The development of educational game-based learning media in natural science subject for elementary school students

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ABSTRACT

This research is based on the lack of innovative learning media that is easily accessible and suitable for the characteristics of students. This research aims to produce a learning media in the form of science learning educational games aimed at fifth-grade elementary school students. This educational game was developed using Construct2. This type of research is research and development (RnD) with the 4D development model (Define, Design, Develop and Disseminate). This educational game validation was obtained from media experts consisting of lecturers, practitioners, and teachers whose fields correspond to the media being developed. The questionnaire distributed to media experts obtained an average value of 0.97 which was categorized as valid. This educational game was also tested on users consisting of 21 fifth grade elementary school students, and obtained an average score of 94.15 in the very good category, this indicates that the science learning educational game for elementary school children is also very suitable for grade students. V elementary school which is evident from the assessment of grade V elementary school students who stated that this media was very good.

INTRODUCTION

Education cannot be separated from the role of innovative learning media. The learning media used must be learning media following students' characteristics. Learning media that are by the characteristics of students will undoubtedly attract more students to take lessons. The use of appropriate media can lead to learning experiences not only limited to the sense of sight but also the sense of hearing so that it can increase students' understanding and will affect learning outcomes for the better (Fridayanti et al., 2022). Learning media is also very helpful for children's psychological development and can provide different learning experiences (Nurfadhillah, 2021).

Some of the reasons why learning media are beneficial in the psychological development of children are: (1) Attract children's attention: Learning media such as images, videos, and animations can make children more interested and more focused on the subject matter being studied. It can help children to understand the material and absorb information better and more efficiently (Hellyana et al., 2023); (2) Increase interest in learning: Engaging and interactive learning media can help increase

children's interest in learning. By actively involving children in learning, for example, by assigning challenging tasks or questions, children become more motivated to learn (Aditama et al., 2022); and (3) Increase Learning Motivation: Motivation is one of the most significant aspects of education in any field that learners desperately need to learn is motivation (Moradi & Noor, 2022). Engaging and interactive learning media can also increase students' confidence and motivation. Students who successfully understand complex concepts through learning media will feel more confident and motivated to continue learning.

Nowadays, there are many kinds of learning media available. Increasingly advanced information Technology certainly has a critical role in this development. Of the many types of learning media public, not all meet the needs of the teaching and learning process. The media is used only as a tool, and the students are only spectators of the media used by the teacher (Cahdriyana & Richardo, 2016).

One of the learning media that is developing today is educational games. Educational games are games that are combined with learning materials. Games have positive functions and benefits for children, including getting to know computer technology, lessons to follow directions and rules, problem-solving exercises and logic, training motor nerves and spatial skills, establishing child-parent communication when playing together, and providing entertainment. Educational games have several advantages that are suitable to be applied to elementary school students because games allow active participation from students, which can increase learning motivation (Sutarman et al., 2022). On the other hand, games certainly also harm children.

The negative impact of games is the onset of addiction to games. Addiction to games can result in children not being motivated to learn and lacking interaction with peers because they prefer gaming activities; activeness also helps parents because they like to play the internet, especially online games (Arianto & Bahfiarti, 2020). In addition to the negative impact, games certainly also have a positive effect. In addition to the negative consequences, of course, games also have a positive effect because children can still be controlled, with time they can still be divided for studying, eating, and other activities such as additional tutoring as well because the parents themselves also always supervise their children while playing (Sihaloho et al., 2020). Educational Games are as functional as other learning media. Educational games foster student learning motivation, make it easier for students to understand learning, and make teaching methods more varied so that students focus more on learning activities (Darmawati et al., 2021).

The world of education should take the positive side of the impact of games on this child. Learning media packaged in games will undoubtedly attract children's interest. The display of learning media in games will stimulate children's thinking power, increase concentration, and solve problems (Nuqisari & Sudarmilah, 2019). Playing games can develop brain abilities related to cognitive or logic-mathematical intelligence such as the ability to calculate, think logically, and solve problems. Games can help children learn if their play can be controlled or limited to ≤ 3 hours daily (Manggena et al., 2017).

Important educational games are developed for students aged 7 – 11 years. This educational game can be an alternative learning medium to attract students' interest. Presenting innovative learning media utilizing computer technology is one of the weaknesses of teachers in elementary schools. Educational background and lack of time hinder elementary school teachers from developing innovative learning media.

Developing learning media in the form of educational games can be built using Construct2. Construct2 is a game creator created by Scirra, one of the software game developers are interested in because Construct2 is easy to use and has many tutorials and templates available. Android is one of the Construct2 devices using HTML5 (Damayanti et al., 2020). Construct2 can be downloaded for free with limited scenes and features, making the game not accessible but different from those licensed to have more scenes and features.

This study contributes to producing a learning media for Natural Science Education Games. This educational game developed is expected to help teachers in delivering material and assist students in understanding science material. This game is built using Construct 2. The material used

in this media is sourced from the Integrated Tematik Terpadu Kurikulum 2013 Tema 4 untuk Kelas V SD/MI book.

METHOD

The type of research used in this study is the 4D Version of Research and Development (R&D). Thiagarajan developed the research stage of 4D model development. This 4D model consists of Define, Design, Develop, and Disseminate. According to Fadilla (2021), the activities carried out at each stage of the development of the 4D Version can be described in Figure 1. (Fadila et al., 2021).

