



Digital Game Design for the Elderly: Implementing a User-Centered Approach to Enhance Cognitive Function

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ABSTRACT

Dementia is a condition marked by a decline in cognitive functions such as memory and thinking, which interferes with daily activities and has become a serious public health issue in Indonesia. This study proposes a mobile game as a medium for cognitive stimulation among older adults, employing a User Centered Design (UCD) approach that prioritizes user needs. The research involved 16 elderly participants to identify their needs, design the game interface, evaluate usability using the USE Questionnaire, and measure the impact of the game. The resulting design emphasized accessibility through a simple interface, clear icons, large buttons and text, and high color contrast. The prototype, developed iteratively with UCD principles, included three short duration games (Memori Warna, Find Pet, and Match Fruits) targeting memory and concentration skills. Usability testing showed a positive learning curve, with improved completion times after repeated trials. The overall usability score was 83.43%, with satisfaction scoring highest at 87.07%. These findings indicate that UCD based mobile games are easy to use, engaging, and hold promise as inclusive tools for supporting cognitive health in the elderly.

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1. INTRODUCTION

Dementia is a condition characterized by a decline in cognitive functions, such as difficulty remembering and thinking, which affects daily activities. If left untreated, dementia worsens with age [1][2]. According to the World Health Organization, there are currently over 55 million people living with dementia worldwide, more than 60% of whom reside in low and middle income countries. Every year, there are nearly 10 million new cases [3].

In Indonesia, the population is entering an aging period, marked by an increase in life expectancy followed by a rise in the number of elderly individuals. This is evident from the growing elderly population, which increased from 18 million (7.56%) in 2010 to 25.9 million (9.7%) in 2019, and is projected to continue rising, reaching 48.2 million (15.77%) by 2035. In 2016, there were an estimated 1.2 million people with dementia; this number is expected to rise to 2 million by 2030 and 4 million by 2050. Several factors contributing to the high cost of dementia care in Asia include a lack of understanding of the disease and insufficient resources and training for caregivers of people with dementia (PWD) [4]. To improve the quality of life for dementia patients, interventions focusing on cognitive stimulation are becoming increasingly important, as regular and serious engagement in games can influence the cognitive abilities of the elderly [5].

Games have been shown to be effective in enhancing motivation and engagement in therapy. Purposefully designed games can support the development of memory, attention, and social skills. Various types of games can be utilized in cognitive therapy for older adults, including board games, card games, and digital games. Indicates that games involving strategy and problem-solving can significantly improve executive function and working memory [6]. The goal of incorporating games into rehabilitation and intervention is to enhance motivation for continued participation in the process while keeping the brain engaged in all functions, including memory [7]. Prevention of dementia can be achieved by maintaining cognitive function in the elderly through regular physical activity [8]. The use of games in therapy can enhance the effectiveness of recovery in an enjoyable way, thereby increasing user motivation and engagement. Therefore, game design should consider rules, challenges, and an engaging interface [9]. Various studies have shown that mentally stimulating activities, such as games and mental exercises, can help slow disease progression and improve cognitive function. Additionally, social games involving interaction with others can enhance social and emotional skills in older adults [10][11]. The accessibility of mobile games and their interactive appeal present great potential as therapeutic tools. However, to design effective games, it is essential to understand the needs and preferences of users, especially the elderly [12].

In efforts to improve the quality of life for people with dementia, various therapeutic approaches have been developed, including cognitive therapy and technology based interventions. One such approach is the use of mobile games, which offer advantages in accessibility and interactivity, making them an effective means to engage dementia patients in brain stimulating activities as a tool for cognitive stimulation.

Mobile games can be an effective tool to reduce cognitive decline in the elderly. Game selection should be tailored to the needs and preferences of older adults, with a user friendly interface to ensure effectiveness and user satisfaction [13][14]. To encourage the adoption of mobile games among seniors and caregivers, the games can incorporate features for therapy based game selection. The application should not only have a good user interface and an attractive visual design, but also be able to engage the elderly by offering easy operation and well-organized buttons and colors [15].

Given Indonesia's growing elderly population, there is a need to develop effective dementia interventions and preventive measures. This includes designing mobile games and fostering technological innovations in healthcare services. This study adopts a User Centered Design (UCD) approach to identify what elderly users desire in a game and how they interact with technology. UCD is a design approach that places the user as the main focus at every stage of the design process. This approach aims to create products that better meet the users' needs and requirements, thereby enhancing the overall user experience [16][17][18]. One of the key attributes of a good application is fulfilling usability aspects. To determine the extent to which a mobile game can be used by users to achieve specific goals effectively, efficiently, and with user satisfaction in its usage context, system testing is required. One method that can be used for application testing is the USE Questionnaire, which consists of four parameters: usefulness, ease of use, ease of learning, and satisfaction [19]. The expected outcome of this mobile game design is an application that is not only engaging and enjoyable but also effective in stimulating cognitive functions. The game aims to enhance memory, attention, and critical thinking skills while providing emotional support through positive social interactions.

