RESEARCH ARTICLE | JANUARY 30 2025

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AIP Conf. Proc. 3250, 050007 (2025)
https://doi.org/10.1063/5.0241044

Serious Game Development for Children Learning to Read Using SAS Strategies

Bambang Robi'in[1, a)], Wahyu Pujiyono[1, b)], Siwi Purwanti[1, c)] and Jesicha Hety Manika[1, d)]

[1]*Univeristas Ahmad Dahlan, Jl. Ringroad Selatan Tamanan Banguntapan Yogyakarta 55191 Indonesia.*

[a)] Corresponding author: bambang.robiin@tif.uad.ac.id
[b)] yywahyup@tif.uad.ac.id
[c)] siwi.purwanti@pgsd.uad.ac.id
[d)] jesicha1800018323@webmail.uad.ac.id

Abstract. Reading and writing at the elementary school level are part of the language skills that students must have. Based on a survey at SD Muhammadiyah Ambarketawang 3 and SDN Balirejo in Yogyakarta, we found problems in elementary schools: more than 60% of grade 1 students could not read, and grade 2 students could not read fluently. One of the causes is a lack of student motivation and interest in learning. Increasing student motivation to learn can be done through educational games (serious games) because they provide learning that can be tailored to students and provide feedback automatically. Many game applications have been developed, but only some are effective and suitable for improving students' reading learning. This research focuses on developing "alfabeta" games using SAS strategies to learn to read. The development of this game uses the GDLC (Game Development Lifecycle) method, which is a game development method that consists of six main stages: initiation, pre-production, production, testing, beta, and release. In measuring the success of application development, testing is carried out using the media quality test method and Single ease question. According to the media quality test, the "alfabeta" game application scored 4.52 on a scale of 5, which means it has very good quality. According to SEQ testing, the "alfabeta" game scored 6.44 out of a scale of 7, which means the application is very easy to use.

INTRODUCTION

Reading and writing at the elementary school level are part of the language skills that are important for students to have [1]. Based on a survey at SD Muhammadiyah Ambarketawang 3 and SDN Balirejo in Yogyakarta, we found problems in elementary schools: more than 60% of grade 1 students could not read, and grade 2 students could not read fluently. The problems are due to a lack of student motivation and interest in learning [2], parents' lack of attention and guidance at home, the minimum duration of student study hours, and the maximum number of students' learning needs due to the COVID-19 pandemic so learning strategies and student learning styles have to change [3]. One learning strategy that can overcome this problem is learning by utilizing technology.

Currently, various technologies have emerged to support learning [4-7] . Mobile device technology has been widely used in education and influences student learning, especially Generation Z [8,9]. The advantage of mobile devices is that they have various features that support game applications [10,11]. Children's activity in playing games has drastically increased along with the penetration of internet users and mobile devices [12-14]. Games are the most immersive, exciting, and fun entertainment [15–17]. *Game Engine* is a middleware that enables the integration of multiple resources into assets with graphical information, programmatic content, and physical simulation parameters. These features meet the requirements for modeling, visualization, simulation, and learning media [18].

Proceedings of the International Conference on Informatics, Mechanical, Industrial, and Chemical Engineering (ICIMICE2023)
AIP Conf. Proc. 3250, 050007-1–050007-14; https://doi.org/10.1063/5.0241044

Game applications can function as entertainment and can also be used for education [19-21]. Although "video games trigger addiction" [22] if applied to education, it can provide benefits by presenting learning that can be tailored to students and can provide feedback automatically to increase learning motivation [23–28]. One of the popular games for increasing student learning motivation is educational game applications (serious games) [29]. *Serious games* are games that solve real-world problems in the real world with a process that means in a fun way [30]. Serious games make learning fun and challenging, especially with a digital format that allows playing "anytime, anywhere" [31]. Many educational games have been developed, but only a few game applications are practical and suitable for improving students' reading learning [32]. Factors that influence game-based learning are gameplay factors (how to play) [33] and storyline (game story) [34,35]. As an essential learning tool, game design considers students' interests and experiences that will be gained as collaborative learning [36].

The question in this research is how to develop educational games that can improve children's reading learning abilities. One strategy that can be used is SAS (Synthetic Analytical Structural). SAS method effectively improves the ability to learn to read and write the beginning. The purpose is to produce games that effectively improve children's reading skills. Adopting appropriate learning techniques in designing content, gameplay, and storylines is necessary. This study focuses on developing a serious game to learn to read with content design using the SAS. This application game is called "alphabeta". "Alfabeta" game application is a game application that runs on mobile devices with the Android operating system.

