Pertanika J. Sci. & Technol. 29 (2): 863 - 883 (2021)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Reducing Cognitive Impairment Among Dementia Users Through Mobile Application

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ABSTRACT

Cognitive impairment includes the lacking ability to remember things, disorientation in remembering the current location, and the struggle to find the correct word. People with dementia (PwD) are often involved in this impairment. With that being said, this project proposes the use of a mobile application to help in improving their cognitive issues. To tackle this problem, features and functionality of a mobile application specifically for dementia users are identified which contributes to the development of a diary application. Identifying and gathering features from previous studies was the initial method. Development of the diary application followed the software development life cycle (SDLC) waterfall method and evaluation of the application was experimented with identified dementia users. The findings of this project are the application set of guidelines gathered from literature into the diary application. Four verified dementia people were involved in the evaluation of the effectiveness of the application. The evaluation of the application includes some good points. Some parts of the application are pointed out for their unsuitable design and suggestions are given to improve the application in the later future.

Keywords: Cognitive, diary, early-stage, features, memory loss, technology

ARTICLE INFO

Article history:
Received: 4 April 2020
Accepted: 27 July 2020
Published: 30 April 2021

DOI: https://doi.org/10.47836/pjst.29.2.09

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ISSN: 0128-7680
e-ISSN: 2231-8526

INTRODUCTION

The human-computer interaction (HCI) is described as the interaction between human and computers. HCI is considered as cognitive in nature as it heavily involves in problem solving, navigation as well as language processing. Now, it is undeniable that people interact with technologies and the internet every day. They utilize these for communication, information searching and entertainment.

In a world where computing is pretty much everywhere now, it is important that all users are catered for when designing an application with good features and functionality. Research suggests that people with dementia are keen to utilize latest technology even though they find it difficult to follow or understand the way to use any mobile application (Holsapple, 2005).

Dementia is a degenerative brain condition in which it is not a natural part of the aging process (Ancient & Good, 2013). People with dementia typically have problems with language impairments, memory loss and mood changes. According to the Alzheimer's Disease Foundation Malaysia (2020), there are about 127,000 people in Malaysia with dementia. This number is projected to be 261,000 by 2030 and will continue to increase to 590,000 people in 2050.

Memory decline is the most noticeable initial symptom of dementia and people with dementia struggle to remember recent events. If this memory degradation continues, their long-term memory would be affected (Lian et al., 2017). This further affects their cognitive ability. Cognitive function impairments are usually accompanying andevery so often it can even precede the disease (Awada et al., 2018). Symptoms of dementia may vary, when mental functions such as the decline in memory and thinking, orientation in space and time, and emotional control are affected, they are suffering from dementia.

The world's population is continuously aging and people living with dementia mostly come from age groups that are above 60 years old. Considering how the estimated number of dementia patients might reach 82 million by 2030, it is unfortunate that there is a lack of understanding and awareness in terms of supporting them to living independently and coping with daily activities through technology (WHO, 2012).

Not only does current technology support people living with dementia to manage their daily activities, but it can also help in improving their life quality by enhancing their independence and self-confidence (Awada et al., 2018). There are numerous kinds of applications nowadays but only a few of these are specifically aimed at people with dementia. There are hardly any applications that have been designed with the viewing requirements of people with dementia in mind (Freeman et al., 2005). Designing interfaces for people with dementia is certainly not an easy task. The challenges lie in the designing of interfaces which can satisfactorily meet the requirements of people with dementia. Research has shown that people with dementia has nothing against wanting to adopt to new

technologies and learn new skills provided that the interfaces are designed well and are easily accessible for people living with dementia (Claire et al., 2000; Awada et al., 2018). Computer interfaces can and should be designed in a way that maximizes their accessibility and enables them to benefit from this.

Ancient and Good (2013) stated that designing interfaces should consider three possible areas where dementia would have an impact on. They are cognitive impairments, motor impairments and visual impairments. They have found that people with dementia struggle with understanding the pinch-zoom functionality of touch screen applications. This involves motor impairments where people with dementia may have slower movements. So, it is wise to take in the consideration of increasing the response time of people with dementia.