2. METHODS

This study involved 16 elderly respondents aged 60–80 from both rural and urban areas, including four individuals with no prior mobile gaming experience. The sample size was determined using a balanced design approach based on the experimental variables employed. Data were collected through direct observation and interviews. Research Steps:

1. Problem Identification

Observations and interviews were conducted in Kutai Kartanegara, East Kalimantan, to explore user needs, expectations, and challenges. Literature reviews supported the understanding of dementia, cognitive stimulation, gamification, UCD, usability, and the USE Questionnaire instrument.

2. Specify the Context of Use

Development of user personas, identification of user needs, and preliminary solutions based on research findings.

3. Specify the User Requirements

Creation of a sitemap, user flow, and wireframes aligned with user needs.

4. Produce Design Solutions

Interface design and prototyping, including layout, icons, colors, and elderly friendly interaction flows.

5. Evaluate the Designs

Usability testing was conducted through usability tests, completion time measurement, learning curve assessment USE Questionnaire with a 1–4 Likert scale.

6. Results Analysis

Discussion of findings from all stages.

7. Conclusion and Recommendations

Summary of results and suggestions for future research.

3. RESULTS AND DISCUSSION

This study involved 16 elderly respondents, consisting of 8 males and 8 females. The respondents came from two different geographical backgrounds rural and urban areas. Each respondent group included four individuals with no prior experience using mobile games. Subsequently, all respondents were assigned codes to facilitate the data collection process.

The codes used consisted of the letter 'R' (standing for 'respondent') followed by numbering from 1 to 16, as shown in **Table 1** for example, R1 refers to the first observed respondent.

Table 1. Respondent Code

Code	Gender	Area	Mobile Game Experience
R1	Male	Urban	No
R2	Male	Urban	No
R3	Female	Urban	No
R4	Male	Urban	Yes
R5	Female	Urban	Yes
R6	Female	Rural	Yes
R7	Female	Urban	Yes
R8	Male	Rural	No
R9	Male	Rural	Yes
R10	Female	Rural	No
R11	Male	Rural	No
R12	Female	Rural	No
R13	Female	Rural	Yes
R14	Male	Rural	Yes
R15	Female	Urban	No
R16	Male	Urban	Yes

At this stage, the user needs identification process was conducted to determine the appropriate application design. The methods used included observation and interviews with 16 respondents. The interviews were designed to gather relevant information regarding respondents' experiences and challenges in using digital devices, as well as their preferences for game types they found appealing. Subsequently, the interview results were compiled to identify key issues faced by the respondents. The interview questions and summary of results, as shown in **Table 2**.

Table 2. Interview Questions and Summary of Results

Interview Questions	Majority Responses
Have you ever used a smartphone or tablet?	Most have, but still experience difficulties
What challenges do you face when using smartphone/ tablet applications?	Confused about app functionality, text is too small, navigation is confusing.
Are you interested in playing digital games?	Yes, if the game is easy to understand and not complicated.
What type of games do you prefer?	Simple games like picture guessing, color matching, or object matching
What features do you consider important in games for elderly users?	Large text, clear buttons, high contrast colors, and easy to understand instructions.
Would you like the game to help train your memory and thinking skills?	Yes, most believe this would be very helpful.
Would you prefer if the game could be played without internet connection?	Yes, for more practical use anytime.
What are your expectations for games specifically designed for elderly users?	Easy to use, enjoyable, not confusing, and beneficial

3.1. Specify the Context of Use

The initial stage of the user centered design process begins with understanding the context of use through observation and interviews. This step aims to explore the needs, limitations, and habits of respondents when using digital devices, which then form the

foundation for developing user personas, identifying user needs, and formulating solutions through mobile game development.

1. User Persona

The user persona aims to represent the characteristics of the application's users, including their background, habits, needs, and challenges. Based on the user personas of 16 elderly respondents, it was found that they preferred mobile games with simple designs, easy to understand interfaces, and minimal technical instructions. However, several complaints were noted, such as difficulty understanding foreign terms, small text sizes, confusing layouts, and concerns about pressing the wrong buttons or losing data. Respondents also experienced difficulty locating the game icon, confusion during initial use, limited device storage, and a lack of usage guidance.

2. User Needs

User needs reflect the expectations, preferences, and goals of respondents in using digital products. The data was collected from respondents' answers regarding application usage and cognitive stimulation, which served as the basis for designing the mobile game. The results of the observations as shown in **Figure 1**.

