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Research Article

Artificial Intelligence (AI) Based Game Development ``Memory Game" for Training Functions Alzheimer and Dementia Cognitive

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Abstract.
Smart games, especially crossword puzzles can be an effective tool in aiding cognitive and physical exercise by stimulating the brain and strengthening brain connections, which can help prevent or slow the progression of Alzheimer's and dementia. This research aimed to develop a crossword puzzle game into a digital version in Bahasa Indonesia with Artificial Intelligence (AI) features. The benefit of this game product can be used as a cognitive therapy for Alzheimer's and dementia sufferers. The research method used is game development using the Game Development Life Cycle (GDLC) model with stages of initiation, pre-production, implementation/development, testing, launch, and maintenance. Implementation of digital version using Unity 3D game engine with AI feature of hint generating. This research was carried out for 8 months. Game testing results were carried out by testing the functionality of game features and the results were that all features functioned well. The innovation and importance *of this work was* to implement the memory crossword puzzle game design into a digital version in Bahasa by implementing artificial intelligence methods for the hints feature. This work will inspire developers to do greater work on Bahasa and implement various features based on AI methods.

Keywords: digital memory games, artificial intelligence, crosswords, game development

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1. INTRODUCTION

Alzheimer's and dementia are degenerative diseases that attack cognitive function in old or elderly people. This disorder is certainly not desirable because it reduces everyone's quality of life. Dementia or dementia consists of various types, one of which is the most common is Alzheimer's [1]. Until now, no cure has been found for this disease, but the risks and symptoms can be reduced with various therapies that can stimulate and improve cognitive function. Cognitive therapy can be done with games or interactive games, both traditional games and digital versions. There are only a few digital versions of cognitive memory games in Indonesian. Meanwhile, there are increasing numbers

of users of mobile versions of digital games at all ages, including children, teenagers, adults, and the elderly. Game users in Indonesia in 2022 will be 170 million people or two-thirds of Indonesia's population.

Elderly access to information and communication technology has increased in the last five years. By 2022, almost half of seniors will use cell phones. Meanwhile, computer use by the elderly has been relatively stable in the last five years, reaching no more than two percent by 2022. In line with the increase in cell phone use, internet access by elderly has also increased. In 2022, 19.42 percent of seniors will have accessed the internet. This figure increased significantly from 2018 when only 5.38 percent of elderly people accessed the internet. Below is the complete data.

TABLE 1: Percentage of elderly who have access to information and communication technology by facility type.

Characteristics	Type of Facility		
	Using a cell phone	Using a computer	Internet access
Gender			
Man	57,32	2,70	23,76
Woman	42,01	1,02	15,38
Age Group			
Young elderly (60—69)	56,27	2,38	23,86
Middle elderly (70—79)	39,87	0,96	12,42
Senior elderly (80 years and over)	23,84	0,20	5,99

Source: BPS, Susenas March 2022

Based on this data, the author developed an interactive game in the form of a crossword puzzle assisted by artificial intelligence that can be used by the elderly via computer/laptop. Smart games can be an effective tool in aiding cognitive and physical exercise. Development of this crossword puzzle game into a digital gaming platform using Indonesian language and AI features in the game. Games can stimulate the brain and strengthen brain connections, which can help prevent or slow the progression of Alzheimer's and dementia. Apart from that, smart games can also provide entertainment and motivation for parents to continue practicing and maintaining their brain health.

Previous research conducted by Sulaeman [2] mapped two motives for elderly people playing TTS, namely affective motives, and cognitive motives. Based on the results of interviews and observations at the retirement reception area at the Ujung Berung branch of the BTPN and Pos Indonesia offices and the elderly community of Sindang Jaya Mandalajati Village, Bandung City, it is known that affective motives (feelings) are in line with the affiliation theory which views the elderly as beings who seek affection

and affections. Acceptance from other people and is also in line with expressive theory which views that a person obtains satisfaction by expressing his or her existence and showing his feelings and beliefs. Meanwhile, the cognitive motive (knowledge) is related to the utilitarian theory which views that a person always has the motivation to obtain useful information. In this context, elderly people are motivated to continue to hone and train their memory so they can think clearly and prevent dementia.