Gowans et al. (2007) proposed several criteria should be addressed to obtain a suitable interface for people with dementia. These criteria include support easy start-up and failure-free activity. Niklasson and Sandström (2016) listed some points needed to be considered when designing a user interface for people with dementia and they included avoiding displaying too much information in one page or screen, utilizing strong contrast between colors and using simple icons.

This research involves the development of a diary application for people with dementia which can encourage them to record diaries of their experiences, achievements, and challenges or just basically their daily life activities. The aim is to offer support to people with dementia in managing and coping with their daily activities.

The remaining parts of this paper are organized as follows. In the Methods section, the three phases of methods which are the research, development and evaluation phases are discussed in detail. The results and discussion section give the implementation outputs of the application and the outcome of application evaluation. The design guideline for the application is also summarized. Conclusion section concludes the research with summary of findings and future works.

RELATED WORKS

Dementia describes various symptoms of cognitive decline that hinder with normal life activities (Kilmova & Semradova, 2016). Cognitive function includes the ability in learning, reasoning, language, spatial ability, and orientation, and handling complex tasks (Group Health Cooperative, 2013). The decline in cognitive function can result in difficulty when using technology (Williams et al., 2013).

Niklasson and Sandström (2016) mentioned that cognitive impairments were one of the symptoms that were linked to our mind and intelligence. They further stated some cognitive symptom examples such as memory loss, orientation, speech, and concentration (Niklasson & Sandström, 2016).

Memory loss makes it difficult for PwD to recall previous events that happened. For instance, they would forget whether they have eaten breakfast earlier or not or they would not remember where they put certain things. It is common for PwD to lose their orientation, especially the ones with moderate and severe dementia. Orientation describes the orientation of both time and place. Finding places and keeping track of the time is quite an impossible task for those suffering from dementia. This is because, as the disease progresses further, time conception is affected and becomes distorted making it tough to even tell which part of the day it is day or night (Niklasson & Sandström, 2016). Speech ability still works alright in the early stages of dementia, but it deteriorates in later stages, therefore causing PwD to lose the ability to speak normally and keeping track of the line of conversation gets more difficult. Cognitive symptom also affects concentration, and this describes how PwD often lose their focus. As mentioned earlier, conversing on one topic with them is hard as they lose concentration.

There is a lack of study regarding the impact of cognitive impairment on their everyday life experience. However, there is one that focuses on the approach that people with dementia use to handle their difficulties. They use their sight, hearing, and touch senses to cope with cognitive decline, and they also try to count on old patterns and routines of everyday life (Johansson et al., 2015). It is suggested that they utilize this approach to obtain a sense of control over their lives more than to be as effective as before. The Table 1 shows the different stages of dementia and how each stage affects PwD in their daily lives (Soufineyestani et al., 2021).

Table 1

Effects of cognitive impairment to PwD daily activities

	Phase 1: Very Mild Dementia	Phase 2: Mild Dementia	Phase 3: Moderate Dementia	Phase 4: Severe Dementia
Cognitive impairment	-Forgets names -Slight memory problems -Difficulty in finding the right words	-Learning ability -Problem solving -Make decision -Finding the right words -Recalling memory	-Short-term memory -Orientation in time and location	**-Language impairment -Often lose concentration**
Activities of daily living (ADL) functions	-Misplaces familiar objects	-Driving -Grocery shopping	-Ability to handle money -Ability to cook -Ability to be independent	-Ability to get dressed -Ability to walk -Incontinence (lack voluntary control over urination and defecation)

As the quality of life for people in most developed countries increases due to health care and medicine being very much advanced nowadays, it does not guarantee that elderly people will not be affected by any illnesses that are common with their age (Coppola et al., 2013). Rather, they are more prone to get diseases that can decrease their cognitive ability. This makes them more dependent on being assisted by other people, mostly in this case, their family members.

Attempts at communication using technology can help lessen these symptoms their severity. As symptoms grow more severe, PwDs become less able to function on their own and would be more and more dependent on the care of those around them. After some time and as their disease further, worsen, they would have to be placed in nursing homes (Coppola et al., 2013). This is because in nursing homes, there would be staff and specialists around all the time and they are more experienced, thus family members would think that that is the best option for better care.

