Evaluating Game Application Interfaces for Older Adults with Mild Cognitive Impairment

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***Abstract*—A digital game is software that is used as alternative entertainment for older adults for brain training. In this study, a digital game prototype for older adults with mild cognitive impairment has been developed called EmoGame and illustrated. The game is intended to assist older adults who experience emotional and cognitive impairment that implement reminiscence therapy in the design of the user interface. Applications for older adults have been developed in many studies, but applications using a reminiscence therapy approach still need to be improved. User interface testing was carried out using the system usability scale (SUS). Interface testing with the SUS instrument was carried out in an organized and precisely measured using ten (10) questions as a benchmark for evaluation among twenty (20) respondents of, older adults. The results of the evaluation of the EmoGame prototype show an assessment score of 82, representing an excellent rating. Future work will improve the prototype to improve the design based on user feedback and iteratively improve the functionalities and interfaces and conduct a longitudinal study to investigate the effect of the games towards improving cognitive among older adults with mild cognitive impairment.**

Keywords*—System usability scale; older adults; mild cognitive impairment

I. INTRODUCTION

EmoGame is an emotional game application to help older adults with emotional and cognitive problems [16]. This game is developed with a reminiscence therapy approach. Reminiscence therapy is a memory therapy used for positive emotions in older adults who typically live with mild cognitive impairment (MCI) [21]. MCI could be a minor cognitive disability when someone has trouble recalling things or thinking clearly. Although the side effects are not sufficiently serious to lead to a diagnosis of Alzheimer's disease, MCI also interferes with emotions, causing negative emotions [31]. Based on this problem, the researchers developed EmoGame to help older adults living with MCI [20]. As a new game that has not yet been marketed, EmoGame requires a test to measure its quality. This test is needed to find the advantages and disadvantages of the game to help its development, facilitating decisions on whether this game is worth using [22]. One such test that can be used to determine the quality of the game is the system usability scale (SUS).

One approach is to ensure that EmoGame has a user-friendly interface. The interface can be measured from the end user's perspective [26]. Such measurement reveals how users evaluate EmoGame, determining whether improvements should be made before publication [18]. To perform interface testing, different strategies can be utilized, including heuristic assessment (HE) and SUS. HE and SUS are part of usability testing [23]. The focus of the two testing methods is the same, namely, assessing the interaction of the software interface, but the two are distinguished by their examiners (evaluators) [28]. HE interfaces testing is carried out by specialists [12], whereas SUS interface testing is specifically done by end users [8]. Therefore, SUS is used to test EmoGame because it emphasizes the perspective of the end user, resulting in evaluation results in line with real situations [24]. The SUS test uses 10 questions, and SUS does not require many tests, minimizing testing costs [15]. However, to further clarify the intended target population, researchers focus on tablet users aged 50 years and above living with MCI [1]. Therefore, this project is expected to be used as an example of conducting quality assurance on EmoGame by measuring the level of usability, and helping researchers decide whether the game can be used or still needs improvement.

This paper is divided into several sections. Section II explains the background related to technology and older adults, including a focus on games. Section III explains the materials and methods used. Section IV provides results and discussions. Section V concludes and gives suggestions for future work.

II. BACKGROUND WORK

A. Games for Older Adults

In information technology, the term "game" is used for entertainment facilities that use electronic devices. A game is a system or program in which one or more players make decisions by controlling objects in the game for certain purposes [10]. In dealing with the ageing process, older adults must maintain physical and mental health to stay healthy and happy. To maintain their physical health, older adults are recommended to exercise regularly with the appropriate duration and type of exercise for their age group [29]. Maintaining mental health is as important as maintaining physical health for older adults [2]. They can do various activities to train the brain as part of efforts to prevent a decrease in brain function, which is a natural part of the ageing process. One such activity is games.

Although most older adults have good mental health conditions, some are at risk of developing brain and mental health problems, especially dementia, senile disease, or depression [3]. Playing video games benefits emotional well-being and cognitive performance [21]. Playing video games has benefits for children and older adults. In older adults, playing video games is good for memory function and positive emotions. These activities can also keep older adults entertained [30].