LITERATURE REVIEW

Structure Analytic Synthetic (SAS)

The SAS method is based on a psychological, pedagogical, and linguistic foundation. From this basis, the source of the steps of the SAS method begins with presenting a whole or structure, analyzing its parts, and then synthesizing the parts into a unified whole [37]. The SAS method is based on structural linguistics: 1. SAS is rooted in structural linguistics because SAS recognizes that sentences consist of several words, words consist of several syllables, and syllables consist of several letters. 2. children must recognize and move between two different structures (top-down and bottom-up approaches) to learn to read. The SAS method can be seen in Figure 1. The proposed research is to apply the SAS strategy in designing educational game content (alfabeta) to improve children's reading skills. The SAS method plays a role in determining the design of application content to produce suitable and effective applications for children's reading learning.

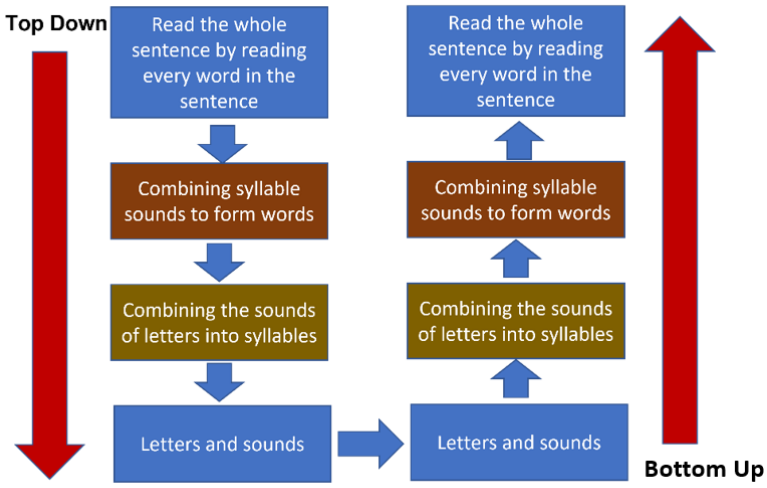

FIGURE 1. SAS Method based on synthetic phonic

Gamification

Gamification is a concept that involves the use of game design elements in contexts outside of games to increase user engagement, motivation, and participation in an activity or process. The main goal of gamification is to encourage individuals to perform certain actions, achieve goals, or learn through elements typically associated with games, such as prizes, scores, competitions, and challenges. Gamification in education has the potential to involve students in learning activities and increase student motivation to learn [38].

Game design, as an important learning tool, pays attention to students' interests and experiences that will be gained as collaborative learning [36]. There are two factors that influence game-based learning, namely gameplay factors [39] and game stories [33-35]. In this study, the gameplay factor and game story were designed based on a learning strategy using the SAS method, which has been proven to be effective in learning to read and write. Although research on the SAS method for learning to read has existed, the integration into a digital game application has not been carried out.

Game Based Learning

Game-based learning is learning using playing techniques as a medium. Game-based learning (GBL) can help alleviate this disinterest and support motivational gain and engagement in the child's learning. "Play" is a significant facet of GBL because, through it, people learn how to connect with and interpret their physical and social worlds [40]. Educational games are games that are intended for education and entertainment. Therefore, innovation and other ways are needed to improve the educational game itself to meet learning needs [16]. Platforms based on video games have advantages in terms of self-study, which are (i) allowing for customized learning, (ii) difficulty increases as the level presented progresses, (iii) allowing students to "go back to the beginning" and review material, (iv) generate feedback automatic feedback of actions performed, and (v) online games are accessible via the Internet, i.e. students can access content when they need it [23]. Two factors that influence game-based learning, namely the gameplay factor and the game story (storyline) [34].

METHOD

Data Collection

Interview

Interviews conducted in elementary schools with resource persons, namely homeroom teachers, said that the way students learn starts from the introduction of letters starting from the letters A - Z, vowels, consonants, word prefixes, word endings, two syllables, three syllables and then repeated repeat until students recognize and memorize if students have difficulty, then the material will be repeated back to the beginning. Then, students who have characters tend to be passive and active. Students really like the learning process using game methods such as guessing words and arranging words using paper media, and students like games that have lots of characters and fun music.

Observation

The results of observations in elementary schools, especially in grade 1, obtained are teachers providing reading lessons to students, especially students who have difficulty in reading. Each student has characteristics that tend to like games that have lots of pictures. Students feel quickly understand if the game contains pictures that give students instructions to solve a problem, arrange letters from A - Z, guess words, and connect several words into sentences. Students tend to like games with bright nuances, such as mobile legends. Students like games with landscape models compared to portraits. Students tend to like music in games that are cheerful and vibrant and voices that can clarify and provide clues to the content of the game.

The "afabeta" game development uses the GDLC (Game Development Lifecycle) method, which is a game development method from the beginning to the release. The stages of the GDLC method are shown in Figure 2.