It is often that products make a notable request on cognitive abilities. However, technologies that are designed for elderly people, especially the ones that are living with dementia, need to take into consideration the number of demands being put. Measures should be taken to minimize the effect on a cognitive impaired (Czaja et al., 2012). Elder people often experience a decrease in their ability to note and remember things and for those living in a situation with dementia will have it worse because of the nature of the condition.

For people with dementia to use and interact with a new technology, the impairment needs to mitigate. This can be done by using cognitive cues or by lessening the memory load. One of the main symptoms of dementia is short term memory loss (Peterson et al., 2009) and that makes interacting with technologies difficult for people living with this condition. Difficulty in remembering will make navigation very challenging as they would find it hard to recall previous information (Etcheverry et al., 2012). Not only does current technology support people living with dementia to manage their daily activities, but it can also help in improving their life quality by enhancing their independence and self-confidence (Awada et al., 2018).

When it comes to designing interfaces, these two approaches should be taken into consideration; (1) a design that is universal which is accessible and manageable to those with disabilities, (2) an easy-to-use technology that is developed applying user-centered technique (Peterson et al., 2009). Ancient and Good (2013) thinks that the factors that should be regarded are accessibility, usability, and user experience. On the contrary, they further proposed that personalization and user acceptance are the main approach in designing interfaces for dementia patients. The concept of personalization refers to the modification of user interface to meet the requirements of the user. However, user acceptance refers to user experience and technology implementation. User acceptance is where the user's previous experience with technology is taken into serious consideration (Awada et al.,

2018). The decline in memory for people with dementia means that they are less capable in navigating through complicated design structures and instructions. Therefore, this should be given attention as to reduce memory load in designing by using, for instance simpler instructions and shorter messages.

Designing interfaces for people with dementia is certainly not an easy task. The challenges lie in the designing of interfaces which can satisfactorily meet the requirements of people with dementia. Research has shown that people with dementia has nothing against wanting to adopt to new technologies and learn new skills provided that the interfaces are designed well and are easily accessible for people living with dementia (Claire et al., 2000; Awada et al., 2018). Computer interfaces can and should be designed in a way that maximizes their accessibility and enables them to benefit from this. Peterson et al. (2009) proposed several criteria should be addressed to obtain a suitable interface for people with dementia. The set of criteria is briefed in the Table 2.

Table 2

Interface criteria suitable for people with dementia

	Challenges
1	Support easy start-up
2	Support intuitive navigation for a novice-user demographic
3	Elicit memories to prompt and support reminiscence, communication and social contact
4	Promote ‘non-immersive’ engagement
5	Support an enjoyable shared experience
6	Support the cognitively impaired person in having a more proactive and equitable role in shared conversations
7	Relieve caregivers of the pressure of constantly needing to ‘prop up’ conversations
8	Promote ‘failure-free’ activity
9	Support customization of content
10	Promote and support good practice in reminiscence intervention

Niklasson and Sandström (2016) had also stated in their study some points that needed to be considered when designing a user interface for PwD. Those points are listed in the Table 3.

Table 3
User interface suitable for people with dementia

	Challenges
1	Utilize a strong contrast between colors.
2	Support intuitive navigation for a novice-user demographic
3	Use simple icons.
4	Avoid displaying too much information in one page or screen.
5	Avoid adding abstract patterns.
6	Avoid using similar colors on background and buttons.

Based on the research conducted by Ancient and Good (2013), designing interfaces should consider three possible areas where dementia will have an impact on. They are cognitive impairments, motor impairments and visual impairments. They had found that people with dementia struggled with understanding the pinch-zoom functionality of touch screen applications. This involves motor impairments where people with dementia may have slower movements. So, it is wise to take in the consideration of increasing the response time of people with dementia. Say for example, an interface which expects a response within a specific length of time such as 'time-outs' when completing an online form. Hence, it is recommended that interfaces must minimize the number of information which the people with dementia are required to take in. This is because the need to remember certain information or position within the system may cause the users to feel disoriented if they are not able to recall their location (Awada et al., 2018).

