Journal of Advanced Research in Applied Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Erudite Survivor: Usability Testing of a Gamification-based Mobile App for Disaster Awareness Among Children

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ARTICLE INFO

Article history:
Received 28 April 2023
Received in revised form 28 July 2023
Accepted 4 August 2023
Available online 16 August 2023

Keywords:
Gamification; mobile application; disaster awareness; children; Malaysian

ABSTRACT

Numerous peer-reviewed studies describe designs for a mobile application for children based on gamification and catastrophe awareness. However, few articles give extensive evaluations of their solutions' usability for end users. The purpose of this study is to present the usability assessment findings of a mobile app aimed at raising children's catastrophe awareness in Malaysia. The study includes 12 target users to test the usability of the Erudite Survivor mobile app prototype. The test evaluation contains a pre-test, post-task and post-test questionnaire (Post-Study System Usability Questionnaire). The primary sections of this Post-Study System Usability Questionnaire are Overall Satisfaction, System Usefulness, Information Quality, and Interface Quality. The Post-Study System Usability Questionnaire revealed the following mean scores: Overall satisfaction (2.09), System Usefulness (2.03), Information Quality (2.06), and Interface Quality (2.25). Users of the prototype were satisfied with the application because the score was near to 1. This application's capacity to teach children about disaster awareness might be viewed as the initial step toward a future improvement of gamification-based disaster education among Malaysian children.

1. Introduction

Gamification involves using game design elements for non-game purposes [1]. It has been successfully applied in various fields like environment, health, employment, commerce, and education [2,3]. In education, gamification has proven to be valuable for enhancing students' motivation, participation, involvement, and interest in learning [4,5].

Serious games have demonstrated considerable potential and advantages in the field of disaster risk reduction [6]. Prior studies, such as those by Arinta *et al.,* [7], Kimura and Kawamoto [8], and Manalang *et al.,* [9], have explored the utilisation of gamification to enhance disaster awareness in Indonesia, Japan, and the Philippines, respectively. Arinta *et al.,* [7] developed a mobile application that employs gamification elements to educate rural communities on proper disaster preparedness, focusing on floods. Kimura and Kawamoto [8] integrated gamification into their e-learning system, presenting a disaster safety manual in a visual novel format and assessing users' knowledge

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https://doi.org/10.37934/araset.31.3.290298

retention. Manalang *et al.,* [9] created Kidzaster, a web-based learning system that imparts knowledge of natural disasters to Philippine students. All three studies highlight the effectiveness of gamification in disaster preparedness education, enhancing the learning experience, improving accessibility to disaster-related information, and fostering user engagement. This applies not only to adults but also to children, who should be educated about disasters from an early age. Despite the presence of several studies investigating the use of gamification to raise disaster awareness in neighbouring countries, research on gamification and disaster preparedness in Malaysia, particularly in the context of children's learning and relevant natural disasters, is limited.

There is a lack of disaster awareness among the Malaysian population, particularly among children who have not experienced major catastrophes resulting in significant losses of life and infrastructure [10]. Neighbouring countries like Indonesia and the Philippines face constant threats from disasters and Malaysia should not be complacent [11,12]. Future projections indicate that the east coast of Malaysia will experience increased rainfall, rising sea levels, and recurrent flooding by 2050 [13]. Natural disasters have the potential to cause not only short-term challenges but also long-term impacts on the nation. Khattak *et al.,* [14] highlighted the vulnerability of Malaysia's energy security to natural disasters, which is critical for the country's sustainable development. Therefore, preparations must be made and the importance of children's roles during disasters should not be underestimated [15]. Gamification has the potential to address this issue [16].

2. Methodology

2.1 Prototype Design

To develop the application, Android Studio is used as the integrated development environment (IDE) alongside the Flutter framework, which is based on the Dart programming language. Android Studio was chosen due to its comprehensive set of tools that enable efficient app construction, debugging, and optimisation. This IDE offers extensive features, including code editing, testing, and debugging capabilities. Additionally, Flutter was selected as the framework of choice because it provides a rich collection of pre-built user interface elements called widgets, along with configurable animations and themes. This empowers developers to create highly personalised and visually cohesive user interfaces across multiple platforms.

