent from one data entry screen to another?
	22	For question-and-answer interfaces, are the valid inputs for a question listed?
	23	Are menu choice names consistent, both within each menu and across the system, in grammatical style and terminology?
	24	Is the structure of a data entry value consistent from screen to screen?
	25	If the system has multipage data entry screens, do all pages have the same title?
	26	If the system has multipage data entry screens, does each page have a sequential page number?
Help Users Recognize, Diagnose and Recover from Errors (E)	27	Is sound used to signal an error?
	28	Are error messages grammatically, correct?
	29	Do all error messages in the system use consistent grammatical style, form, terminology, and abbreviation
	30	Do error messages inform the user of the error's severity?

Error Prevention (F)	31	Are menu choices logical, distinctive, and mutually exclusive?
	32	Is navigation between windows visible and straightforward if the system displays multiple windows?
	33	Do fields in data entry screens and dialogue boxes contain default values when appropriate?
Recognition Rather than Recall (G)	34	Does the data display start in the upper-left corner of the screen?
	35	Are multiword field labels placed horizontally (not stacked vertically)?
	36	Are borders used to identify meaningful groups?
	37	Has the same color been used to group related elements?
	38	Is color coding consistent throughout the system?
	39	Is there good color and brightness contrast between the image and background colors?
	40	Is the first word of each menu choice the most important?
	41	Does the system provide mapping: are the relationships between controls and actions appear to the user?
Flexibility and Minimalist Design (H)	42	Do users have the option of clicking directly on a field or using a keyboard shortcut on data entry screens?
	43	Do users have the option of clicking directly on a menu item or using a keyboard shortcut?
Aesthetic and Minimalist Design (I)	44	Does each data entry screen have a short, straightforward, distinctive title?
	45	Are field labels brief, familiar, and descriptive?
	46	Are there pop-up or pull-down menus within data entry fields with many but well-defined entry options?

Help and Documentation (J)	47	Is the information easy to find?
	48	Is the visual layout well designed?
	49	Is the information accurate, complete, and understandable?

3.2 Content Validity

Content validity was conducted to determine the reliability of each questionnaire used in the heuristic evaluation. This content validity process was conducted by getting an expert review to determine whether each questionnaire is reliable or not to be used in the heuristic evaluation. Content validity can be defined as the degree to which each element in the instrument is relevant and is not part of the construct for that assessment [33]. In addition, the content validity process measures the appropriate construct items to be part of a questionnaire. After the content validity process is conducted, if the results are not reliable, the items in the instrument will be deleted from the questionnaire. Three experts did these content validity processes to get a review expert for each construct that will be used later during the heuristic evaluation.

3.3 Content Validity Index

Before the heuristic evaluation was conducted, the content validity index (CVI) process was done for each item in the heuristic evaluation questionnaire. CVI is used to determine content validity. Content validity is used to identify whether the items used represent that assessment's domain. Content validity is measured by using I-CVU (item content validity index) or S-CVI (scale content validity index). I-CVI is a measurement of the validity of an individual item, and an expert rate it. Based on the result, it can help the researcher to delete or maintain the items in the questionnaire. CVI is advised to use three to ten evaluators [28]. The CVR (content validity ratio) was calculated using a formula of CVR = (Ne – N/2)/(N/2) wherein Ne is referred to the number of panelists indicating “essential” meanwhile N refer to the total number of panelists. According to the “Lawshe” the CVR range starts from 0 to 1 [34]. On this study, the experts will rate the heuristic evaluation checklist according to the judgement assessment based on the rating that they have made.

Content validities were conducted to determine the reliability of each questionnaire used in the

4. RESULT AND ANALYSIS

This section discussed the findings of this study. It comprises a low-fidelity prototype's content validity index value and usability percentage. Table 2 shows the CVI value for heuristic evaluation, consisting of an item that cannot meet the CVI indices with a value of 0.67. If the CVI value exceeds 0.79, the item is relevant, and if the value is below 0.70, then the item is eliminated [35]. Based on the Waltz and Bausell method [36], items higher than 0.79 are suitable. Meanwhile, for items with a CVI < 0.79 were eliminated or revised.

For this heuristic evaluation, the expert is needed to evaluate the validity of a set of items or questions, typically in questionnaires that are needed in the heuristic evaluation. In this study, the experts are chosen based on the human-computer interaction background. Three experts were involved in this evaluation. 3–5 experienced evaluators can identify 75–80% of all usability problems, and 3–5 novice evaluators can find 40–60% of the issues [37]. The severity ratings used for this heuristic evaluation are 1-5, where scale 1 is strongly disagree, scale 2 is disagree, scale 3 is neutral, scale 4 is agree, and scale 5 is strongly agree. The scope of respondents to these heuristic questionnaires will be evaluated by experts in human-computer interaction.