It is also a fact that people with dementia may have problems with perceiving colors, shapes, and movements. It is important to ensure that the readability is improved for all users with dementia, with suggestions of reducing the density of the text (Ziefel, 2010). Poor interfaces such as small font, button and icon sizes can discourage them from further use (Rodrigues et al., 2014).

As suggested by Freeman et al. (2005), interfaces should be designed bearing in mind that the user may forget the task at hand. Recognition is better than recall, thus they suggest that retrieval cues should be used whenever appropriate. So, to aid with this recognition memory, visual cues such as pictures or icons with the combination of verbal cues should be fully utilized. It is also likely that learning to navigate the site will

be helped by keeping different pages as structurally similar as possible, so that even if the surfer does not consciously remember how to navigate each page, implicit memory derived from viewing previous pages will help to promote easier navigation of the current page (Freeman et al., 2005).

An older study by Morris and McKiernan (1994) suggested that the language on the interface should not be complex and should avoid more abstract or metaphorical language. For instance, the customary use of ‘‘home’’ to signify a link to the home page might be confusing and difficult for them to understand. People with dementia may have difficulties in concentrating and giving attention to multiple tasks at one time. Hence, when designing interfaces, the number of items on the page that requires attention are to be cut down.

METHODS

Research Phase

Definition of dementia, the symptoms of dementia, the needs, and requirements of people with dementia in mobile application features and functionality were studied through literature and preliminary studies. The study of literature was utilized to obtain information and more knowledge regarding dementia and the design considerations for people with dementia. The sources for these literatures were mainly from ResearchGate, which was an academic social networking site designed to facilitate access to academic research. The preliminary study was done by interviewing an expert in the field of dementia in Kota Kinabalu which was also the Head of the Comfort Aged Care Center (Hassan et al., 2020). A design guideline was obtained from the information gathered from this phase.

Development Phase

The development of the application for this research followed the Software Development Life Cycle (SDLC) Waterfall method. Figure 1 shows the SDLC waterfall phases. How the stages of this method are adapted into the development of the application is briefed as follows.

Planning. This phase for this project started with studying existing literature and conducting preliminary research, which is described in research phase. Here was where user requirements and design features were identified and searched for.

Analysis. This was where all important information regarding design features and functions for mobile application for people with dementia was picked out and gathered to produce a set of design guidelines. These guidelines were utilized in the design and implementation phase.

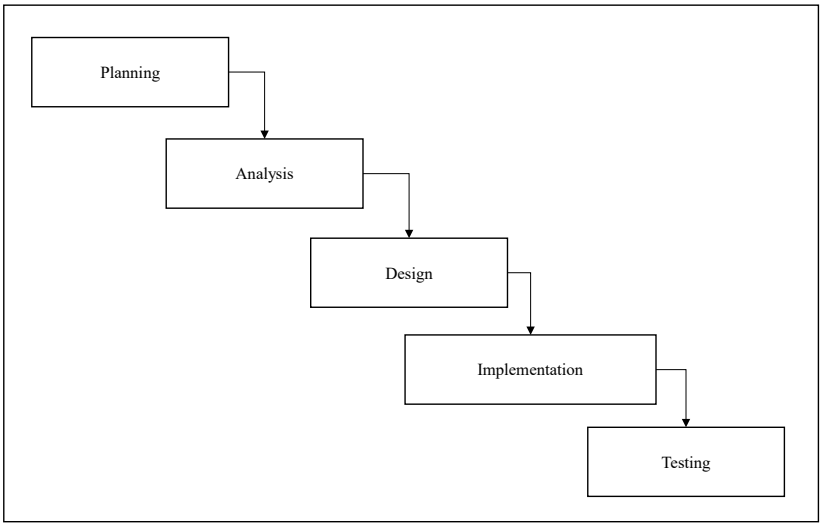


Figure 1. Phases in SDLC waterfall method

Design. Following the guidelines obtained from the previous phase, the design framework for this application was planned and created in this phase.

Implementation. The development of the Diary application was done in this phase.

Testing. This was the stage where the diary application was being tested by dementia patients to evaluate its effectiveness towards their cognitive problems and at the same time identified if there were any crashes or defects.