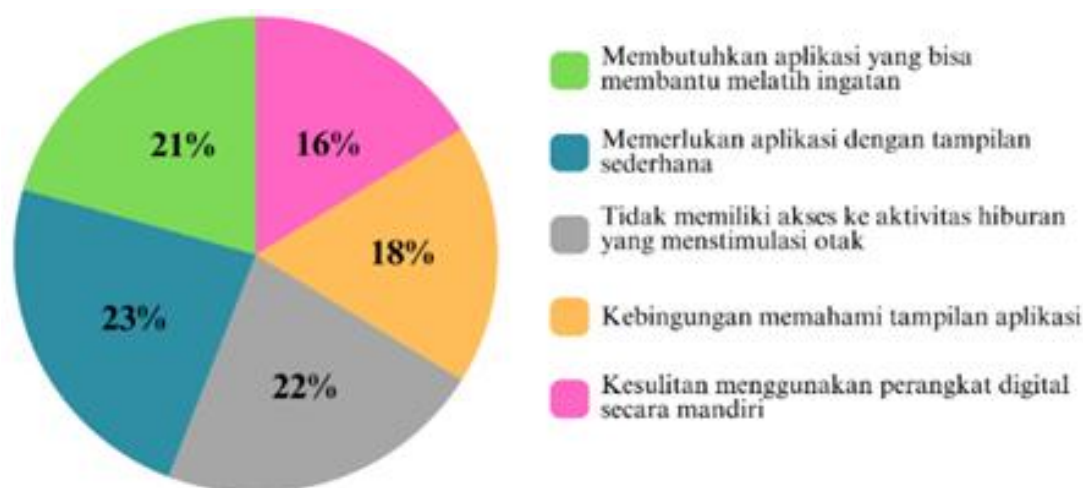


Figure 1. Findings from Respondent Observations

Based on the interview results, it was found that most elderly individuals had used digital devices such as smartphones or tablets, but still experienced difficulties in operating them. The most frequently mentioned issues included small font sizes, confusing app navigation, and a lack of clear guidance. Respondents expressed interest in digital games, provided that the games were simple and easy to understand. Features considered important in games for the elderly included the use of large fonts, clear buttons, high contrast colors, and simple instructions. Most respondents also stated that they preferred games that could help maintain memory and thinking skills. Additionally, games that could be played without an internet connection were considered more practical and aligned with their needs.

3. Problem Solving Problems

Based on an analysis of the problems faced by respondents when using digital devices, several solutions can be identified to improve accessibility and user comfort. First, the application should be designed with an elderly friendly interface, including large text, wide clickable buttons, and high contrast color combinations to reduce reading and navigation difficulties. A simple and consistent layout can also reduce confusion in operating the app. To help elderly users understand how to play the game, interactive guidance in the form of visual

tutorials such as illustrated instructions should be available and accessible at any time. These guides are particularly important when users open the application for the first time.

On the other hand, cognitive features should also be integrated into the game, including activities involving memory, concentration, or other brain stimulating exercises with gradually adjustable difficulty levels to remain challenging yet not overwhelming. Game integration can be a solution to stimulate the brain while providing enjoyment for respondents. The interface should follow simple design rules and allow flexible playing time. Considering the limited internet access for some respondents, the application should also be able to function offline to ensure they can still use it at any time without relying on a network connection. Support through socialization and assistance either through brief training or help from family members and caregivers is essential to help respondents overcome initial difficulties in using digital devices. With the implementation of these solutions, respondents are expected to use digital technology more independently and comfortably while also gaining cognitive health benefits.

3.2. Specify the User Requirements

The second stage of User Centered Design focuses on specifying user requirements. In this phase, visual representations such as the sitemap, user flow, and wireframe are created to illustrate the navigation structure, usage flow, and interface design of the game to be developed.

1. Site Map

The sitemap illustrates the relationships between pages and the main navigation paths that users will follow. This mapping helps in designing a logical and accessible navigation system that aligns with the needs of the elderly users. The sitemap as shown in **Figure 2**.

