

Inclusive Design Requirement in Designing Accessibility for Low Cognitive Users Keperluan Reka Bentuk Inklusif dalam Reka Bentuk Ketercapaian untuk Pengguna Kognitif Rendah

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ABSTRACT

In recent years, there has been extensive research on applying gamification in learning applications. However, there is little published information on the accessibility of gamification learning applications. Accessibility is essential for disabled users to access the application. There is a general lack of empirical research investigating the requirements of gamification applications for low cognitive users. Few studies have described the impact of limitations low cognitive users face with accessibility that distress their learning process. This study attempt to design learning gamification application for low cognitive user. Based on the requirement needs of low cognitive user, the application design was implemented and tested. Usability testing results showed positive feedback from implementing accessibility requirements in learning gamification applications.

Keywords: Accessibility; children; cognitive theory of multimedia learning; gamification; low cognitive user; universal design of learning; self-determination theory

ABSTRAK

Dalam beberapa tahun kebelakangan ini, terdapat penyelidikan yang meluas tentang penggunaan gamifikasi dalam aplikasi pembelajaran. Walau bagaimanapun, masih kurang penerbitan yang menjurus kepada penerapan ciri ketercapaian dalam aplikasi gamifikasi pembelajaran. Ciri ketercapaian adalah penting bagi pengguna kelainan upaya untuk memastikan mereka mampu mencapai sesuatu aplikasi. Umumnya, masih kurang penyelidikan secara empirikal yang mengenal

pasti keperluan aplikasi gamifikasi khusus untuk pengguna kognitif rendah. Kajian terdahulu telah menggambarkan kesan batasan ketercapaian pengguna kognitif rendah yang telah mengganggu proses pembelajaran mereka. Justeru itu, kajian ini bertujuan untuk mereka bentuk aplikasi gamifikasi pembelajaran khusus untuk pengguna kognitif rendah. Berdasarkan keperluan pengguna kognitif rendah yang dikenal pasti, reka bentuk aplikasi telah dibangunkan dan diuji. Keputusan pengujian kebolehgunaan telah menunjukkan maklum balas positif hasil penerapan ciri ketercapaian dalam aplikasi gamifikasi pembelajaran yang dibangunkan.

Kata kunci: Ketercapaian; kanak-kanak; teori kognitif pembelajaran multimedia; gamifikasi; reka bentuk sejangat pembelajaran; teori determinasi sendiri

INTRODUCTION

Several applications and assistive devices and gadgets have been designed consistent with the growth of technological development (Keskinova et al. 2021). The use of these new technologies into education is rapid, and multimedia is becoming the component of choice for educational and learning applications (Osman et al. 2016). Among them is the use of digital games for learning purposes, known as game-based learning is common in today's educational systems. (Mulyadi & Mat Zin 2019). The aim is that learner will eventually learn something from the games (Ahmad et al. 2019). There are many approach of games use in learning such as serious games, game based learning and gamification. In learning, gamification can motivate individuals to learn and engage (Dichev et al. 2020; Ifigenia et al. 2018). The main idea of gamification is to harness the potential of the game in terms of learning and motivation (Tengku Wook et al. 2021). The gamification approach in education can benefit teachers and students (Ifigenia et al. 2018). However, most electronic learning has become a wall for students with disabilities (Calle-jimenez & Sanchez-Gordon 2021). Accessibility should be a concern when designing products and services that people with disabilities can access. Accessibility is a process used for inclusive design. Inclusive design is an approach in designing products and services to be accessed by all users (Wilson et al. 2019).

LITERATURE REVIEW

Gamification

Nick Pelling first introduced the term of gamification in 2002 (Buckley et al. 2018). Gamification uses game elements and game thinking to involve users with the application (Khaleel et al. 2019). In 2011, Deterding defined gamification as applying the elements of games in a different context (Buckley et al. 2018). Gamification contains the elements that can promote the way people learn (Ifigenia et al. 2018). Learning gamification aims to attract students to learn (Dichev et al. 2020). In designing learning gamification, the main concern is to include the user requirement (Khaleel et al. 2020). However the requirements in designing learning application for disabilities learners are depend on the problem in learning and the type of disabilities that they faced (Ifigenia et al. 2018). Therefore, to ensure that learning gamification applications can be designed for disabilities learner, inclusive design must be applied.