Evaluation Phase. Quantitative method was used to evaluate the effectiveness of the diary application and whether its design and features were suitable for people with dementia. Figure 2 shows the flow procedure of the evaluation process.

Participants for the application testing and evaluation were recruited from the Comfort Aged Care Center and the main criteria for selecting them included people who were diagnosed with an early stage of dementia. To identify them, a questionnaire developed by Maki et al. (2013) was given to them to answer. Among 20 of the people in the center, only four were identified to be at early stage of dementia and they were willing to participate.

The evaluation process was conducted in two different sessions: one with traditional diary and the other with the diary application. The four selected participants were divided into these two groups and each group consisted of two people. They were divided randomly among these two groups. They were asked to each write diaries for two days with the assistance and guidance of one caregiver in each phase. This means that two caregivers

were assigned to each phase and they were responsible in observing and following up the participants' progress on writing their diaries.

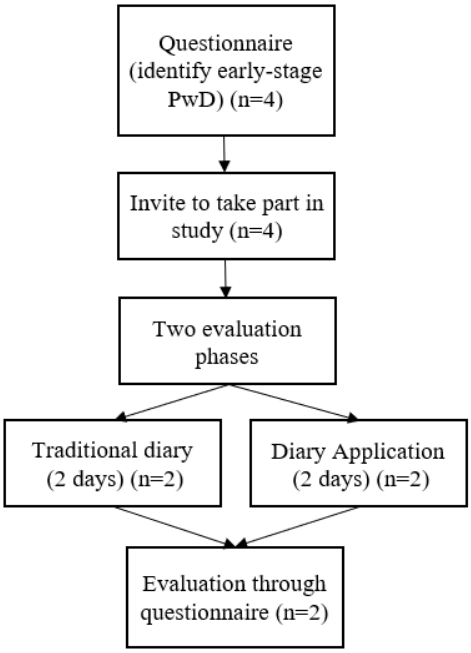


Figure 2. Flow procedure of evaluation process

At the end of each phase, participants completed a set of close-ended questionnaires to measure the effectiveness between both phases. Participants described their experience and their evaluation on using the traditional diary and the diary application using a 5-point Likert scale (strongly agree = 5 to strongly disagree = 1). To get feedback on the design of features and functions of the application, the caregivers that assisted the participants were given a set of open-ended questions. This was done to receive comments and suggestions for the improvement of the application in the future.

RESULTS AND DISCUSSION

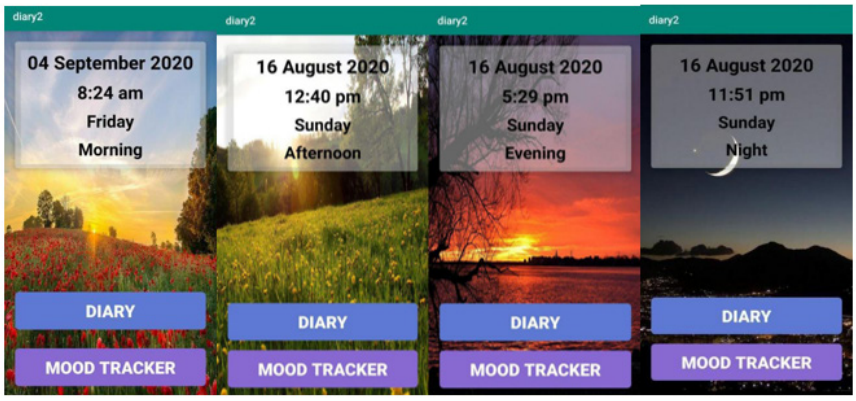
All information collected and gathered from literature study and preliminary research are summarized as seen in Table 4 which is then used as design guideline in developing the application. There are not many researchers studying on the use of mobile applications for dementia patients. Most studies only focus on the design consideration and creating interfaces based on those guidelines (Awada et al, 2018; Peterson et al., 2009; Ancient & Good, 2013; Claire et al., 2000; Gowans et al., 2007; Niklasson & Sandström, 2016;

Ziefel, 2010; Rodrigues et al., 2014) and existing applications (Dementia/Digital Diary/ Clock, My House of Memories: Dementia & Alzhemeimer's App, CogniCare - Support for Dementia Care and Alzhemeimer's Daily Companion) only focus on the information for awareness, audio for diary input, emergency help, and automatic link on calendar sync. They are limited research touching on developing applications that caters patients' cognitive disability by applying those design guidelines.