Computer cognitive training programs are an effective and valuable way to improve cognitive function in older adults and may assist in slowing the decline in cognitive function associated with dementia. This study involved 4,885 people aged 50 years and over, and the results show that playing smart games can help improve cognitive abilities in older people in the long term. Smart games can also help improve cognitive function and mental well-being in older adults with depression [3]. This study involved 63 elderly people who experienced depression and the results showed that playing smart games can help improve cognitive abilities and improve mood in older people. In addition, smart games that were developed specifically to help cognitive exercises in older people can improve cognitive abilities in older people and can help prevent or slow the development of Alzheimer's and dementia, brain health [4]. Some games used to train the cognitive functions of Alzheimer's and Dementia sufferers include crossword [5], puzzle games (and memory games by matching cards [5]. However, these games are traditional games and not yet digital. This is the background for the development of intelligence-based games artificial "sweet memory" to train the cognitive functions of Alzheimer's and dementia sufferers in a digital version. There are several advantages of digital games compared to traditional games, including:

1. Easier accessibility: Digital games can be accessed easily and quickly via electronic devices such as computers, laptops, or smartphones. Meanwhile, traditional games require special preparation, such as buying or making the game yourself, as well as gathering friends or family to play together.

2. Flexibility of time and place: Digital games can be played at any time if there is an adequate internet connection and device. This is different from traditional games which often require a certain time and place to play.

3. The cognitive development of the player can be recorded in the game application both from the value and time to complete the game.

Crossword puzzle game in Hausa language and Evaluation of the prototype based on a usability test has shown that a good percentage of the users can use the system effectively and they welcomed the idea of the new game [6]. This Study developed

a crossword puzzle game implemented in Bahasa. Artificial Intelligence (AI) for Game Development found an AI model to fulfill three basic needs in most games: the ability to move the character, the ability to decide where the character will move, and the ability to think tactically or strategically [7]. The innovation and importance of this work was to implement the Memory crossword puzzle game design into a digital version in Bahasa by implementing artificial intelligence methods for hints feature. This work will inspire developers to do more great works on Bahasa and implement various features based on AI methods. The advantages and applications of this procedure were as follows:

1. For seniors 60 years and over is to prevent Alzheimer's and dementia

2. For Alzheimer's and dementia sufferers, this game can be a therapy and treatment medium to slow down symptoms.

In this study, the research problem is: The formulation of the problem of developing an artificial intelligence-based game "sweet memory" to train the cognitive functions of Alzheimer's and dementia sufferers can be described as follows:

1. How to design crossword memory games as a therapy for Alzheimer's and dementia?

2. How to implement crosswords games into Digital Version?

3. How to implement crosswords in Bahasa Indonesia?

2. MATERIAL METHODS

The game development methodology used is the Game Development Life Cycle (GDLC) method [8] [9]. This method consists of six main stages, namely initiation, pre-production, production, testing at the developer level (alpha), testing at the user or player level, and the last is release. Each development phase is carried out in stages as in Figure 1. In this research, the output is a prototype with testing up to alpha testing.

The stages in this research methodology include:

1. Initiation

   At this stage, the concept of the game that will be built is created. in the form of an analysis of what the game will be like, the initiation will produce results. In simple game concept and description. The initiation will also explain about game scenario, characters, storyline, player goals, platform used, and game engines.
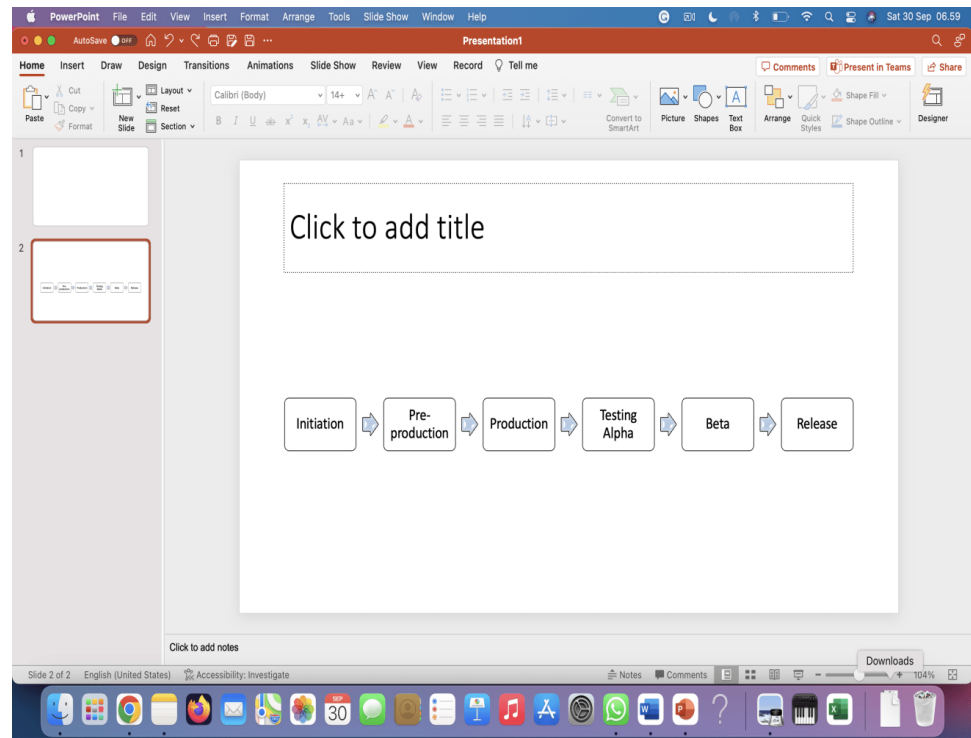
Figure 1: Game Development Life Cycle, The figure should be cropped properly.

2. Pre-production

Before the magic of coding and pixel art begins, game development undergoes a crucial stage called pre-production. This is where ideas are brainstormed, concepts fleshed out, and a solid foundation is laid. Imagine a planning party, where the core concept, target audience, and unique features are meticulously crafted. Research fuels this brainstorming, ensuring the game resonates with its intended market.The Game Design Document (GDD) acts as the blueprint, meticulously outlining everything from story and levels to art style and mechanics. Prototypes are built, serving as miniature versions of the game to test core mechanics and ensure they're truly fun. With a budget in place and a dream team assembled, pre-production sets the stage for a successful game development journey. It's the foundation upon which your vision will be built, and by taking the time to plan, experiment, and build a strong team, you're setting yourself up for a masterpiece.

3. Production

The production stage in game development is implementing the game design which is carried out at the pre-production stage. Implementation is carried out by coding, that is, the developer starts to code the game. Implementation of digital version using Unity 3D game engine and C# programming language. Apart from that, the process of creating graphics, animations, sound effects, and dialogue are

also needed. Implementation of AI with hint generathing algorithm [10] [11]. The pseudocode is as follows :

```
// Choose a random candidate word

string chosenWord = FilterWords[Random.Range(0, FilterWords.Count)];

// Build the hint based on desired difficulty

string hint = "";

switch (difficulty)

{

case Easy:

hint = chosenWord;

break;

case Medium:

hint = GetPartialDefinition(chosenWord);

break;

case Hard:

hint = RevealLetters(chosenWord);

break;

}
```

4. Testing

Testing plays a critical role in game development, just like the final quality check before launching a rocket. Think of it as the last hurdle before players blast off into your immersive world. Functional testing ensures all features work as designed, while performance testing assesses how the game handles different hardware and environments. Testing isn't just about fixing bugs; it's also about refining the overall experience. Playtesters, from seasoned gamers to fresh-faced newcomers, provide invaluable feedback on everything from controls and difficulty to story pacing and emotional impact. This feedback helps developers polish the game into a gem that shines for everyone. By employing a comprehensive testing strategy, developers can ensure their game is not only technically sound but also engaging, enjoyable, and ready to take players on an unforgettable journey. Testing isn't just about fixing bugs; it's also about refining the overall experience. Playtesters, from seasoned gamers to fresh-faced newcomers, provide invaluable feedback on everything from