Inclusive design

The terms Inclusive Design (Coleman, 1993), Universal Design (Centre for Universal Design, 1997), and Design for All (European Institute for Design and Disability, 2004) are used to promote

equality (Zhu, Li, et al. 2020), regardless of the people's ability, age, tradition, race, lifestyle, and gender (Zhu, Gruber, et al. 2020). Universal Design is commonly used in America and Japan, while Design for All is in Europe (Lloyd-Esenkaya et al. 2020). Inclusive design is not a fixed but a constantly growing design approach (Szewczenko & Widzisz-Pronobis 2020). This is because the person with a disability has different problem. For example, elderly may have vision problems, hearing problems, cognitive processes such as short-term memory as well as psychometric problems such as difficulty with fine motor coordination (Rusdi et al. 2017). Based on various results obtained of the requirement for those with disabilities and the elderly, the objective of inclusive design can be achieved (Wilson et al. 2019). The inclusive design aims to meet everyone's needs by ensuring that the products or services can be accessed (Fallah et al. 2021; Lloyd-Esenkaya et al. 2020). The earlier objective of the inclusive design was to make sure that two inclusive groups could access the design of products and services, i.e., the elderly and disabled (Lim et al. 2021). Later, the inclusive design moved toward meeting the needs of all individuals (Zhu, Gruber, et al. 2020). The inclusive design attempts to offer resolutions for everyone in designing products and services (Szewczenko & Widzisz-Pronobis 2020).

The concept of diversity in inclusive design can be extended to user needs, environment, tradition, lifestyle, and social-cultural factors (Zhu, Gruber, et al. 2020). Inclusive design enhances the guidelines and principles in development when the product or service is designed for people with disabilities (Szewczenko & Widzisz-Pronobis 2020). The inclusive design uses accessibility and usability to address the problems people face (Calle-jimenez & Sanchez-Gordon 2021). Accessibility is a list of strategies, processes, and needs not only for technologies, services, and methods (Greco 2019). The concept of equality cannot be achieved without concern for accessibility (Egard 2021). Most applications and learning tools provide learning barriers because they are not designed to meet the needs and abilities of the users, preventing them from continuing the courses (Calle-Jimenez & Sanchez-Gordon 2021). Before accessibility is designed, how it should be planned, developed, and applied must be considered (Egard 2021).

Accessibility has become the main concern in most disciplines and fields (Greco 2019). In study by Keskinova et al. (2021), several requirements listed to provide accessibility of a museum for children with autism. The requirements are by creating materials for them, using technology, improving the interacting skills of the staff, and adapting how other museums handle autistic children (Keskinova et al. 2021). This will help children with autism to access the museums and break down the barriers they faced. A comprehensive design like this is important to ensure that no individual discriminated against when using a product or service. In education, inclusive education aims to ensure that all learners can access the course without any discrimination (Calle-Jimenez & Sanchez-Gordon 2021). This study attempt to design learning gamification application for low cognitive user.

LOW COGNITIVE USERS

The Center for Disease Control and Prevention (CDC) has listed four key of disabilities: (1) vision, (2) hearing, (3) mobility, and (4) cognitive impairments (Mancilla & Frey 2021). Cognitive impairment is the problem when the person has problem in learning, focus, memorizing and making choice that affect their life. Cognitive impairement can be sorts from mild to severe. Low cognitive user can be categorize as mild cognitive impairment. Low cognitive users have a below-average intelligence quotient (IQ) without health problems. They are not categorised as users with

learning disabilities (Suarez et al. 2017). They are considered to have low intelligence compared to normal children (Farooq & Aslam 2017). They have difficulty of learning because of their poor cognitive ability (Farooq & Aslam 2017; Salomi D & Sundaram 2018; Vasudevan 2017) and low motivation (Salomi D & Sundaram 2018; Suarez et al. 2017). As a result, they have problems learning in normal classes (Salomi D & Sundaram 2018). In learning, gamification can help the individual student to learn and participate with learning gamification application (Dichev et al. 2020; Ifigenia et al. 2018). Gamification has the ability to exploit the potential of games in terms of learning and motivation (Tengku Wook et al. 2021). Studies has showed that gamification give advantages for both teachers and students (Ifigenia et al. 2018). However, most learning application has become a barrier for students with disabilities (Calle-jimenez & Sanchez-Gordon 2021). This is because they need design approach that can help them access products and services. Therefore, this paper aims to identify inclusive design requirements for low cognitive users.