Users were asked to test the homepage screen upon starting the app. In the homepage, users can decide their next course of action. If the users want to learn more information on disasters, they can click on the Disaster Information button to access the Disaster Information section. Besides accessing other pages, users can also pause and resume the background music in the homepage by clicking the button with the speaker icon at the bottom of the screen. Additionally, users can also change the language used in the app (Figure 1).

To assess the efficacy of the application in achieving the project's objective, conducting usability testing is imperative [17]. This testing aims to evaluate the app's performance in enhancing disaster awareness, users' perception of it, and identifying areas for potential improvement. The usability testing process encompasses several tests carried out by the participants, including a pre-test questionnaire, prototype testing, and a post-test questionnaire. The pre-test serves as a preliminary assessment of the users' skills and knowledge before engaging with the app. The post-test, on the other hand, measures the users' skills and knowledge after utilising the app.

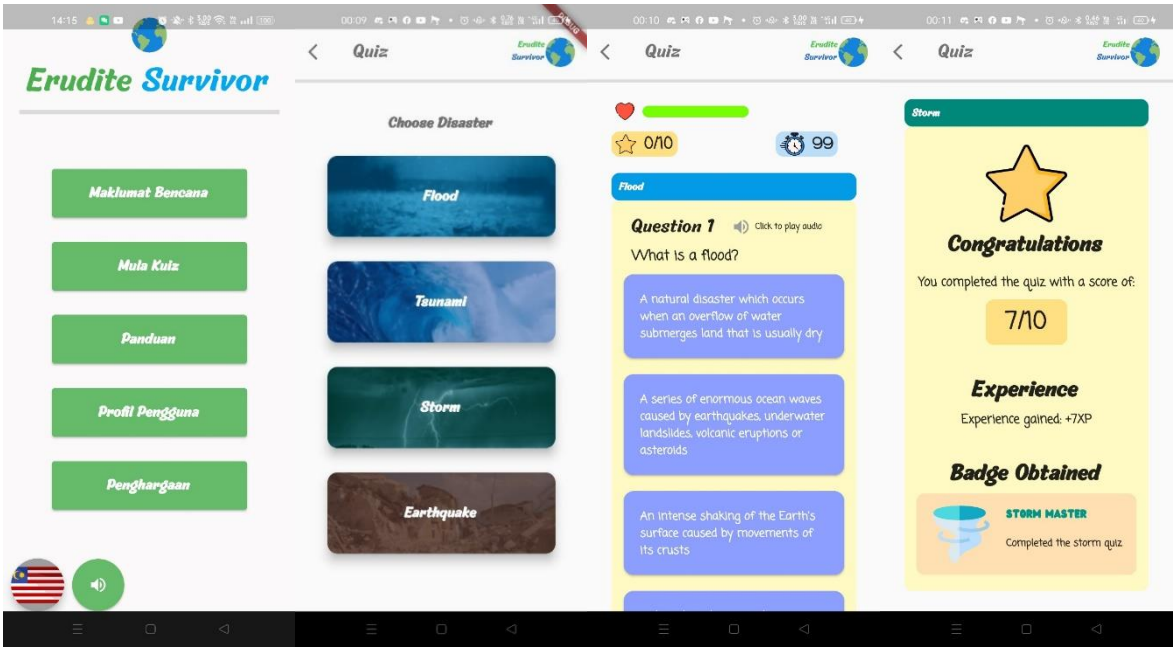

Fig. 1. From left to right: *Erudite Survivor* home screen; Choose Disaster menu; Quiz–question; Quiz result

The questionnaire also includes questions that are a part of the standardised version three Post-Study System Usability Questionnaire (PSSUQ) as used by Mohamad Jamil *et al.,* [18]. PSSUQ is commonly utilised to ascertain users' level of satisfaction after performing tests on systems. It employs a 7-point Likert scale and yields a total result by averaging scores from those seven points. The score ranges from one, which means strongly agree, to seven, which means strongly disagree. We can summarise that a lower score signifies greater satisfaction and performance. Additionally, the PSSUQ also possesses three other sub-scales which are system usefulness (SYSUSE), information quality (INFOQUAL) and interface quality (INTERQUAL) [19]. These sub-scales provide a more comprehensive overview of the numerous elements that impacts systems or applications. The subscales involved in the PSSUQ scoring and their method of calculations are:

i. Overall: the average scores of questions one to 16.
ii. SYSUSE: the average scores of questions one to six.
iii. INFOQUAL: the average scores of questions of seven to 12.
iv. INTERQUAL: the average scores of questions 13 to 15.