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5. Beta

Beta testing occupies a critical space within the game development process, analogous to unveiling a meticulously crafted creation to select audiences for their discerning feedback. This stage involves releasing a near-final version of the game to a carefully curated group of players, often comprised of dedicated fans and seasoned gamers. Their valuable insights, akin to a final dress rehearsal, provide developers with an opportunity to refine their work before the official launch. Beta testers, acting as pioneers venturing into the game's world, offer invaluable feedback through their playthrough experiences. They meticulously document bugs, glitches, and areas requiring improvement, furnishing developers with essential information for fine-tuning the game's balance, mechanics, and overall user experience. Beyond technical aspects, their feedback delves into narrative pacing, character development, and emotional resonance, ensuring the game resonates deeply with its target audience. Beta testing fosters a symbiotic relationship between developers and players. While developers gain invaluable insights and identify potential issues prior to release, players experience the thrill of early access and the satisfaction of shaping the game's final form. This collaborative process cultivates a vibrant community around the game, generating excitement and anticipation for its official launch. The beta testing phase can also be continued with usability testing [12][13][14] .

6. Release

The release stage in game development is the crucial moment when the game is ready to be published and available to players. At this stage, the development team selects a suitable distribution platform, such as game consoles, PCs, or mobile devices, and starts planning a marketing strategy. They may need to get approval and certification from the platform's publisher, especially if the game is released on consoles. Apart from that, physical preparations can also be made if the game will be released in physical form, such as designing packaging and producing physical copies of the game. For games that will be released digitally, the development team uploads the game to a digital distribution platform such as Steam or the App Store. Marketing and promotion of the game begins before launch with teaser trailers, screenshots, gameplay footage, and social media to build buzz and interest from potential players. Once a game is officially released, the development team must

remain active in monitoring player feedback, addressing technical issues that may arise, and releasing updates or fixes as necessary. The release stage is the time when a game is finally available to the public, and good quality and post-release support can have a big impact on the game's success in the market.

3. RESULTS AND DISCUSSIONS

The Result of Game Development Process can describe as below :

1. Initiation

   At this stage, the concept of the game that will be built is created in the form of an analysis of what the game will be like, the initiation will produce results of a simple game concept and description. The initiation will also explain about game scenario, characters, storyline, player goals, platform used and game engines. The game that will be built is a digital crossword puzzle game with a target age of over 60 years. The crossword puzzle memory game aims to train cognitive and memory skills and is a recommended therapy for Alzheimer's and dementia sufferers. Crosswords are created in four levels with different levels of difficulty. The platform used is desktop-based, with the recommended device being a personal computer, laptop, or tablet. The implementation of crosswords uses the game engine unity 3D. The Game uses vocabulary in Indonesian.

2. Pre-production

   At the pre-production stage in this research, game design was carried out, namely interface design, visual asset design, game mechanics and level design before being implemented in digital form. The level 1 design is in Figure 2 and level 2 in Figure 3 below:

Before implementation, the design results were approved and curated by an expert, namely Dwiweko Soeprijono, a crossword puzzle book writer from Kompas. After the results are good, it will proceed to the next stage, namely the implementation or production stage. The level 3 design is in Figure 4 and level 4 in Figure 5 below:

3. Production

Crossword puzzles are a classic and engaging word game enjoyed by people of all ages. Developing a crossword puzzle game using C# and Unity presents a great opportunity to learn programming and game development concepts while creating a fun and educational experience for players that can also improve cognitive abilities. Key components of Game Design consist of :
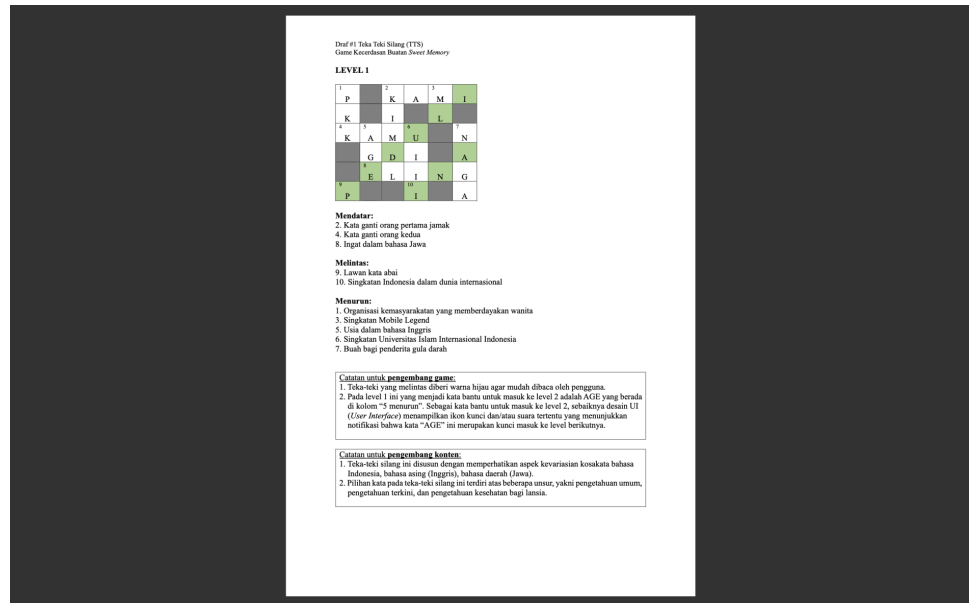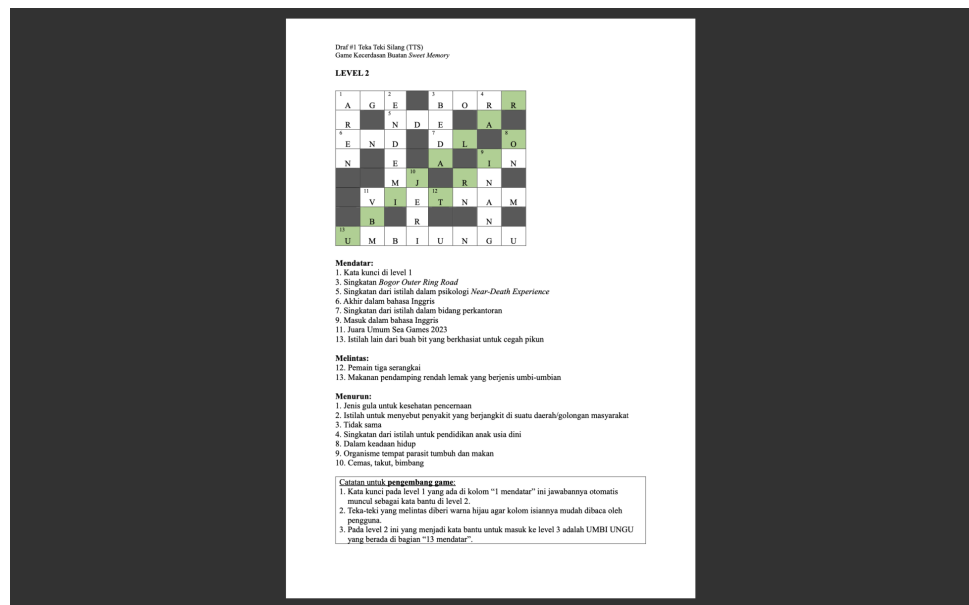
Figure 2: Design of Level 1.

Figure 3: Design of Level 2.

1. Gameplay: Players will be presented with a grid of squares containing letters and clues. They must use their knowledge of vocabulary and spelling to fill in the blanks and complete the crossword.