METHODOLOGY

The requirement needs have been obtained from the analysis phase. Based on the literature, the author identifies the problem and limitations of low cognitive users and the accessibility problems they face. The process continues with the requirement analysis for low cognitive users. The results obtained from requirement analysis are inclusive design with requirements for low cognitive user's accessibility. The inclusive design requirements have been implemented in the development of NUMERATica. The techniques used to evaluate NUMERATica is usability testing. The processes involved are shown in Figure 1.

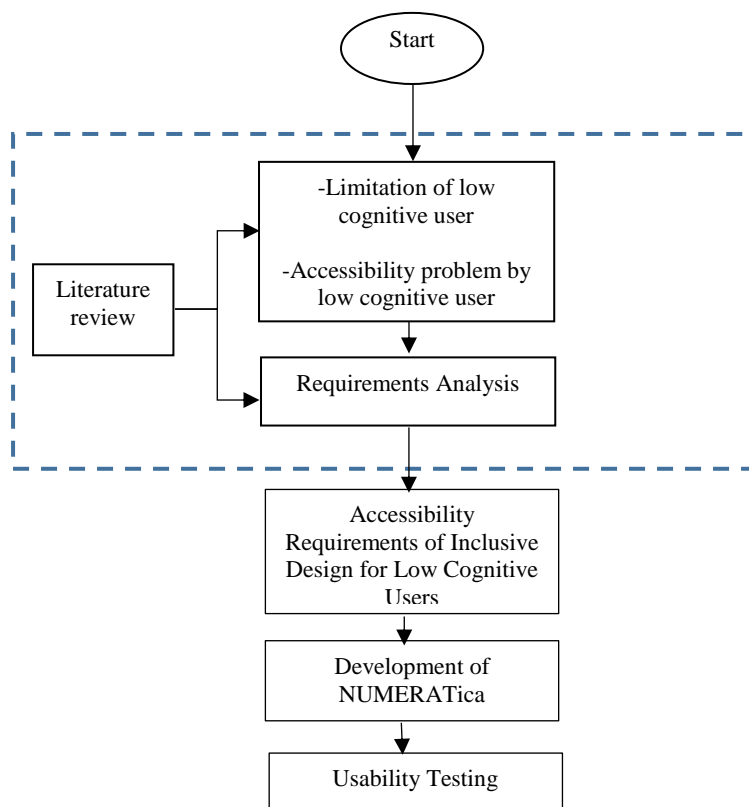


FIGURE 1. Analysis Process in designing inclusive for low cognitive users' accessibility

LOW COGNITIVE USERS LEARNING PROBLEMS

This study attempts to design gamification applications for low cognitive users. Since the users of this study are low cognitive user children, the study has to identify the problems they face. Compared to adult users, children's cognitive skills are still developing; so, their reasoning abilities are weaker than those of adults (Liu 2019). Children may have problem to access the application because of their with limited cognitive (Liu 2019). Children get confused with the much-complicated structure of navigation (Sherwin & Nielson 2019). Children need a design that can reduce cognitive load (Liu 2019). They need instruction that is clear and specific (Liu 2019). Another reason is that their physical capabilities are limited (Liu 2018). Children also have limited motor skills (Liu 2018). Low cognitive users have poor cognitive abilities (Novitasari et al. 2018; Salomi.D & Sundaram 2018; Suarez et al. 2017; Vasudevan 2017) and are not motivated in learning (Salomi D & Sundaram 2018; Suarez et al. 2017). Low cognitive users may have problems or difficulty with new symbols and interface patterns (World Wide Web Consortium 2020). Thus, they need a simple design and does not have a complicated navigation structure (World Wide Web Consortium 2020). They are not easy to adapt to the new design (World Wide Web Consortium 2020). Low cognitive users need extra time to recognise the design relationships and the information because they only can hold about one to three items at one time in their memory (World Wide Web Consortium 2020). The instructions must be clear and simple. They also need images and graphics that they familiar in order to understand content or instruction (World Wide Web Consortium 2020).