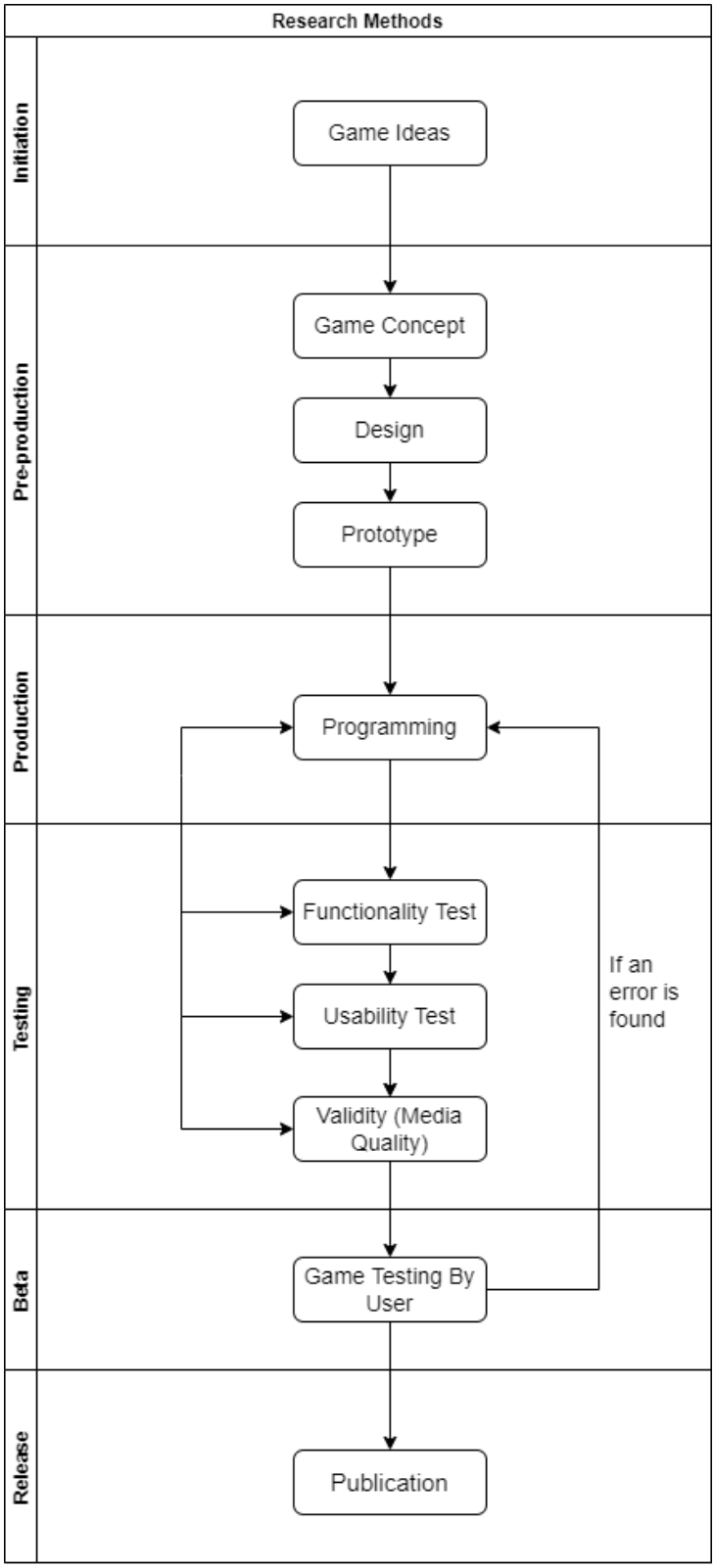

FIGURE 2. Game development lifecycle method used in the study

Initiation

In the early stages of research applying the initiation method (game idea), game development starts from game ideas. Game ideas were obtained by observing and interviewing students and homeroom teachers in elementary schools regarding students' reading development, student learning methods, and students' interest in games. The purpose of the results of observations and interviews is to make a basic reference in making educational games for elementary school students, especially in grade 1.

Pre-Production

The second stage is the refinement of the concept of the game, namely by producing the space theme and collecting data that will be needed for the game-making process, such as the homeroom teacher's teaching method by introducing the letters A - Z, vowels, consonants, word prefixes, word endings, two syllables and three syllables. The refinement of the concept and documentation data is continued with the design and prototype stages. At the design stage, the game design will be based on the SAS (Structure Analytic Synthetic) strategy to design "alfabeta" game content.

Production

The third stage is the beginning of making a prototype, namely making game assets where each asset is made one by one, such as materials, letters A - Z, buttons, fonts, planets, sounds, backgrounds and others. The game design is needed, and then a prototype is made using Figma to see the results of all assets, which will later be used as a reference in making educational games.

Testing

This testing is alpha testing carried out by the developer. Testing is done by the Blackbox method and media quality test. This test is carried out to determine whether the functional application is running well.