General Design of Application

This Diary application has five functionalities which are time, date, music, diary, and mood tracker. However, mood tracker is not fully functioning thus, this feature is omitted for testing and evaluation.

Start Page. This page is where the time and date functions are put. It is placed at the very top of the screen, as seen in Figure 3. Following the design guideline, the date and time functions are included on this page. This is because PwD loses track of time often. This helps tackles their problem with time orientation. The background has an image of flowers in it (Freeman et al., 2005), and the buttons at the bottom of the page are not placed too close to each other (Yamagata et al., 2013; Coppola et al., 2013). Different images are set as the background following the time of the day. For example, when it is morning, an image that indicates that it is now the morning is set as background, and an afternoon-looking image is set when the time of the day is currently in the afternoon. PwD, find it entertaining if there are images of flowers or animals inserted (Freeman et al., 2005).



(a) (b) (c)

Figure 3(a), (b) & (c). Start page with different background images following the time of the day: morning, afternoon, evening, and night.

Table 4

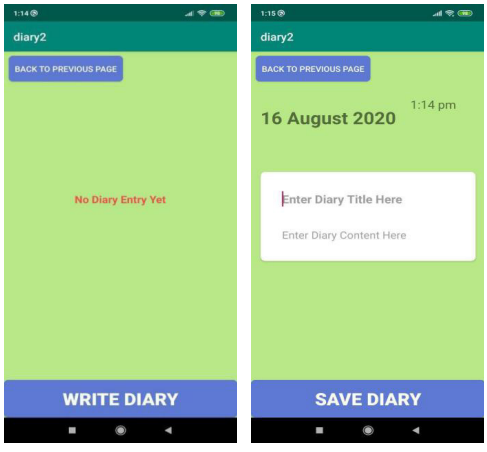
Design guideline for application development

No	Design guideline
1	Reduce number of items to remember (Ancient & Good, 2013)
2	Use simpler instructions (Awada et al., 2018)
3	Minimize number of information. Only add necessary ones (Awada et al., 2018)
4	Reduce density of text (Ziefel, 2010)
5	Keep different pages as structurally similar as possible (Freeman et al., 2005)
6	Avoid using abstract or metaphorical language (Morris & McKiernan, 1994)
7	Avoid placing buttons close to each other (Yamagata et al., 2013)
8	Avoid clustered images or abstract patterns and elements (Hassan et al., 2020)
9	Use familiar and simple icons (Niklasson & Sandström, 2016)
10	Avoid any hidden message or pop-ups which can confuse PwD (Gowans et al., 2007; Hassan et al., 2020)
11	Use strong contrast between colors. PwD can easily see with red and green colors best (Niklasson & Sandström, 2016; Hassan et al., 2020)
12	Avoid very deep and difficult navigation (Hassan et al., 2020)
13	Place important information at the top of the screen as that location is seen first when opening an application (Niklasson & Sandström, 2016)
14	Use images like animals or flower as they can be entertaining for PwD (Freeman et al., 2005)
15	Buttons and fonts should be large in size (Hassan et al., 2020)
16	Use music (Hassan et al., 2020)
17	If music is added to the application, make sure sound is clear (Hassan et al., 2020)
18	Increase response time for applications that include time-outs (Awada et al., 2018)
19	Include functions like a calendar with today's date and time (Hassan et al., 2020)

Below the time and date, there are the Diary and Mood Tracker buttons. Diary button brings users to the Diary feature and the Mood Tracker button brings users to the Mood Tracker feature. Also, music is automatically played the moment users open the application. Though, there is no function to stop the music.

Diary Feature. Figure 4(a) shows the Diary main page. Use of contrast between colours are utilized (Niklasson & Sandström, 2016) and the buttons and fonts are large (Hassan et al., 2020).