INCLUSIVE DESIGN FOR LOW COGNITIVE USERS

The elements of accessibility should not be designed as an add-on but customised in areas such as interface presentation that allows the students to choose options based on their needs (Gronseth 2018). When designing accessible electronic content, the students should be able to predict, navigate, adapt, use, and comprehend, and the contents should be compatible and unique (Gronseth 2018). Studies showed that the implementation of inclusive design not only can be use by disabilities but also can promote learning and motivation for them (Benítez-Lugo et al. 2021). Low cognitive user children need certain design to access the application. User design can be implemented to avoid cognitive load in low cognitive children. This study implemented two types of user design; user design for low cognitive user and user design for children. User design for children is important to be implemented because children's cognitive skills abilities are weaker than those of adults (Liu 2019). Children also have limited motor skills (Liu 2018b). They need a design that can help them explore the interface with their limited motor. The large size of the button and colorful (Liu 2018b) that four times larger than the adult can help them. The interface also should avoid dragging, scrolling (Liu 2018b). While user design for the low cognitive users is important to reduce cognitive load as the low cognitive users can only hold about one to three items at one time in their memory (Cooper et al. 2021). To help them, the user design structure and hierarchy of the page must be easy to follow (Cooper et al. 2021). The structure of navigation has to be reduced or limited (Liu 2018b). They also need user design that can help them learn such as repetition functions. Low cognitive users need repetition in learning (Farooq & Aslam 2017; Vasudevan 2017). The requirements are synthesised in Table 2.

TABLE 1. Accessibility Requirements of Inclusive Design for Low Cognitive Users

Categories	Sub-Categories	Element	Accessibility features
User Design	Children design	Text	Using 14-point text size.
		Navigation	Reduced the structure and navigation hierarchy.
			Avoid the use of dragging, scrolling.
		Button	Uses larger and more prominent buttons. The size of the touch target is 4 times larger than that of an adult user.
		Audio	Provides a sound function on the button.
	Low cognitive user design	Text	Use common terms or basic terms.
		Graphic	Use familiar and recognizable symbols.
		Navigation	Uses a structure and hierarchy that is easy to follow.
		Audio	Use a simple tone and voice.
		Button	Provide a repetition function/process in the learning content.
			Provides back button functionality.
		Game element	Avoid using game elements with competition and earning badges that can cause anxiety. Instead use game elements with rewards to increase motivation.
	Children/low cognitive user design	Instruction	Use clear and simple language and instructions.

IMPLEMENTATION

The main menu screen of the NUMERATica gamification application contains five modules, namely recognize module, the pronounce module, the sing module, the play module and the quiz module as shown in Figure. The use of the terms recognize, pronounce, sing, play and and quiz apply the use of common terms understood by low cognitive users. The use of common or basic terms is important for low cognitive users (World Wide Web Consortium 2020). The structure and hierarchy of the screen pages are arranged so that they are easy to follow. This is because low cognitive users need time to understand the relationship between the design and the information content on the screen (World Wide Web Consortium 2020). The first level starts with the start screen and is followed by the Main Menu. In the main menu there are five buttons that represent five modules, namely the number recognition module, the number pronunciation module, the singing module, the play module, and the quiz module as shown in the diagram below. In the play module consist of three levels, level 1, level 2 and level 3. Users can choose to exit the gamification application through the start screen and main menu as Figure 2.