Betha Testing

This test is an application test by the user. The test method used is a single ease question (SEQ). The test was carried out by ten users. Respondents will be asked to run the "alfabeta" game application to find out its performance then respondents will be asked to answer the SEQ questionnaire questions.

RESULT AND DISCUSSION

System Analysis

Data obtained from interviews and observations are analyzed to determine system requirements. The results of the analysis are formulated into functional and non-functional system requirements. Table 1 shows functional requirements data and Table 2 shows non-functional requirements.

TABLE 1. Functional requirements

No	Description
1	The application can display the main menu
2	Application can show a close button
3	Applications can display the play menu (play)
4	The application can display the back button on the play menu (play)
5	The application can display a guessing menu
6	The word guessing menu application can display letter questions
7	The word guessing menu application can display vowel questions
8	The word guessing menu application can display consonant questions

TABLE 1. Cont.

No	Description
9	The guessing menu application can display some leaks about two syllables to proceed to the syllable menu
10	The application can display the material of the alphabet letters in the guessing game
11	The application can display points in the guessing game
12	Applications can display lives in guessing games
13	The application can display the time in the guessing game
14	The application can display the volume button to repeat the sound of the guessing game
15	The application can display the back button in the guessing game
16	The application can display the back button at the end of each guessing game
17	The application can display a syllable menu
18	The application can display questions about consonants + vowels
19	The application can display two-syllable letter questions
20	The application can display three-syllable questions
21	Application can display prefix and suffix letters (NG & NY)
22	Applications can display two-syllable material in syllable games
23	Application can display points on syllable games
24	Application can display life in syllable games
25	Application can display time on syllable games
26	Application can show a volume button to repeat syllable game sound
27	Application can display the back button on syllable games
28	The application can display the back button at the end of each syllable game
29	The application can display a guessing picture menu
30	Applications can display picture questions in picture guessing games
31	The application can display points in the guessing game
32	Applications can display lives in guessing games
33	The application can display the time in the guessing game
34	The application can display a question reply button in the guessing game
35	The application can display the back button in the guessing game
36	The application can display the back button at the end of the guessing game
37	The application can display the word install menu
38	The application can display points in the word plug game
39	The app can display the time on the word plug game
40	The application can display the volume button to repeat the sound of the word plug game
41	Application can display the back button on the word plug game
42	The application can display the back button at the end of each word plug game
43	The application can display the results of all points on the main menu of the reading game

TABLE 2. Non-functional requirements

No	Parameter	Description
1	Availability	Games can be accessed 24/7, meaning this application can be used every day for 24 hours.
2	Ergonomics	Game design has an interface that is easy for users to understand
3	Portability	The game runs on Android-based smartphones
4	Memory	The size of the game in this application is a maximum of 50 MB
5	Response time	The time this application responds on a smartphone is less than 10 seconds
6	Safety	No personal data requested by the app
7	Security	Safe
8	Communication	The game used provides one language, namely Indonesian

Design

Storyline

The storyline is created to provide an idea of how the game will run from start to finish. This storyline is shown in Figure 3 below.