Figure 4(b) gives the Write Diary page. The buttons and fonts here are also large (Hassan et al., 2020). On the title and content input area, there are texts giving description to indicate where to write. These are called hints. This is to give the users an easy understanding. Once diary entries are written and saved, they are added to the Diary main page like in Figure 5. Other pages of the application include the Detail page and the Edit Diary, and they are shown in Figure 6(a) and 6(b) respectively. Note that every page except the start page, is similarly structured (Freeman et al, 2005).



(a) (b)

Figure 4(a) & (b). Diary main page and Write Diary page

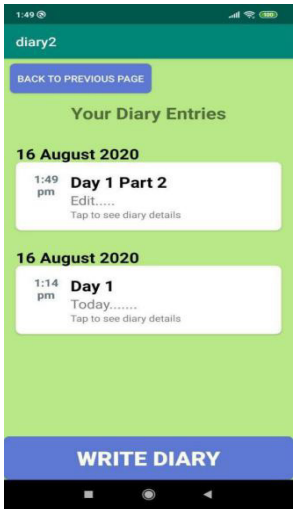
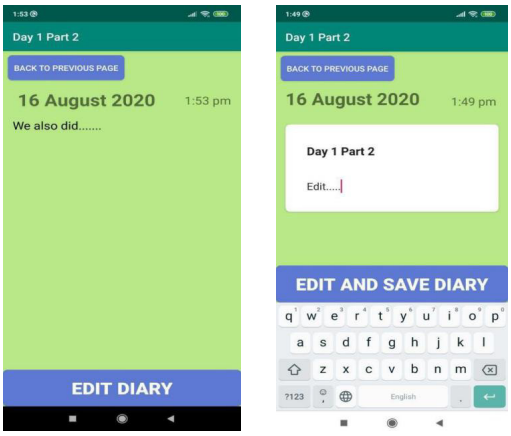


Figure 5. Diary main page with new added diary entries



(a) (b)

Figure 6(a) & (b). Details page and Edit Diary page

Evaluation of Application

Table 5 shows the brief detail of the four participants that participated in the evaluation process. The four participants were aged between 60 to 70. As mentioned, the main criteria for selecting participants were early stage of PwD. From Table 5, it is shown that three of them were male and one was female. All four of them were married and their final education was being undergraduates. Participants 1, 2 and 3 had very mild severity dementia and participant 4 had mild severity, all of which were considered as early-stages of dementia (Surr et al., 2017).

Table 5

Details of participants

	Participant 1	Participant 2	Participant 3	Participant 4
Age	64	65	65	67
Gender	Male	Male	Female	Male
Marriage	Married	Married	Married	Married
Education	Undergraduate	Undergraduate	Undergraduate	Undergraduate
Severity	Very mild	Very mild	Very mild	Mild
Years living with dementia	2	3	3	3
Evaluation phase	Traditional Diary	Traditional Diary	Diary Application	Diary Application

Evaluation and Measurement of Effectiveness. The set of questionnaires to evaluate and to measure the effectiveness of both traditional diary and diary application are adapted from Zhou et al. (2019) and Al-Aidaroos and Abdul Mutalib (2015). They are closed-ended questions where the respondents' answers are limited to a fixed set of evaluation questions. Table 6 gives the findings of the close-ended questionnaires by the mean average for participants using a traditional diary and Table 7 shows the result for participants using diary application.

A comparison between the means of both data is done to evaluate their effectiveness. This comparative analysis is adopted from a study by Turumogan et al. (2019) and the result is shown in Table 8.

Table 6

Participants' evaluation towards traditional diary(n=2)

No.	Evaluation question	Strongly Agree **5**	Agree **4**	Neutral **3**	Disagree **2**	Strongly disagree **1**	Mean
1	Was it convenient to use?				2		2.0
2	Was it time-consuming?		1	1			3.5
3	Was it easy to use?			1	1		2.5
4	Was it enjoyable?		1	1			3.5
5	Did you ever lose focus while writing?		2				4.0
6	Did you experience any mood changes while writing?				2		2.0
7	Did you find it difficult to write/ type?	1	1				4.5
8	Can this increase your efficiency in your everyday life?	1	1				4.5
9	Does this encourage you to write diary in the future?		2				4.0