2.2 Usability Testing Procedure

The evaluation of the Erudite Survivor mobile app involved a testing process, comprising a pre-test questionnaire, prototype testing, and a post-test questionnaire. This methodology draws inspiration from previous studies on the effectiveness of gamification in enhancing disaster awareness, as demonstrated by scholars such as Matsuno *et al.,* [20], as well as Teague *et al.,* [21], who utilized the pre-test and post-test approach to measure user performance. The subsequent step involved the analysis of data collected during the usability testing phase. Descriptive statistics were employed to analyse the participants' scores from the PSSUQ and their levels of knowledge before and after using the Erudite Survivor app. Descriptive statistics were chosen due to their efficiency in presenting comprehensive information in a clear and understandable manner [22].

This study included a sample of 12 male participants aged between seven and 12 years old, selected from seven primary schools in the state of Sarawak. Convenience sampling was employed to recruit participants, considering its accessibility and cost-effectiveness. The movement control order (MCO) presented challenges in obtaining a larger sample size, as parents and school authorities expressed reluctance to allow their children or students to participate in the research due to concerns related to the COVID-19 pandemic. Fear of infection is one of the primary concerns [23]. Some potential participants that were approached online cited issues with internet connectivity or a lack of suitable devices, resulting in their inability to participate. This is a problem that mainly affects communities from rural areas [24]. Given the circumstances, convenience sampling was an appropriate method, considering the difficulties in travel and finding individuals within the targeted age range. While the sample size may appear relatively small, it is sufficient for the study as long as the obtained data meet the research's quality requirements. This is supported by the work of Kimura and Kawamoto [8], who conducted a study with a similar sample size of 15 participants, emphasising that a large sample size is not necessarily required to validate the obtained data.

3. Results and Discussion

3.1 Pre-test Results

The pre-test questionnaire aimed to assess participants' knowledge levels prior to using the Erudite Survivor application. Participants were asked about their knowledge of natural disasters as a whole and their survival knowledge in disaster situations. Results showed that 83.3% of participants claimed to have knowledge about natural disasters, while 16.7% reported not having any knowledge. Regarding knowledge levels on natural disasters, 41.7% indicated low levels, 41.7% reported average levels, and 16.7% expressed high levels. In terms of survival knowledge during natural disasters, only 33.3% of participants stated that they had acquired such knowledge, while the remaining 66.7% had no knowledge. Among the participants, 50% reported low levels, and 50% claimed average levels. Participants mentioned various sources of information, including formal education (58.3%), reading materials (66.7%), and electronic media (25%).

The questionnaire further investigated participants' awareness and knowledge related to specific natural disasters, namely floods, tsunamis, storms, and earthquakes. For floods, 83.3% of participants reported familiarity with the topic, while 16.7% stated otherwise. Regarding knowledge levels on floods, 66.7% reported average levels, 16.7% mentioned low levels, and 16.7% expressed high levels. In terms of survival knowledge during floods, 66.7% had no knowledge, while 33.3% claimed to have learned about survival methods. Participants' self-rated survival knowledge levels during floods were distributed as follows: 41.7% average, 25% low, 16.7% high, and 16.7% very low. The main sources of information on floods and survival methods were formal education (58.3%), reading materials (58.3%), electronic media (25%), and other sources (8.3%).

Regarding tsunamis, 66.7% of participants reported familiarity with the topic, while 33.3% stated otherwise. Knowledge levels on tsunamis were distributed as follows: 41.7% average, 33.3% low, 16.7% very low, and 8.3% high. Concerning survival knowledge during tsunamis, 66.7% had no knowledge, while 33.3% claimed to have learned survival methods. Participants' self-rated survival knowledge levels during tsunamis were distributed as follows: 41.7% very low, 41.7% low, 8.3% average, and 8.3% high. Participants mentioned acquiring knowledge on tsunamis through formal education (33.3%), reading materials (50%), and electronic media (41.7%), while 25% stated that they had not learned about tsunamis.