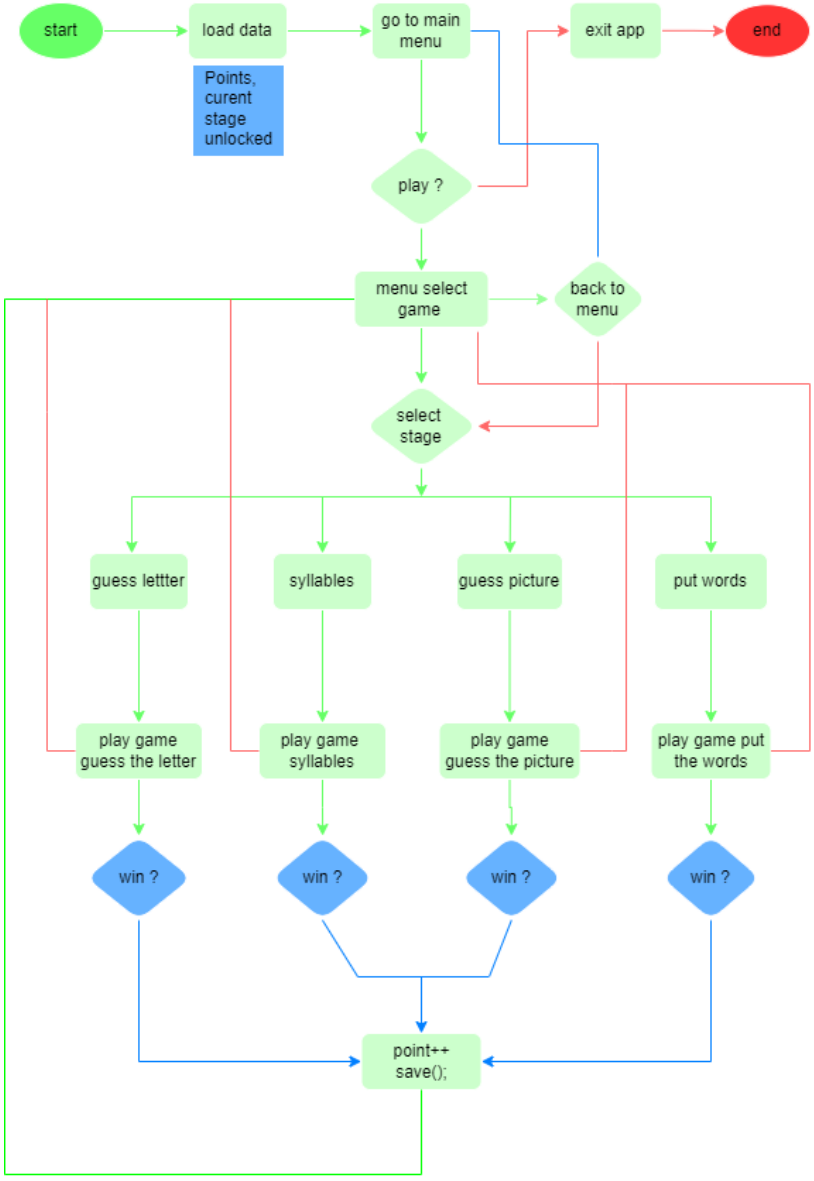

FIGURE 3. Storyline alfabeta game

Students (users) enter the reading application and see the main menu of the reading game, then select the play menu to see some of the available game menus. If students choose the first game level, which is guessing words, students will answer 30 questions consisting of choices of letters of the alphabet, vowels and consonants, and two syllables and guess words as leaks for the second game, namely syllables. If students choose the second game level, namely syllables, students will start pairing consonants and vowels, pairing two syllables, pairing three syllables, and pairing prefixes and endings (NG & NY). If the student chooses the third menu level, which is guessing the picture, the student will begin to match the correct letters for the name of the picture, and if the student chooses the last level,

the word pairs are perfect sentences that are scrambled and need to be rearranged. Students will start looking for words that have been scrambled by listening to the instructions from the questions.

Game Rule

Guess the word game:
1. Given three lives on each stage
2. Given 30 seconds for each question
3. If the question is answered with a time >= 24 seconds, then the points obtained are 100 points,
4. If the question is answered with a time >= 14 seconds, then the points obtained are 50 points,
5. If the question is answered with a time >= 1 second, then the points obtained are 10 points,
6. And life will be reduced if wrong in answering questions.
7. Points will be saved on the main menu page.

Syllable games:
1. Given three lives on each stage
2. Given 30 seconds for each question
3. If the question is answered with a time >= 24 seconds, then the points obtained are 100 points,
4. If the question is answered with a time >= 14 seconds, then the points obtained are 50 points,
5. If the question is answered with a time >= 1 second, then the points obtained are 10 points,
6. And life will be reduced if wrong in answering questions.
7. Points will be saved on the main menu page.

Guess the picture game:
1. Given three lives on each stage
2. Given 30 seconds for each question
3. If the question is answered with a time >= 24 seconds, then the points obtained are 100 points,
4. If the question is answered with a time >= 14 seconds, then the points obtained are 50 points,
5. If the question is answered with a time >= 1 second, then the points obtained are 10 points,
6. And life will be reduced if wrong in answering questions.
7. Points will be saved on the main menu page.

Word pairs game:
1. Given 20 seconds for each question
2. Each question is given 100 points
3. Game will be over if you don't solve the problem in less than 20 seconds
4. Points will be saved on the main menu page

Game Leveling

Based on the SAS method, which is based on structural linguistics: 1. Recognize that sentences consist of several words, words consist of several syllables, and syllables consist of several letters. 2. Children must recognize and move between two different structures (top-down and bottom-up approaches) to learn to read, so the arrangement of alphabet game levels is based on the bottom-up approach. This level starts from recognizing letters, consonants, and vowels, recognizing syllables, recognizing words, and composing sentences.

Basically, the play menu has four levels called:
1. Level 1, called guess the letters have an easy level of difficulty. Consists of 52 questions in 2 sessions.
- The questions start from the letters of the alphabet starting from questions 1 – 26 in session 1
- Vowels and consonants starting from questions 27 – 52 in session 2

2. Level 2, called syllable, has a fairly easy level of difficulty. Divided into five sessions, namely one syllable, two syllables, and three syllables, Ng, and NY
- Session 1 is one syllable. There are 125 combination questions between 21 consonants and five vowels.
- Session 2 is two syllables. There are 125 questions.
- Session 3 is three syllables. There are 50 questions
- Session 4, namely Ng. There are 50 questions.
- Session 5, namely Ny There are 50 questions.