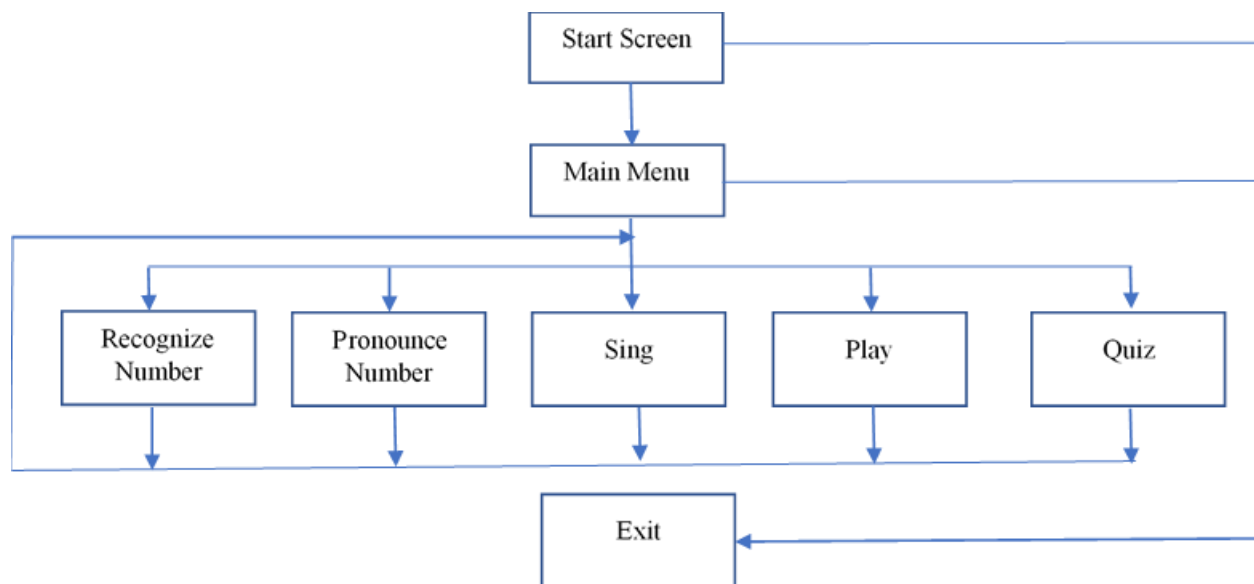


FIGURE 2. The structure and hierarchy of NUMERATica

Designing a recognize number screen like Figure 3 using a simple tone and voice is necessary especially for low cognitive users (World Wide Web Consortium 2020). The use of the back button is provided to give the user the option to return to the previous screen and the use of the next button to go to the next screen. While the use of the home button gives the user the option to return to the main menu.



FIGURE 3. Recognize Number screen

USABILITY TESTING

Before conducting the study, an application for research study was submitted to the Ministry of Education and was approved by the Ministry of School and the Department of State. The study obtained an informed consent form signed by each participant before the start of the test. Participants in this test were eight pupils aged 8-year-old Standard 2 from remedial class. Five participants were boys and the other three were girls. The teacher acted as a facilitator throughout the testing process. The process began with the facilitator explaining the process flow and instructions being tested. One by one student was called in to test the prototype. The pupils' task was to test gamification applications with accessibility elements implemented.

USABILITY EVALUATION

Based on usability evaluation, the results show that the usability of the start screen is 100 percent. The usability of the main menu, the usability of the pronounce number module and quiz menu are 98 percent. the finding of the usability of the recognize number is 97 percent, the finding of the usability of play is 96 percent, and the finding of the usability of the singing module is 95 percent as shown in the Table 2.

TABLE 2. Result of Usability Testing

Screen/Menu	Result			
	Effectiveness	Efficiency	Satisfaction	Usability
Start Screen	100	100	100	100
Main Menu	100	100	94	98
Recognize Number	99	98	94	97
Pronounce Number	100	100	94	98
Sing	97	95	94	95
Play	98	97	94	96
Quiz	100	100	94	98

DISCUSSION

Technology and applications have become a wall for users with disabilities. Low cognitive users need certain requirements to access the applications and technology. The inclusive design offers a solution to the problem. An approach of accessibility in inclusive design identifies the requirements for the users. Thus, the objective to this paper is to identify the accessibility requirements of inclusive design for low cognitive users. This is to help the low cognitive children to access the learning gamification application. Based on the empirical results obtained, it can be concluded that the implementation of inclusive design with requirements for low cognitive users has provide the accessibility for low cognitive users. The results obtained are in line with a previous study that implementation of inclusive design has overcome the barriers faced by the disabilities (Benítez-Lugo et al. 2021; Mohid 2017).

This study has identified inclusive design requirement in designing gamification for low cognitive users. Elements of text, graphics, navigation, button, instruction, audio, content, and games elements based on low cognitive user needs are important in designing the application for low cognitive users. These elements can remove the barrier and wall for low cognitive users with applications and technology.

CONCLUSION

In this paper, several accessibility requirements of inclusive design for low cognitive users has been identified. The requirement are for text, graphics, navigation, button, instruction, audio, content, and games elements. Based on the requirements, the learning gamification application has been developed and tested. The results of usability testing have shown implementation of inclusive design has deliver the accessibility for low cognitive user.

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