All participants exhibited awareness of storms, with varying levels of knowledge. Most participants (83.3%) believed their knowledge on storms to be average or high, while only a small

portion (16.7%) considered their knowledge to be low. Regarding survival knowledge during storms, the majority (75%) reported low levels of knowledge. Participants acquired storm-related knowledge through diverse sources, including formal education (50%), reading (58.3%), and electronic media (66.7%).

Similarly, all twelve participants acknowledged awareness of earthquakes, but their knowledge levels differed. Half of the participants perceived their earthquake knowledge as low, while 25% considered it average, 8.3% high, and 16.7% very high. In terms of survival knowledge during earthquakes, the majority (75%) reported not having learned how to survive them. Only 25% possessed knowledge in this area. When asked to assess their own knowledge, a majority of participants expressed insufficient knowledge, with 58.3% considering their knowledge as low and 25% as very low. However, 8.3% believed they had average knowledge, and another 8.3% reported high levels. Participants gained earthquake-related knowledge through various means, including formal education (50%), reading (66.7%), electronic media (50%), and other sources (8.3%).

3.2 Post-test Results

The post-test questionnaire consisted of two sections: knowledge assessment and satisfaction rating. The first section assessed participants' new knowledge levels and survival knowledge on floods, tsunamis, storms, and earthquakes after using the Erudite Survivor application. All twelve participants reported an improvement in their knowledge of all the mentioned natural disasters after using the Erudite Survivor application. The majority of participants (66.7%) believed they had attained high levels of knowledge, while 25% perceived their knowledge as very high, and 8.3% considered it at least average. Similarly, participants reported enhanced knowledge of survival techniques for each specific type of disaster, with 75% indicating high levels of knowledge and 25% reporting very high levels.

Significant improvements in participants' understanding of floods were observed, with 100% reporting increased knowledge and 91.6% considering their knowledge level as high or very high. Regarding survival knowledge during floods, 75% expressed high levels of knowledge, while 16.7% indicated very high levels. Similar patterns emerged for tsunamis, with all participants recognizing their improved knowledge, and all of them describing it as high or very high. In terms of survival knowledge during tsunamis, 91.6% reported high or very high levels of knowledge. Findings for storms were consistent, as 91.6% of participants indicated high or very high levels of knowledge, with a similar 91.7% reporting high or very high levels of survival knowledge. Moreover, all participants reported increased knowledge of earthquakes, with 91.7% rating their knowledge as high or very high. Survival knowledge during earthquakes also showed improvement, with 83.3% reporting high levels and an additional 8.3% mentioning very high levels. Overall, participants recognized the valuable impact of the Erudite Survivor app in enhancing their knowledge and survival skills across various natural disasters. They expressed confidence in applying the acquired knowledge in real-life situations.

The second section of the post-test questionnaire asks the user to answer the PSSUQ to assess their satisfaction level when using the Erudite Survivor mobile application. Table 1 displays the PSSUQ score among the respondents.

Table 1
Post-Study System Usability Questionnaire (PSSUQ) Score among the Respondents

No	Questions	Mean	Maximum	Minimum
1	Overall, I am satisfied with how easy it is to use this system.	2.08	5	1
2	It was simple to use this system.	2.17	5	1
3	I was able to complete the tasks quickly using this system.	2.08	5	1
4	I felt comfortable using this system.	1.58	5	1
5	It was easy to learn to use this system.	2.08	6	1
6	I believe I could become productive quickly using this system.	2.17	5	1
7	The system gave error messages that clearly told me how to fix problems (example: Message after failing a quiz).	1.92	5	1
8	Whenever I made a mistake using the system, I could recover easily and quickly.	2.00	5	1
9	The information (such as on-screen messages, online help, and other documentation) provided with this system was clear.	2.25	5	1
10	It was easy to find the information I needed.	2.00	5	1
11	The information was effective in helping me complete the tasks.	2.17	6	1
12	The organization of information on the system screens was clear.	2.00	6	1
13	The interface of this system was pleasant.	2.17	6	1
14	I enjoyed using the interface of this system.	2.33	6	1
15	This system has all the functions and capabilities I expect it to have.	2.25	6	1
16	Overall, I am satisfied with this system.	2.25	6	1