3. Level 3 is called guess the picture has a difficult level of difficulty. Consists of 30 randomized picture guessing questions. The further the question level is up, the longer and more letters and pictures appear.
4. Level 4, called word pairs, has a very difficult level of difficulty. Consists of 30 questions that have been scrambled pairs of words. The further the level of the question, the more words that appear.

Storyboard

The storyboard is an image of the storyline of a game. Figure 4 is a storyboard of the game "alfabeta"

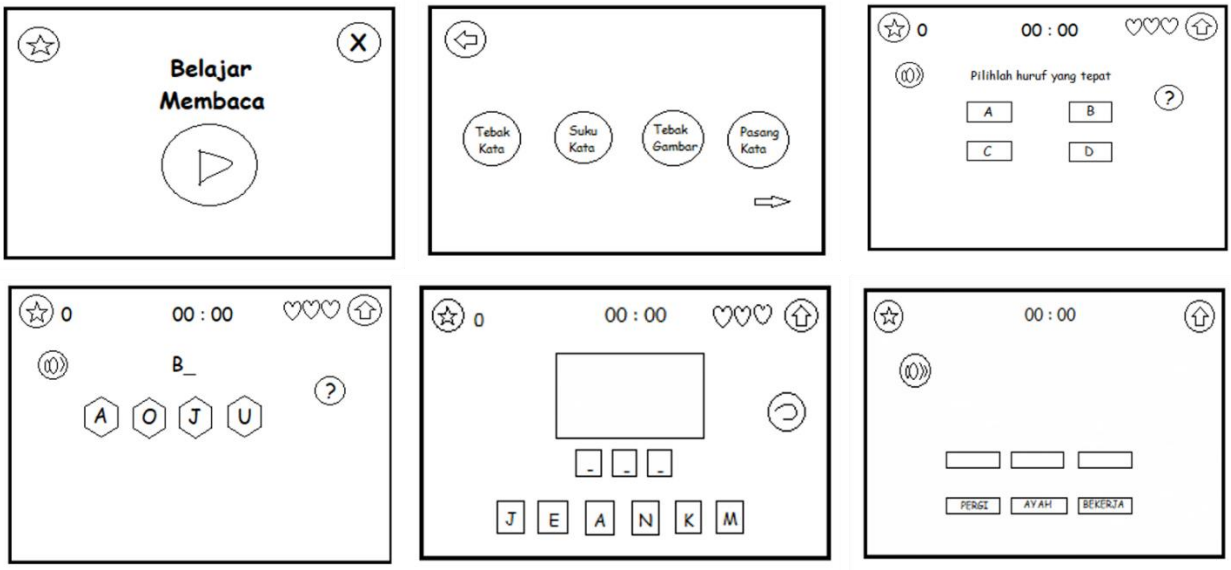

FIGURE 4. Storyboard "Alfabeta" game

Production

"Alfabeta" game applications are made by taking into account the designs that have been designed both visually and architecturally and game flow. Alphabeta game applications are made by preparing assets in advance, namely the necessary materials such as background images, button images, narration sounds, pronunciation sounds and so on. Image assets are created using an image processing application such as Adobe Photoshop, while sound assets are created using the Audacity application. After all the assets have been created, the next step is the programming stage. This stage is carried out to produce an "alfabeta" game application program. Build this Alphabeta application game, and it was made using the Unity software. The results of the "alfabeta" game application can be seen in Figure 5 below.