B. Technology for Older Adults

Gerontechnology is a field that combines gerontology and technology, and it involves research and development of techniques, technology products, services, and environments based on knowledge of the ageing process [4]. The use of various types of gerontechnology by the elderly can help them to lead healthier, more independent, and socially better lives [10]. Gerontechnology is concerned with researching the biological, psychological, social, and medical aspects of ageing and exploring the potential offered by technological advances [11]. Gerontechnology was developed to comprehensively improve the quality of life of older adults [13].

Technologies are defined as assistive devices or technology-based services that aim to help the elderly perform their activities. Such services can combine multiple devices at once [22]. Preventive home modifications, such as handrails, have been shown to reduce the risk of falls, especially in the bathroom. Assistive technologies enable independence and improve the quality of life in older adults who have just been discharged from the hospital, helping limit the need for personal assistance [5]. This technology is also useful for nurses, especially in lifting and carrying patients, thereby minimizing injuries in nurses [20].

Technologies also include assistive technologies and tools to facilitate physical rehabilitation and social inclusion. Examples include video or computer games designed to provide interactive rehabilitation programs for older adults and people with stroke, as well as touch screen monitors for people with dementia to access memorable objects or entertainment features [14]. Environmental and individual-centred design technologies are also included in this scope [27]. Here, the whole environment is considered to help older adults to live independently and reduce the burden of care on their families or others who provide support [25]. Examples include hidden doors to minimize the risk of older adults with dementia leaving the house without surveillance and getting lost [6]. Such gerontechnology is possible because the technology used is easy to source and apply.

III. Material and Methods

To obtain true and accurate research results, the research methods used in evaluating EmoGame can be explained as follows:

Fig. 1 shows the steps used in this process.

We took survey data from the respondents and socialized the application we had made and distributed questionnaires. Then we collect data or analyze the data we have obtained from research surveys, Table I. So from that data, we processed using the SUS (System Usability Scale) formula in order to get results from user satisfaction using the application.

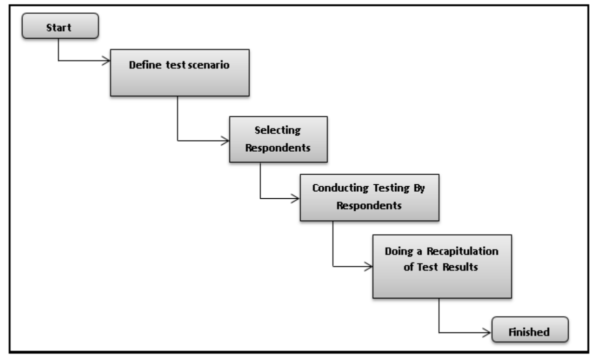

Fig. 1. Research Steps

TABLE I. SUS Testing Instrument (System Usability Scale)

No	Question
1	I think that I would like to use this system frequently.
2	I found the system unnecessarily complex.
3	I thought the system was easy to use.
4	I think that I would need the support of a technical person to be able to use this system.
5	I found that the various functions in this system were well integrated.
6	I thought there was too much inconsistency in this system.
7	I imagine most people would learn to use this system very quickly.
8	I found the system very cumbersome to use.
9	I felt very confident using the system.
10	I needed to learn a lot of things before I could get going with this system.

Fig. 1 shows the steps of the research as follows: 1) determining the test scenario, 2) selecting respondents, 3) conducting testing with the respondents, and 4) summarizing the test results. In the first step, a test scenario is created, which begins with the software to be tested being explained and a questionnaire being developed [9]. In the second step, the respondents who will assess EmoGame are selected. In the third step, respondents are asked to evaluate EmoGame based on SUS. In the fourth step, test results are obtained according to SUS calculations.

The SUS uses a five-point scale, where 5 is “strongly agree” and 1 is “strongly disagree”. Table II provides further details.