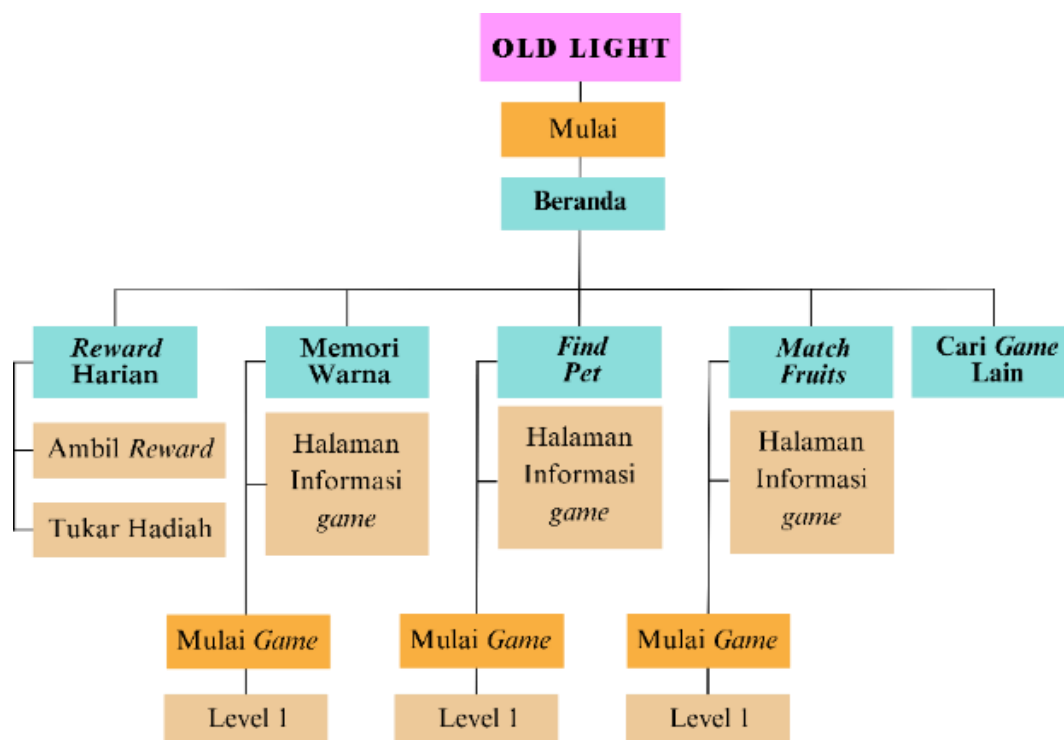


Figure 2. Site Map

2. User Flow

The user flow illustrates the step by step path showing how users navigate from one page to another to achieve specific goals within the application. The purpose of designing the user flow is to ensure that user interactions proceed efficiently and without confusion. The user flow as shown in **Figure 3**.



Figure 3a. User Flow for Opening the Game.

Figure 3b. User Flow for Memory Color, Find Pet, Match Fruits.

Figure 3c. User Flow for Reward.

3. Low Fidelity Wireframe Design

The low fidelity wireframe is designed as an initial guide for developing the medium fidelity prototype. This design presents the layout of key elements such as buttons, text, icons, and navigation without visual details or color schemes, and is structured based on the previously identified needs of the respondents is shown in **Figure 4**.

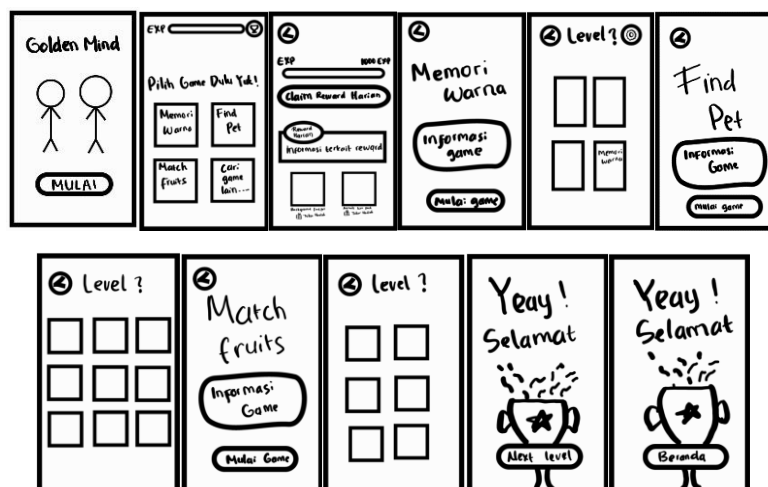


Figure 4. Wireframe Low Fidelity

4. Medium Fidelity Wireframe Design

Before designing the medium fidelity wireframe, a design guideline was developed as a reference for interface development. This guideline focuses on design principles tailored to the needs of older adults, including clear visuals, adequate font and button sizes, simple navigation, comfortable colors, and intuitive icon usage. The game interface in this study is designed to be simple, clean, and uncluttered, making it easier for elderly users to focus on key elements. The font used is Fredoka, with font sizes of 18, 24, and 32 pt. Buttons are designed to be large enough for easy visibility and touch interaction. All text is presented with high contrast against the background to enhance readability. The navigation structure is kept simple and linear to facilitate easy movement between screens. Each navigation button is accompanied by a clear and recognizable icon and label to prevent user confusion when exploring the app interface. The color selection follows color psychology principles, serving not only an aesthetic function but also supporting the user's psychological comfort. The chosen colors avoid low contrast and overly bright tones that could cause eye strain. Instead, color gradients are used selectively to add visual variety without overwhelming the user.

Icons serve as essential visual elements that support the understanding of functions or information without relying on lengthy text, as shown in **Table 3**. In the design of this mobile game, icons are used consistently and intuitively to simplify user navigation and interaction. This design strategy is specifically tailored to accommodate the needs of older adults who may have limitations in visual and cognitive abilities.