Table 7

Participants' evaluation towards diary application (n=2)

No.	Evaluation question	Strongly Agree **5**	Agree **4**	Neutral **3**	Disagree **2**	Strongly disagree **1**	Mean
1	Was it convenient to use?		2				4.0
2	Was it time-consuming?		1		1		3.0
3	Was it easy to use?	2					5.0
4	Was it enjoyable?	1	1				4.5
5	Did you ever lose focus while writing?		1		1		3.0
6	Did you experience any mood changes while writing?				2		2.0
7	Did you find it difficult to write/type?		1	1			3.5
8	Can this increase your efficiency in your everyday life?	1	1				4.5
9	Does this encourage you to write diary in the future?	2					5.0

Table 8

Means of traditional diary and diary application according to the evaluation questions

Evaluation question	Mean (Traditional Diary)	Mean (Diary Application)
Was it convenient to use?	2.0	4.0
Was it time-consuming?	3.5	3.0
Was it easy to use?	2.5	5.0
Was it enjoyable?	3.5	4.5
Did you ever lose focus while writing?	4.0	3.0
Did you experience any mood changes while writing?	2.0	2.0
Did you find it difficult to write/ type?	4.5	3.5
Can this increase your efficiency in your everyday life?	4.5	4.5
Does this encourage you to write diary in the future?	4.0	5.0

Based on Table 7, the chart of the comparison of means between the two diaries is made. It is found that the mean of diary application for the positive questions (convenient, time-consuming, easy, enjoyable and encouragement) are seen to be at a more beneficial level than the mean of traditional diary. Diary application is deemed to be more convenient, less time-consuming, easy to be used, enjoyable and gives encouragement to write diaries in later future. From the Table 7, it can also be concluded that PwD tend to lose focus while writing. This could be affected by how PwD are starting to find it less easy to write, as seen on the mean result of traditional dairy for "difficult to write" (Mean=4.5). For both traditional and application, it is discovered that the participants did not experience any change of moods. The mean result for "efficient" is equal for both as well (Mean=4.5). They thought that writing diaries might help them became more efficient in everyday life which was a very positive response, and this could give them more confidence and support in improving their cognitive impairments especially memory loss.

Evaluation of Design and Functions of Diary Application

Open-ended questionnaire was given to the caregiver that were assigned to assist and help the participants during application testing and evaluation process. The findings of it are listed as follows.

1. Font sizes are large enough. However, the fonts for the time and date can be made larger.
2. Image background can be distracting. Makes the date and time to be seen less clear. Should change to brighter color to make a contrast or make it simpler with plain background with single color.
3. Music is nice to listen to.
4. Buttons do not seem like buttons. Need to tell the users in advance that they are buttons to be clicked. Better to add shadow or simple animation to make it seem like they are clickable. Wordings on button can be seen clearly, simple and easy to understand.
5. Background color for Diary pages are contrast with the button colors. Can see texts on page clearly.
6. Scrolling function in Diary main page is difficult for them. It is better to put up and down button to act as scroller.
7. Does not contain too much information which is good.
8. Back buttons are at the same position in every Diary page which is also good.
9. Better to include record voice option in case PwD would prefer to speak and record themselves rather than typing.
10. Also, better to include a reminder function that connects with calendar.

CONCLUSION

The evaluation of the application was obtained through close-ended and open-ended questionnaires for the participants and caregivers to answer, respectively. It is discovered that the based on the result to measure effectiveness, the diary application gave a higher result on the positive questions, where it is inferred to be more convenient, easy, and enjoyable. From the result of the open-ended questionnaires, there were some good points and suggestions were given to further improve the application. For further development, the mood tracker can be completely developed and a voice recording function can be included for the possibility that people with dementia would prefer speaking directly rather than typing on the device. Future works can include in developing a similar application that targets on the caregivers instead.

ACKNOWLEDGEMENT

Researchers thank Universiti Malaysia Sabah (UMS) for the support of resources and facilities needed to prepare research. Also, appreciation is extended to the participants and the caregivers of Comfort Aged Care Center for helping and participating in the process of completing this project.

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