The PSSUQ scores were then used to calculate the four subscales mentioned in the usability testing plan, which are overall satisfaction, system usefulness (SYSUSE), information quality (INFOQUAL), and interface quality (INTERQUAL) as shown in Figure 2.

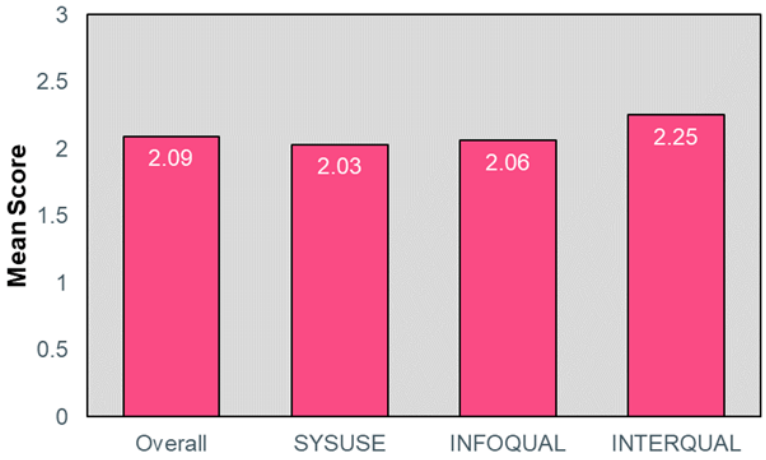

Fig. 2. Post-Study System Usability Questionnaire (PSSUQ) Subscale Scores

The PSSUQ scores range from one to seven (four is the middle point and regarded as neutral). All questions had a mean score within the range of 1.58-2.33. Nevertheless, a minority of participants have voiced out some dissatisfaction with usability, as can be seen in the maximum score of questions, which are either five or six. Their discontent is mainly caused by high expectations on the app in general since they were more interested in a full video game experience instead of a simple gamification app. The scores were then used to obtain the results which presents the subscale scores for the PSSUQ. The scores for the subscales were calculated using the method of calculation stated in the usability testing plan. Based on the results, it can be said that the participants were generally pleased with the app's usability. The mean scores of the subscales are 2.09 for overall satisfaction, 2.03 for SYSUSE, 2.06 for INFOQUAL, and 2.25 for INTERQUAL.

4. Conclusions, Limitation, and Future Work

In conclusion, the study demonstrates the effectiveness of the Erudite Survivor app prototype in raising disaster awareness and its positive reception among end users. The analysis of pre-test and post-test questionnaire results reveals that users significantly increased their knowledge of natural disasters after using the app, with a majority reporting higher levels of knowledge compared to before. The PSSUQ findings indicate a satisfactory mean overall satisfaction score of 2.09, reflecting users' positive perception of the app's usability and efficiency. This highlights the potential of gamification in enhancing the learning process. However, certain limitations should be acknowledged. The study encountered challenges in recruiting a larger sample size due to age restrictions, particularly during the Movement Control Order (MCO). The absence of female participants also limits the generalizability of the results, emphasizing the need for gender-balanced participation. To address these limitations, future research should aim to increase the sample size and enhance participant diversity. Additionally, the gamification elements of the app could be further improved to enhance the overall user experience, despite the usability testing mean scores being just below 50%. This study serves as a valuable foundation for future research on gamification and disaster awareness in Malaysia, contributing to better preparedness among Malaysians when faced with natural disasters. It is hoped that further investigations will build upon these findings and continue to advance the understanding in this important domain.

Acknowledgement

We would like to thank the Faculty of Computer Science and Information Technology as well as the Research, Innovation and Enterprise Centre, Universiti Malaysia Sarawak, for supporting this work (F08/SpMYRA/1661/2018).

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