2. Features:

3. Difficulty levels: Implement different difficulty levels with varying grid sizes and clue complexity.
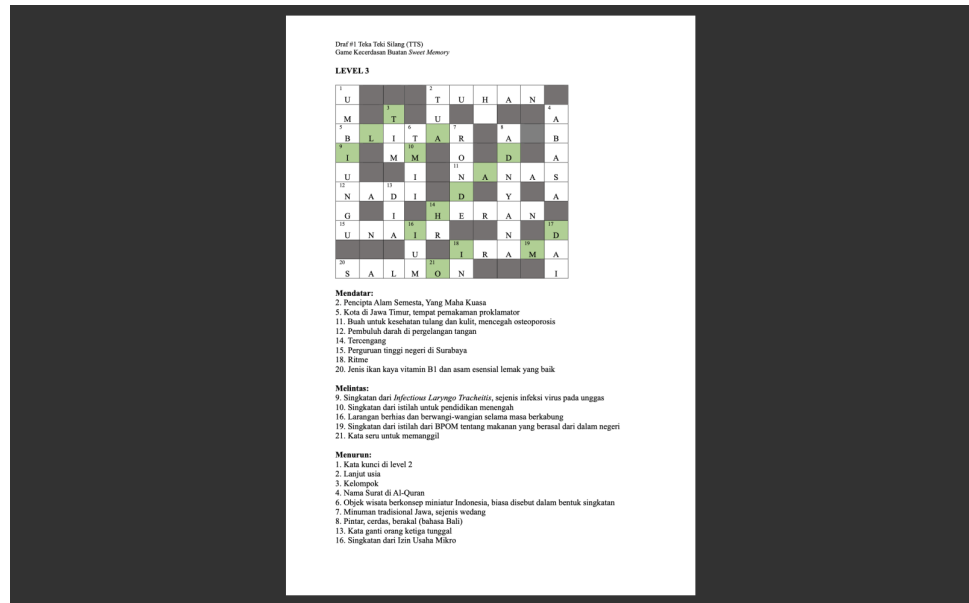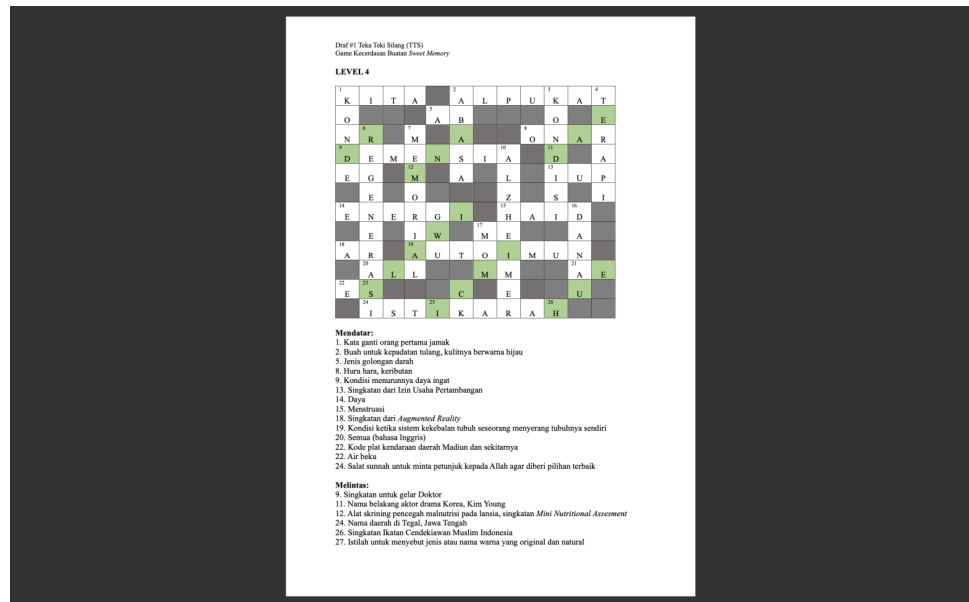
Figure 4: Design of Level 3.

Figure 5: Design of Level 4.

4. Hints and solutions: Offer optional hints or reveal solutions for players who get stuck.

5. Daily puzzles: Generate new crossword puzzles daily to keep players engaged.

6. Leaderboards and achievements: Encourage competition and engagement by implementing leaderboards and achievements.

7. Customization: Allow players to customize their experience with options like themes and sound effects.

c. Technical aspects also be consideration :

1. C# scripting: Utilize C# scripting for game logic, including grid generation, clue management, user input handling, and scoring.

2. Unity UI: Build the user interface using Unity's UI system, including buttons, menus, and text boxes.

3. TextMesh Pro: Use TextMesh Pro for displaying crossword clues and answers with enhanced font control and text rendering.

Game implementation using the Unity 3D game engine with 2-dimensional assets. The way to play crosswords is as follows:

1. Pay close attention to the question number, whether it is decreasing or horizontal. Because if you make a mistake, the crossword puzzle will not be answered perfectly.