TABLE II. Rating Scale Score

Questions	Score
Strongly Disagree	1
Disagree	2
Neutral	3
Agree	4
Strongly agree	5

After the questionnaire data given to the respondents was collected, and then the results of the collected data were calculated responses by [10]:

1) Odd questions, namely, 1, 3, 5, 7, and 9 are reduced by 1 in the score given by the respondent. Odd SUS score =$\sum$Px 1, Where Px is the number of odd questions.

2) Even questions, namely 2, 4, 6, 8, and 10 scores given to respondent are used to subtract 5. Even SUS score = ∑5 – Pn where Pn is the number of even questions.

3) The conversion results are then added up for each respondent and then multiplied by 2.5 to get a range of values between 0 – 100. (∑ odd score − ∑even score) x 2,5.

4) After the score of each respondent has been known, the next step is to find the average score by adding up all the scores and dividing by the number of respondents. This calculation can be seen with the following formula [7]:

$$\overline{X} = \frac{\sum x}{n}$$

$\overline{X}$ = average score
$\sum x$ = total score SUS
n= number of respondents

where X the average score, ∑ x is the total score of the System Usability Scale and n number of respondents. From these results will obtain an average value of all assessments of respondents' scores. To determine, there are 2 (two) ways to grade the assessment results used [11].

The first determination is seen from the level of user acceptance, grade scale and rating adjective consisting of the level of user acceptance there are three categories, namely not acceptable, marginal, and acceptable. Meanwhile, in terms of grade level, there are six scales, namely A, B, C, D, E and F. From the adjective rating, consists of worst imaginable, poor, ok, good, excellent, and best imaginable [17].

The second determination is seen from the percentile side range (SUS score), which has a rating grade consisting of A, B, C, D and E [19]. Determination of results assessment based on SUS score percentile rank done in general based on the results user rating calculation. Second, this determination can be seen in Table III and Fig. 2.

TABLE III. SUS SCORE PERCENTILE RANK

Grade	Description
A	Score >= 80,3
B	Score >= 74 and < 80,3
C	Score >= 68 and < 74
D	Score >= 51 and < 68
E	Over score < 51

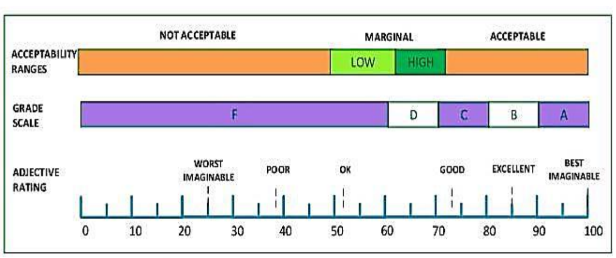

Fig. 2. Determination of assessment results (Bangor, Kortum, & Miller, 2009).

IV. RESULTS AND DISCUSSION

A. *Emogame Application*

Starting from the main menu, the user will enter the main page shown in Fig. 3. To start the game, the user clicks the start button.

Fig. 3. EmoGame prototype.

Memory Puzzle Game (Fig. 4): Players are presented with a set of face-down cards. They flip a card to see a picture and then look for a matching card with the same picture. If they find a match, they can look for the next pair. The player finishes the game when they find all pairs. This puzzle game is useful for training the cognitive abilities of older adults.

Fig. 4. Games puzzle memories.

Game of Memory Exploration (Fig. 5): In this game, players explore a village house and remember the pictures that are in the house. The images are of old and antique items commonly used in the past. The intent of this exploration is to train the brain with old images, encouraging good memories and positive emotions. Players explore the village house and recall the objects in the house, following the instructions given by the game. The player must complete the stages one by one. The goals of this game are to recall past objects with a reminiscence therapy approach and to increase positive emotions.

Fig. 5. Games exploration of memories.

Music of Memories (Fig. 6): If players do not want to play the other games, they can listen to music. These selections of old music were chosen to potentially help older adults recall memories of their pasts. Here, players can choose memorable songs, which are expected to help older adults gain positive and cognitive emotions. This development of this module's game followed feedback during a pilot study that suggested using music that was liked by older adults.

Fig. 6. Music memories.