Table 3. Use of Icons

Icon Name	Function	Usage Location
Back arrow icon	Navigates to the previous page	Top left corner
Information icon	Provides instructions or how to play	Game start page
Fruit & number icon	Main object for the game of matching fruits and numbers	<i>Match Fruits</i> page
Cute animal icon	Game object for matching animals	<i>Find Pet</i> page
Color card icon	Game object to be remembered	<i>Memori Warna</i> page
Trophy & confetti icon	Indicates success	Result page

After establishing the design guidelines, the medium fidelity stage was carried out by arranging visual elements in greater detail, as shown in **Figure 5**. This design presents the shape of buttons, icons, text sizes, and a more precise content layout, referring to the needs of older adults such as easy navigation, readability, and a simple user interface.

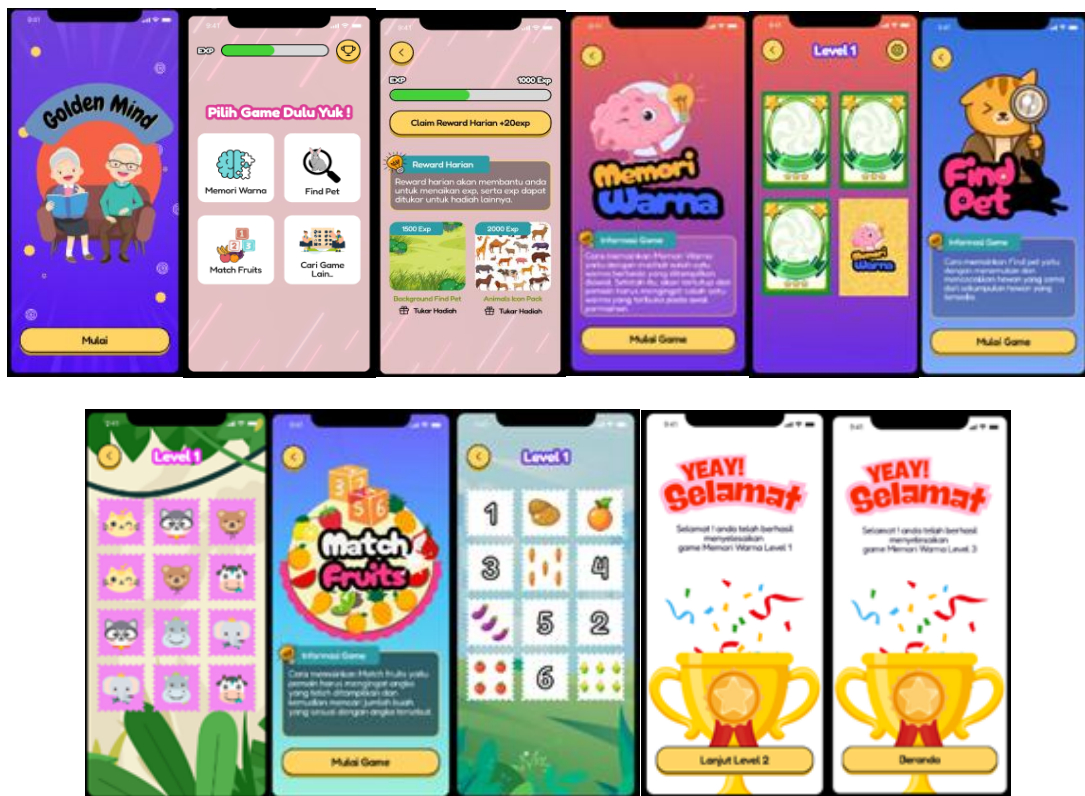


Figure 5. Wireframe Medium Fidelity

3.3. Produce Designs Solutions

The third stage in the user centered design approach is the process of generating design solutions. This stage focuses on developing solutions that meet the needs and characteristics of the identified respondents. The design solution developed is a mobile game consisting of three games Memori Warna, Find Pet, and Match Fruits. The design considers aspects such as ease of use, visual comfort, and simple interactions that suit older adult users. All game elements are designed to be easily accessible and usable, including by respondents with no prior experience in playing mobile games. This stage also includes the creation of a mobile game prototype with an engaging visual appearance.

Interface Design Development. This step involves the development of the design solution, covering the creation of the interface in visual form up to the prototype stage, as shown in **Figure 6**. The interface design process uses digital design tools, specifically Figma. Figma was chosen because it offers ease in creating responsive and collaborative designs, and it supports realistic interactive prototype visualization. The design is developed in the form of a website prototype that simulates the appearance of a mobile application to facilitate initial testing and evaluation