2. When you get the question, look for the answer column. If it decreases, fill it down. If it's horizontal, fill it to the side (right)

3. "Match" the number of words in your answer to the number of boxes provided. If it's the same, you can fill it in immediately and continue working on other questions. The gameplay display is shown in Figure 6
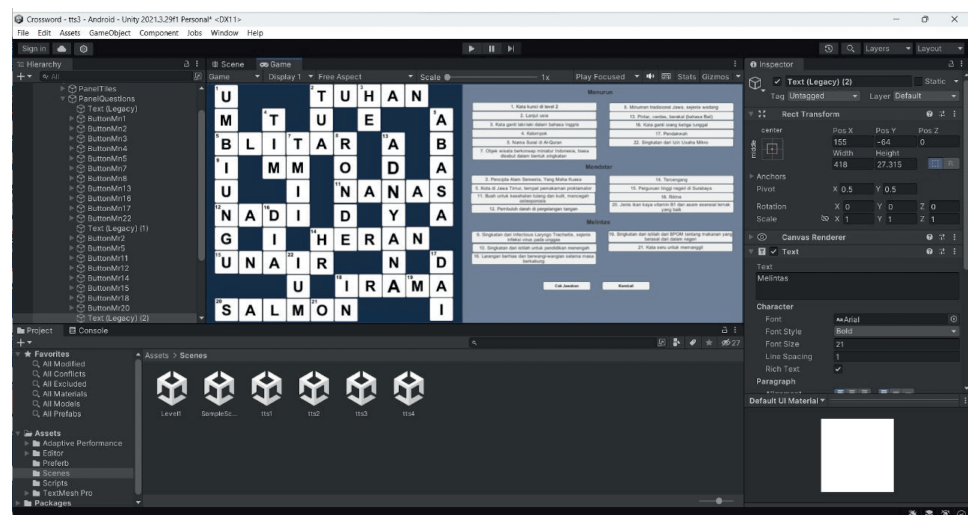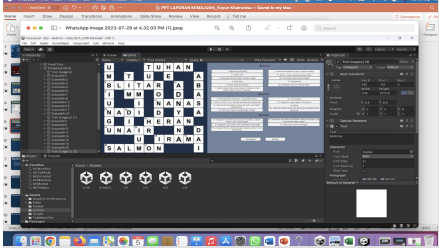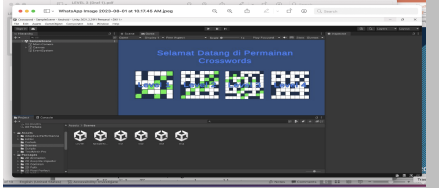

Figure 6: Gameplay of each level.

4. Testing

Testing in this context means internal testing carried out to test operational functions and gaming capabilities. Specific testing methods for each prototype stage. Improvement Testing relates to quality of enjoyment and quality of accessibility criteria [15] The alpha test results are listed in table 1 below :

TABLE 2: Alpha Testing Blackbox.

Test Case	Expected results	Output	Results
Access the game splash screen	The game application will display the main splash screen splash screen		[√] Succeed [ ] Failed
Access the start button	The start button directs the player to the choice of game to be played		[√] Succeed [ ] Failed
Choose the level	Player chooses the level to be played		[√] Succeed [ ] Failed
Checking Answers	The player checks whether the answer is correct or not, if there is still something wrong then an answer notification will appear		[√] Succeed [ ] Failed
Access back button	Player returns to the beginning of the main menu		[√] Succeed [ ] Failed

The choice of words in the level 1, 2, 3, and 4 TTS game scenarios includes general knowledge, current knowledge, and elderly health knowledge. Variations in diction are useful in triggering elderly people to remember names, places, events, foreign words, and simple things in everyday life. At this level, the difficulty level is in the low category

to refresh the elderly's brain so that it can work more optimally at the next level. This argument is strengthened by the result of research [16] on 101 people who were studied for 12—18 months. The result showed that those treated with the TTS game were able to delay memory decline by 2.54 years on average.