Twenty respondents were invited for testing with the SUS instrument [3]. However, to obtain more accurate data, 20 respondents were invited to test EmoGame. The characteristics of the respondents were gender, education level, experience using smartphones, and age. For educational level, two of the respondents had undergraduate degrees. All respondents had more than five years' experience of using smartphones. Finally, all respondents were 50 years of age and over. The mini-mental state examination (MMSE) screening was used to find older adults with MCI, and 20 respondents were obtained from the SUS assessment.

Respondents who tested EmoGame can represent end users whom are older adults living with MCI. Thus, the representation of end users from the level of education, age, gender, and experience in using smartphones from the respondents' characteristics reflects reality [25].

B. Assessment Results

This study uses data from as many as 20 respondents consisting of older adults who use the EMOGAME application. Respondents will answer 10 questions given. The results of the answers from respondents will be calculated using equations (1), (2), and (3) so that it will produce an average score as shown in Table IV:

TABLE IV. ASSESSMENT

No	Results	Score
1	30 x 2.5	75
2	32 x 2.5	80
3	35 x 2.5	88
4	29 x 2.5	73
5	32 x 2.5	80
6	30 x 2.5	75
7	32 x 2.5	80
8	31 x 2.5	78
9	31 x 2.5	78
10	31 x 2.5	78
11	34 x 2.5	85
12	34 x 2.5	85
13	30 x 2.5	75
14	36 x 2.5	90
15	35 x 2.5	88
16	32 x 2.5	80
17	36 x 2.5	90
18	36 x 2.5	90
19	35 x 2.5	88
20	33 x 2.5	83
	Average	1640/20= 82

Information from Table V shows R is the respondent and the Qn question. The results from the questionnaire $-n$ can be obtained with an average score of 82. The following (Fig. 7) are the respondents' responses to some of the questions asked.

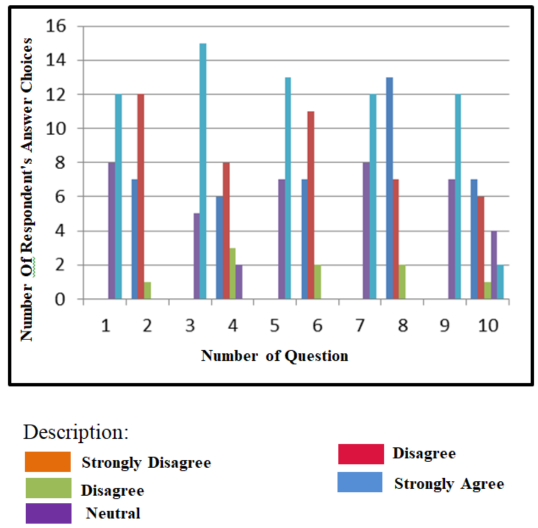

Fig. 7. Graph of SUS results.

In Fig. 7, it can be explained that there were 10 questions given to the respondents, and there were several results that stated negative and positive. For the results of negative statements, there are questions number 2, 4, 6, 8 and 10 where the respondents are quite understanding in using this EmoGame application. As for the results of the positive statements that respondents understand and like in playing the EmoGame application game, the positive statements are found in questions number 1, 3, 7.5 and 9. As for the percentage value generated from the SUS 82 value, it is in the range of 80% to 90%.

V. CONCLUSION

The EmoGame application was evaluated based on research conducted on 20 respondents. Results indicated that the average score obtained from a questionnaire was 82. EmoGame is considered satisfactory regarding adequacy, Grade A on the grade scale, and excellent in descriptive word rating. The assessment with a percentile rank of the average score (82) is in Grade A, where the value exceeds 80. A score of 82 means that EmoGame is suitable for end users as a game to help older adults living with MCI and to support the cognitive and emotional health of older adults.

Future work is to improve the design based on user feedback and iteratively improve the functionalities and interfaces. A longitudinal study with the sample respondents of older adults will be carried out and larger data collections will be analyzed to represent the older adult's user perception and experience.

ACKNOWLEDGMENT

We are grateful to all participants in this study. This study was supported by the university research grant UKM GUP-2019-066.

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