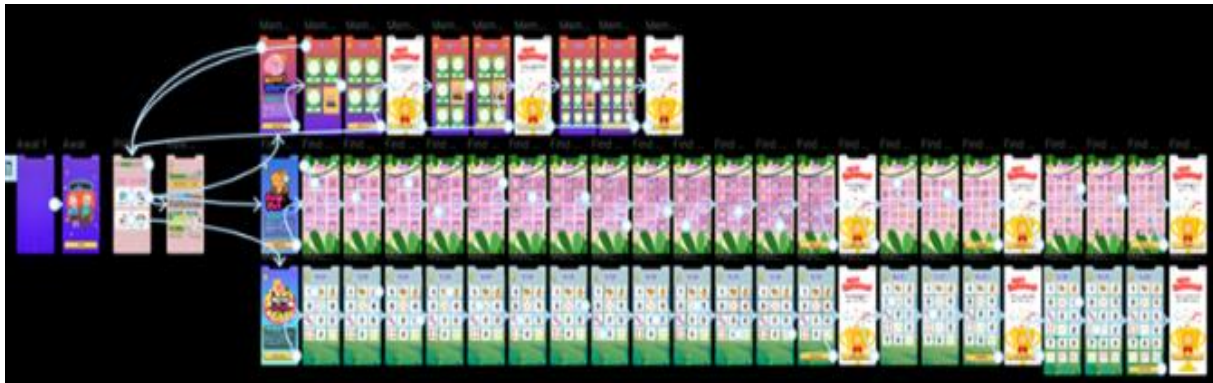


Figure 6. Interface Display Prototype

3.4. Evaluate the Designs

The fourth stage of the user centered design process is evaluation through usability testing to ensure that the interface and functions meet the needs of older adults. This method observes respondents' ability to complete the game design tasks, ease of use, and level of satisfaction. The testing was conducted in two stages (before and after treatment) to optimize the design based on respondent feedback.

1. User Testing Before Treatment

The testing involved 16 elderly respondents who played the game prototype from the menu to the reward screen. The objective of this test was to evaluate the usability of the initial design. Observation results revealed three main issues insufficient color contrast making it difficult to identify important elements, non intuitive icons causing confusion, and text size being too small, making it hard to read.

The issues experienced by respondents in the initial design were classified based on visual interface aspects (color, icons, and text). The observation results were then visualized in a chart to illustrate the distribution of respondents in each aspect, as shown in **Figure 7**. Based on the chart, the "Clear Icons" category received the highest score with 16 respondents, indicating that the icons were appropriately designed and easy to understand. Additionally, 11 respondents experienced difficulty due to the text size being too small, while 5 respondents stated that the text was completely unreadable. Regarding the color aspect, 9 respondents indicated that the color contrast was sufficient and distinguishable, while 7 respondents found the color contrast to be inadequate. These findings suggest an inconsistency in color usage, which could lead to confusion.

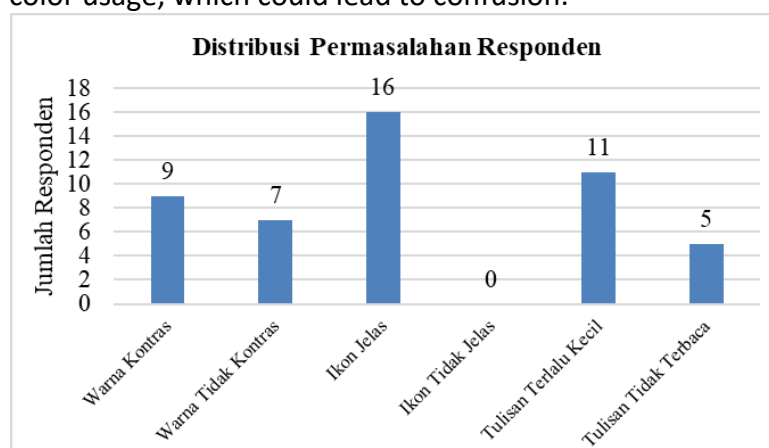
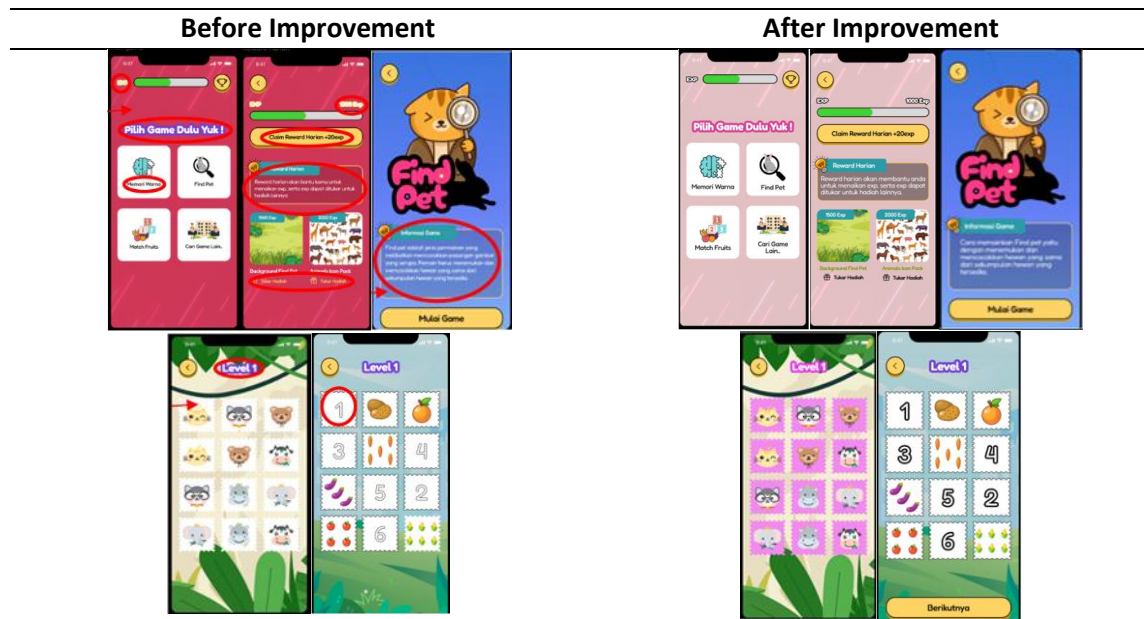