Table 2 shows CVI value for heuristic evaluation. It shows that that S-CVI value is 0.85, and its value is greater than 0.79. Hence, it shows that the items are relevant in this heuristic evaluation. The amount of CVI is in a range of 0–1; a score closer to 1 has a higher validity. Items with scores > 0.79 were accepted; items with scores between 0.70 and 0.79 needed revisions; and items with CVI < 0.7 needed corrections.

Table 2: CVI value for heuristic evaluation.

Item	Expert1	Expert 2	Expert 3	No of agreement	CVI
a6	2	3	4	2	0.67
c1	2	3	4	2	0.67
d9	2	3	4	2	0.67
h1	3	3	1	2	0.67
h2	3	4	1	2	0.67
i3	3	4	1	2	
Total I-CVI	33				
S-CVI/Average	0.85				

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These evaluations used a quantitative analysis operated by an expert to determine the efficiency of the proposed low-fidelity prototype. The purpose of this heuristic evaluation is to define and inspect software usability. So based on these results, it will help increase the efficiency of the usage of these low-fidelity prototypes in the classroom environment. Table 3 shows the usability percentage of a low-fidelity prototype that was conducted in this study.

Table 3: Usability percentage of a low-fidelity prototype.

Heuristics	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5	Evaluator 6
H1	5	3	5	4	4	5
H2	2	2	2	2	2	2
H3	3	3	3	3	3	3
H4	9	9	5	8	8	9
H5	3	3	1	3	2	3
H6	2	1	2	2	2	2
H7	4	3	1	4	4	4
H9	2	2	2	2	2	2
H10	3	3	1	3	2	3
Total Average	1.00	0.88	0.67	0.94	0.88	1.00
Usability Percentage (%)	100	87.88	66.67	93.94	87.88	100

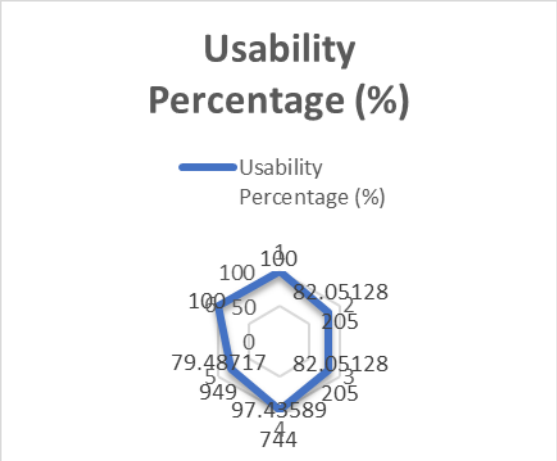

Figure 2. Radar chart of Usability Percentage Heuristic Evaluation

Figure 2 shows a radar chart of the usability percentage heuristic evaluation that six (6) experts conducted. These results show that Evaluator 1 and Evaluator 6 have a 100% usability percentage, followed by Evaluator 4 at 93.94%. Evaluator 2 and Evaluator 3 are 87.88%, and Evaluator 5 is 87.88%. The overall results show that all the usability percentage is over 77.5%. Hence, it represents a good user experience level. Other than that, the comments from the panel expert also need to be considered to improve the design of interface learning technology for disabled learners. This will also help the designer maximize the usability and efficiency of these low-fidelity prototypes for disabled learners.

5. CONCLUSION

This paper demonstrates the content validity index and heuristic evaluation that will be conducted to determine the efficiency of the low-fidelity prototype for disabled learners in the classroom. The feedback from an expert will help to determine flaws in the design of the low-fidelity prototype for disabled learners. Hence, it will increase the efficiency of a user in using these prototypes. Using these low-fidelity prototypes will improve the understanding of disabled learners towards the learning content.

6. FUTURE RESEARCH

The aim of this study is to minimize the errors that can affect the use of the system by determining the efficiency of the 3M learning application using Nielsen's heuristic evaluation. Based on the results achieved, it shows this 3M learning application has achieved a good user experience level. After receiving some feedback from an expert, this research received a few suggestions for improvement for future works. It is recommended that further research be undertaken in several areas.

First, the experts suggested that the exit menu button needs to be changed to another icon because it might confuse the user. At the same time, an interactive element can be added to ensure engagement between disabled learners and 3M learning applications. Hence, this future research will be carried out to improve the 3M learning application, as it may help disabled learners to make learning easier with the usage of the 3M learning application.

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