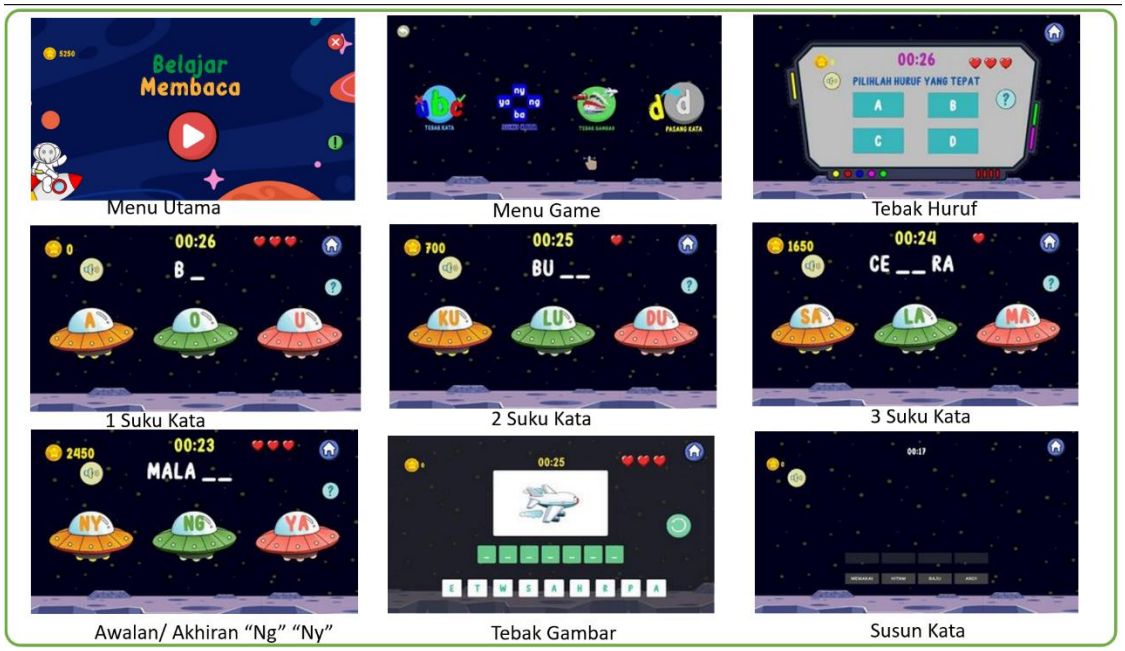

FIGURE 5. Screenshot of “Alfabeta” Game

Testing

Media quality testing was conducted to determine whether the Alphabeta game application has quality content and media as learning media that can be used to improve children's reading skills. This test is carried out by media experts by trying the application and then answering the questionnaire. The questionnaire was prepared by taking into account the content and media quality indicators with 35 questions. The media quality test was carried out by three media experts. The test results get a score of 4.52 on a scale of 5. The test results data are presented in table 3 below.

TABLE 3. Media quality test results

Questions	Respondent's assessment (3 people)						
	1	2	3	4	5	total	Average
P1	0	0	1	0	2	13	4,33
P2	0	0	0	1	2	14	4,67
P3	0	0	1	1	1	12	4,00
P4	0	0	0	2	1	13	4,33
P5	0	0	0	0	3	15	5,00
P6	0	0	1	0	2	13	4,33
P7	0	0	0	3	0	12	4,00
P8	0	1	0	1	1	11	3,67
P9	0	0	0	0	3	15	5,00
P10	0	0	0	0	3	15	5,00
P11	0	0	0	0	3	15	5,00
P12	0	0	1	1	1	12	4,00
P13	0	0	2	1	0	10	3,33
P14	0	0	0	1	2	14	4,67
P15	0	0	0	1	2	14	4,67
P16	0	0	0	0	3	15	5,00
P17	0	0	0	2	1	13	4,33

TABLE 3. Cont.

Questions	Respondent's assessment (3 people)						
	1	**2**	**3**	**4**	**5**	**total**	**Average**
P18	0	0	0	3	0	12	4,00
P19	0	0	0	1	2	14	4,67
P20	0	1	0	1	1	11	3,67
P21	0	0	1	0	2	13	4,33
P22	0	0	0	1	2	14	4,67
P23	0	0	0	0	3	15	5,00
P24	0	0	0	1	2	14	4,67
P25	0	0	0	1	2	14	4,67
P26	0	0	1	0	2	13	4,33
P27	0	0	0	1	2	14	4,67
P28	0	0	0	1	2	14	4,67
P29	0	0	0	0	3	15	5,00
P30	0	0	0	0	3	15	5,00
P31	0	0	0	1	2	14	4,67
P32	0	0	0	0	3	15	5,00
P33	0	0	0	0	3	15	5,00
P34	0	0	1	0	2	13	4,33
P35	0	0	0	1	2	14	4,67
Total							**158,33**
Average							**4,52**

The test results show that this alphabet game application has very good quality as a learning medium to improve children's reading skills. The 35 questions in Table 2 are 21 questions regarding material aspects and 14 regarding media. In the material aspect, the results of this score show that the "alphabeta" game application has appropriate and adequate material coverage for learning to read. Learning content can be adjusted to students' conditions and ability levels. In the media aspect, the score results show that the "alphabeta" game application has very good quality in appearance, color combination, text clarity, button consistency, sound clarity, and other media aspects. Based on the results of media quality testing, game content design using the SAS strategy has produced game applications that are suitable as educational media to improve children's reading skills.

Betha Testing

This test was conducted by ten respondents. Testing with SEQ is an early and frequent measure of user attitudes and can indicate likely future behavior. This measurement is carried out by giving tasks to the user regarding what must be done. In this test, there are 43 tasks that respondents must carry out. After completing the task, respondents will be asked for their opinions regarding ease in carrying out the task. This level of ease is assessed with a range of 1 to 7. 1 indicates the difficulty level, while 7 indicates ease. The results of this test are presented in table 4.

TABLE 4. SEQ test results

Task	Respondent's assessment (10 people)								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Average**
T1	0	0	0	0	0	1	9	69	6,9
T2	0	0	0	0	0	1	9	69	6,9
T3	0	0	0	0	0	0	10	70	7
T4	0	0	0	0	0	2	8	68	6,8
T5	0	0	0	0	0	1	9	69	6,9
T6	0	0	0	1	2	3	4	60	6

TABLE 4. Cont.