Figure 7. Respondents Based on Icon, Color, and Text Clarity in the Initial Design

Therefore, a redesign of the interface is necessary. **Table 4** presents a comparison of the game interface before and after improvements based on the results of the usability testing conducted in the before treatment stage.

Table 4. Identification of Respondents' Visual Issues



Based on the results of the user testing evaluation in the *before treatment* stage, which identified visual issues such as overly bright background colors, low color contrast, and small text size (18 pt), design improvements were made by applying a pastel pink background, increasing the text size to 32 pt, and optimizing color contrast and element thickness. These changes resulted in a more comfortable and readable interface for elderly users.

2. User Testing After Treatment

User testing after treatment was conducted to evaluate the effectiveness of the game design in providing cognitive stimulation for the elderly. The evaluation covered three aspects: completion time, learning curve, and the USE Questionnaire. In the completion time test, 16 elderly respondents were asked to play three types of games (Memori Warna, Find Pet, and Match Fruits) three times each. Completion time was measured in seconds to assess respondent efficiency and the effectiveness of the interface improvements. In the Memori Warna game, the average time decreased from 65 seconds (session 1) to 40 seconds (session 3). The Find Pet game showed a reduction from 83 seconds to 46 seconds, while Match Fruits went from 81 seconds to 47 seconds. The fastest completion times were recorded in the third session: 20 seconds by Respondent 4 for Memori Warna, 22 seconds by Respondent 6 for Find Pet, and 28 seconds by Respondent 16 for Match Fruits. This decrease indicates a positive learning curve, as shown in **Figure 8**, demonstrating an improvement in the users' ability to understand gameplay flow and adapt to the interface after repeated interactions. The improvements in readability, icon clarity, and layout design have proven effective in enhancing interaction for elderly users.

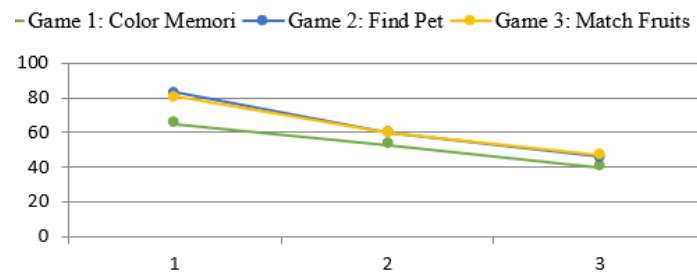


Figure 8. Average Completion Time per Trial Char

In addition to measuring time, the evaluation was also conducted through usability testing using a set of statements compiled into a questionnaire. Each respondent rated 30 statements, which were categorized into four factors: usefulness, ease of use, ease of learning, and satisfaction. The evaluation used a 4 point Likert scale, with the following categories: strongly disagree (1), disagree (2), agree (3), and strongly agree (4). The average score for each statement was calculated to assess the system's feasibility, both overall and based on each individual factor. After data were collected from all respondents, the next step was to calculate the mean score for each questionnaire item. This score was obtained by summing all respondents' scores for a particular statement and dividing it by the total number of respondents ($n = 16$). The recap of the assessment results as shown in **Table 5**.

Table 5. Questionnaire Recapitulation Results

Factor	No	Statement	Score
<i>Usefulness</i>	1	Helps with activities	3.31
	2	More active and enthusiastic	3.31
	3	Useful	3.44
	4	Organizes activities	2.94
	5	Facilitates daily activities	3.38
	6	Saves time	3.06
	7	Meets needs	3.69
	8	Meets expectations	3.38
	Total <i>Usefulness</i>		26.50
<i>Ease Of Use</i>	9	Easy to use	3.75
	10	Simple interface	3.31
	11	Easy to understand	3.44
	12	Clear steps	3.38
	13	Customizable	2.81
	14	Requires little effort	3.25
	15	No need to read the manual	2.88
	16	Works consistently	3.31
	17	Liked by new or old users	3.25
	18	Errors easily fixable	2.88
	19	Always usable	3.38
	Total <i>Ease of Use</i>		35.63