4. CONCLUSION AND RECOMMENDATION

The crossword digital memory game was developed in prototype form so that its development reached alpha testing. The results of alpha testing are that all the main features can be run well. There are several suggestions curated by a team of crossword experts as follows:

1. This crossword puzzle is prepared by considering aspects of variations in language vocabulary Indonesian, foreign language (English), regional language (Java).

2. The choice of words in this crossword puzzle consists of several elements, namely general knowledge, the latest knowledge, and health knowledge for the elderly.

The development of this crosswords game has just reached the alpha testing stage, then it needs to be beta tested and released to the appropriate platform for example Android Play Store, Appstore, Steam, Stich io, and many others.

Acknowledgement

References

[1] Sianturi AG; SIANTURI. Aditya Gloria Monalisa. Stadium, Diagnosis, dan Tatalaksana Penyakit Alzheimer. Majalah Kesehatan Indonesia. 2021;2(2):39–44.

[2] Sulaeman, Dodi. 2017. Karakteristik Lansia Pensiunan Pembaca TTS. PRoListik, 1(2), 2017: Juni, 169—184.

[3] KUEIDER, Alexandra M., et al. Computerized cognitive training with older adults: a systematic review. PloS one, 2012; 7.7: e40588.

[4] ROH, Hyun Woong, et al. The effectiveness of a motivational enhancement smartphone application promoting lifestyle improvement for brain health: A randomized controlled trial. Plos one, 2022; 17.6: e0267806.

[5] AMALIATI. Lilis Faiza. PENGARUH BOARD GAME TERHADAP PENINGKATAN FUNGSI KOGNITIF PADA LANSIA DI PANTI WERDHA MOJOPAHIT KABUPATEN MOJOKERTO. 2020. PhD Thesis. STIKES BINA SEHAT PPNI MOJOKERTO.

[6] Apake, A., & Thomas, G. Implementing A Crossword Puzzle Game in Hausa Language. 2019

[7] Millington I. AI for Games. CRC Press; 2019. https://doi.org/10.1201/9781351053303.

[8] Bonomo D, Lauf AP, Yampolskiy R. (2015, July). A crossword puzzle generator using genetic algorithms with Wisdom of Artificial Crowds. In 2015 Computer Games: AI, Animation, Mobile, Multimedia, Educational and Serious Games (CGAMES) (pp. 44-49). IEEE. https://doi.org/10.1109/CGames.2015.7272960.

[9] Thanasuan K, Mueller ST. Crossword expertise as recognitional decision making: an artificial intelligence approach. Front Psychol. 2014 Sep;5:1018.

[10] TYAS. S. S.; KHAIRUNISA, Y. Usability Testing for Student Academic Information System in State Polytechnic of Creative Media. Journal of Physics: Conference Series. IOP Publishing; 2021. p. 012012.

[11] KHAIRUNISA, Yuyun, et al. Software Usability Measurement Inventory for Student Information Academic System at Politeknik Negeri Media Kreatif. IJISTECH (International Journal of Information System and Technology), 2020; 4.1: 559-565.

[12] RAYHANI. Mitha Syafiiah; TYAS, Sari Setyaning; KHAIRUNISA, Yuyun. Uji Usability Aplikasi Pembelajaran Interaktif Sebagai Sarana Belajar Literasi Finansial Untuk Siswa Kelas 7 di SMPIT Nurul Ilmi. Engineering and Technology International Journal. 2023;5(02):93–107.

[13] Pragantha J, Haris DA. ""Serenade Tower" Hack and Slash Game." IOP Conference Series: Materials Science and Engineering. Vol. 1007. No. 1. IOP Publishing, 2020.

[14] UDJAJA, Yogi, et al. Game-based Learning Increase Japanese Language Learning through Video Game. Int J Adv Comput Sci Appl. 2022;13:2.

[15] JULIANUS. Ervan; HIDAYAT, Eka Wahyu; SULASTRI, Heni. Android-Based Traditional Games [Jurnal Informatika dan Sains]. JISA. 2020;3(1):21–6.

[16] Pillai JA, Hall CB, Dickson DW, Buschke H, Lipton RB, Verghese J. Association of crossword puzzle participation with memory decline in persons who develop dementia. J Int Neuropsychol Soc. 2011 Nov;17(6):1006–13.