Task	Respondent's assessment (10 people)								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**	**Average**
T7	0	0	0	1	0	5	4	62	6,2
T8	0	0	0	3	0	3	4	58	5,8
T9	0	0	0	0	0	3	7	67	6,7
T10	0	0	0	0	0	2	8	68	6,8
T11	0	0	0	1	0	1	8	66	6,6
T12	0	0	0	0	1	3	6	65	6,5
T13	0	0	0	0	1	2	7	66	6,6
T14	0	0	0	0	0	3	7	67	6,7
T15	0	0	0	0	0	3	7	67	6,7
T16	0	0	0	0	0	2	8	68	6,8
T17	0	1	0	2	0	3	4	56	5,6
T18	0	0	0	0	3	5	2	59	5,9
T19	0	1	0	0	2	6	1	55	5,5
T20	0	0	0	1	3	3	3	58	5,8
T21	0	0	0	0	0	0	10	70	7
T22	0	0	0	0	0	0	10	70	7
T23	0	0	0	0	0	1	9	69	6,9
T24	0	0	0	0	1	2	7	66	6,6
T25	0	0	0	0	0	1	9	69	6,9
T26	0	0	0	0	0	3	7	67	6,7
T27	0	0	0	0	1	3	6	65	6,5
T28	0	0	0	0	1	1	8	67	6,7
T29	0	1	1	1	0	3	4	55	5,5
T30	0	0	0	0	0	1	9	69	6,9
T31	0	0	0	0	0	2	8	68	6,8
T32	0	0	0	0	1	1	8	67	6,7
T33	0	0	0	1	0	0	9	67	6,7
T34	0	0	0	0	0	1	9	69	6,9
T35	0	0	0	0	0	1	9	69	6,9
T36	1	2	1	0	0	4	2	46	4,6
T37	0	1	0	1	0	6	2	56	5,6
T38	0	1	1	2	0	4	2	51	5,1
T39	0	0	0	0	0	6	4	64	6,4
T40	0	0	2	0	0	5	3	57	5,7
T41	1	0	0	0	0	2	7	62	6,2
T42	0	0	0	0	0	0	10	70	7
T43	0	0	0	0	0	0	10	70	7
Total									**277**
Average									**6,44**

Based on the results of the SEQ test in table 3, the "alfabeta" game scored 6.44 out of a scale of 7. The score from this test can be related to predicted completion rates and task times from SEQ scores. The score of 6.44 from this test, when combined with predicted completion rates and task times from SEQ scores, has a completion score level of 90,5% with a task completion time of 1.3 minutes, as shown in Figure 6.

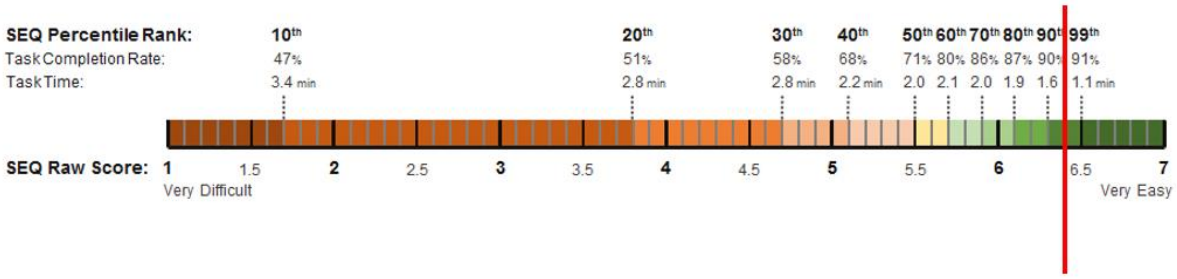

FIGURE 6. Relationship between SEQ scores, completion rates, and task times

The SEQ test results data in Table 4 and Figure 6 show that the alphabet game application is very easy for children to use. The success of developing this alphabet game is in line with previous research where the development of this educational game must pay attention to gameplay and storyline factors [33-35]. The preparation of the gameplay and storyline in developing this "alfabeta" game adopted the SAS strategy with a bottom-up approach, starting from recognizing letters, consonants, and vowels, recognizing syllables, recognizing words, and composing sentences.

CONCLUSION

"Alfabeta" game development using the SAS method supports the reconstruction of games that have systematic and structured content so that they are easy to use and make the level of the game in accordance with the user's learning achievement ability which continues to increase. This "alfabeta" game has been successfully developed with a score of 6.44 out of a scale of 7, which means it is very easy to use based on the beta test.

ACKNOWLEDGMENTS

Thank you to the National Research and Innovation Agency of the Ministry of Education and Culture of the Republic of Indonesia for funding this research.

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