Factor	No	Statement	Score
<i>Ease Of Learning</i>	20	Quick to understand	3.50
	21	Easy to learn	3.44
	22	Comfortable to learn	3.56
	23	Quickly get used to it	3.13
Total <i>Ease of Learning</i>			13.63
<i>Satisfaction</i>	24	Feeling satisfied	3.56
	25	Would recommend it	3.38
	26	Enjoyable	3.63
	27	Met expectations	3.31
	28	Interesting	3.38
	29	Want to keep playing	3.44
	30	Happy while playing	3.69
Total <i>Satisfaction</i>			24.38
Total Overall			100.125

The equation used to calculate the level of usability using the USE Questionnaire is as follows [1]:

$$k(\%) = \frac{s \times y \times d}{s \times y \times ha} \times 100\% \quad (1)$$

$$= \frac{\text{usability score obtained}}{\text{maximum usability score}} \times 100\%$$

Explanation:

Pk (%) : Usability level in percentage

S : Scale score

y : Number of statements

d : Number of respondents

ha : Maximum score

The data obtained is then converted based on the eligibility category table as shown in **Table 6** [20].

Table 6. Feasibility Category by Percentage (%)

Percentage (%)	Classification
<21	Very Infeasible
21-40	Infeasible
41-60	Fair
61-80	Feasible
81-100	Highly Feasible

USE Questionnaire Overall Measurement

Based on the overall calculation of the USE Questionnaire, the average score obtained was 100.125 from 30 statements with 16 respondents. The usability percentage is calculated as follows [2]:

$$(PK) = \frac{100.125 \times 16}{4 \times 30 \times 16} = \frac{1602}{1920} = 83.43\% \quad (2)$$

Thus, a usability percentage score of 83.43% indicates that the product or application tested falls under the "Highly Feasible" category based on the available feasibility classification. This means that, in general, the application has met users' expectations in terms of usefulness, ease of use, and satisfaction.

USE Questionnaire Measurement on Usefulness Aspect

The usefulness aspect is used to measure the extent to which the application helps users effectively achieve their intended goals. Based on the measurement results, an average score of 26.50 was obtained from 8 statements and 16 respondents, and calculated as follows [3]:

$$(PK1) = \frac{26.50 \times 16}{4 \times 8 \times 16} = \frac{424}{512} = 82.81\% \quad (3)$$

A percentage score of 82.81% indicates that the usefulness aspect also falls under the "Highly Feasible" category, meaning the application is considered very helpful in assisting users to complete their desired tasks or objectives.

USE Questionnaire Measurement on Ease of Use Aspect

The ease of use aspect aims to assess how easily the application can be used by users, in terms of both appearance and interaction. From the calculations, an average score of 35.63 was obtained from 11 statements and 16 respondents, calculated as follows [4]:

$$(PK2) = \frac{35.63 \times 16}{4 \times 11 \times 16} = \frac{570.08}{704} = 80.97\% \quad (4)$$

Thus, the score of 80.97% indicates that this aspect also falls under the "Highly Feasible" category, meaning the application's interface and features are considered easy to understand and use by users.

USE Questionnaire Measurement on the Ease of Learning Aspect

The ease of learning aspect aims to assess how quickly users can understand and learn how to use the application. Based on the collected data, the average score for this aspect was 13.63 from 4 statements, with a total of 16 respondents, and it can be calculated as follows [5]:

$$(PK3) = \frac{13.63 \times 16}{4 \times 4 \times 16} = \frac{218.08}{256} = 85.19 \quad (5)$$

With a percentage score of 85.19%, the ease of learning aspect is categorized as "Highly Feasible." This indicates that the application is easy to learn and understand by users.

USE Questionnaire Measurement on the Satisfaction Aspect

The satisfaction aspect is used to determine the level of user satisfaction with the application overall. The average score obtained was 24.38 from 7 statements. With a total of 16 respondents, the calculation is as follows [6]:

$$(PK4) = \frac{24.38 \times 16}{4 \times 7 \times 16} = \frac{390.08}{448} = 87.07\% \quad (6)$$

The result of 87.07% shows that the satisfaction aspect also falls into the "Highly Feasible" category, meaning users feel very satisfied with the application in terms of appearance, functionality, and overall user experience.

4. CONCLUSION

Based on the needs analysis of 16 older adults, a simple interface design with clear icons, large text, and high contrast colors emerged as key factors, supported by the role of caregivers. The prototype was developed using a User Centered Design approach, resulting in three games (Find Pet, Match Fruits, and Memori Warna) that adhered to accessibility principles. Usability testing results showed significant improvements across four aspects ease of use, satisfaction, usefulness, and ease of learning. Observations demonstrated that older adults were able to complete tasks related to memory, attention, and pattern recognition more quickly and with fewer errors, indicating cognitive stimulation potential.

Recommendations for future researchers include developing additional accessibility features, expanding field testing across diverse geographical and demographic settings, and conducting long-term studies using cognitive assessment tools to ensure user comfort, validate findings, and accurately measure the game's impact on cognitive abilities in older adults.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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