Figure 1. Research and Development Version 4D

The first stage of this 4D Model is the defining (define) stage. At the defining stage, the steps are problem determination, needs analysis, and material analysis. The second stage is the design stage, which compiles learning materials and designs the initial form of educational games. The third stage is development, an activity to make educational games and conduct validation tests. The fourth stage is the dissemination stage which is carried out to promote the development product to be accepted by users (Kurniawan & Dewi, 2017; Musril et al., 2020).

The methods used in collecting research data are observation, interviews, and questionnaires. Observation and interview methods are used to extract information about obstacles and problems teachers and students face in science learning. The questionnaire method is used to ask respondents questions to determine the validity of science learning educational games.

Questionnaires are made by understanding the concepts and variables to be measured to ensure the validity of media and materials. Two questionnaires are used in this research and development: validation questionnaires and student response questionnaires. Validation questionnaires were given to experts in the IT field consisting of lecturers, teachers, and practitioners. In contrast, the student response questionnaire was distributed to SDN 13 Sungai Sariak grade V students, Baso District, Agam Regency. The experts who filled out the validation questionnaire were 11 people, and the number of students who filled out the questionnaire was 21 people.

Validation questionnaires are used to measure the feasibility of a medium (Efriyanti et al., 2021). The validity test is carried out by referring to the statistical formula Aiken's V, as seen in Formula 1. The Aiken formula validity determination category states that a product is valid if it has a range of Aiken's V values from 0.60 –1.00 and invalid if Aiken's value is small from 0.60. (Aiken, 1985).

$$V=\sum s/[n(c-1).........[\text{Aiken"s V}] \qquad (1)$$

S is r – lo where lo is low validity research figure and c is the highest validity research figures. R is the number that an assessment gives and n is the number of appraisers, R i.

$$K = \frac{F}{N \ x \ I \ x \ R} \ x \ 100\% \qquad (2)$$

To find out the percentage of eligibility for each indicator assessed by students, it can be seen in Formula 2. K is the percentage of eligibility criteria, and F is the total number of respondents' answers. N is the highest score in the questionnaire, I is the number of questions in the questionnaire, and R is the number of respondents. (Febrianti et al., 2021).

The percentage of student response questionnaire data obtained was calculated using the Guttman scale. The analysis results will draw conclusions about students' opinions on the Science Learning Education Game using the Likert scale with criteria seen in Table 1.

Table 1. Criteria for Assessing Data on Percentage of Student Response

Percentage (%)	Criteria
0 – 20	Poor
21 – 40	Bad
41 – 60	Good Enough
61 – 80	Good
81 – 100	Very Good

RESULTS AND DISCUSSION

Results

Research and Development of Educational Game Learning Media for Elementary School Age Children using the 4D Version of Research & Development (R&D) Type. There are 4 (four) stages in this research, namely Define, Design, Develop and Disseminate. The first stage of the study is Define.

At the Define stage, a needs analysis is conducted by interviews with fifth grade elementary school students and teachers who teach in elementary schools. From the interview results, it can be concluded that children of grade V elementary age are very interested in games. They are also curious if the learning media used is in the form of educational games. Another piece of information obtained from the interview is a book used as a learning resource for grade V elementary school children. Grade V elementary school children use *Tematik Terpadu Kurikulum 2013 Revisi tahun 2017* book. During the interview, the learning process uses the book Theme 4. In the Integrated Thematic book, the 2013 Curriculum consists of 4 sub-themes, namely Sub Theme 1 *Peredaran Darahku Sehat*, Sub Theme 2 *Gangguan Kesehatan pada Organ Peredaran Darah*, Sub Theme 3 *Cara Memelihara Organ Peredaran Darah Manusia*, and sub-Theme 4 *Kegiatan Berbasis Proyek dan Literasi* (Subekti, 2017).

The second stage of design is by compiling media and material product specifications. The material is prepared based on the *Tematik Terpadu Kurikulum 2013 Revisi 2017* book Theme 4. At this stage, it is determined how many slides each theme will be displayed in the Science Education Game, and chose the number of questions for each theme that will be displayed in the game. At the Design stage, a design was determined to be used as a reference in developing science educational games. The design model of the science education game was created using Use Case Diagrams and Activity Diagrams.

A use case diagram is a diagram that describes the interaction between users and the application system. The system's functionality is illustrated using a use case diagram (Damayanti et al., 2020). The design of the use case diagram of this Science Education Game is shown in Figure 2.

From the use case diagram in Figure 2 above, users can turn on and off music in the game, see instructions for using the game, open the About page, open the learning menu and game menu, and close the application. Users can open the learning menu sub-theme 1, learning menu sub-theme 2, learning menu sub-theme 3, and learning menu sub-theme 4. The four menus can be accessed after opening the study menu. After opening the game menu, users can also display the Sub Theme 1 Game Menu, Sub Theme 2 Game Menu, Sub Theme 3 Game Menu and Sub Theme 4 Game Menu.

Describing the workflow or process activities of the Science Learning Education Game are depicted as an activity diagram. The designed activity diagram consists of 2 parts: the learning menu activity diagram and the game menu activity diagram. The learning menu activity diagram can be seen in Figure 3.

The activity diagram of the learning menu draws user activities using the Science Learning Education Game. The activity starts from accessing the game, then the system will display the Learning Menu Theme 1,2,3 and 4. Then the user clicks on the Theme 1,2,3 and 4 menus and the system will display a learning menu per theme. Then the user plays the game to view the material and the system will display the material.
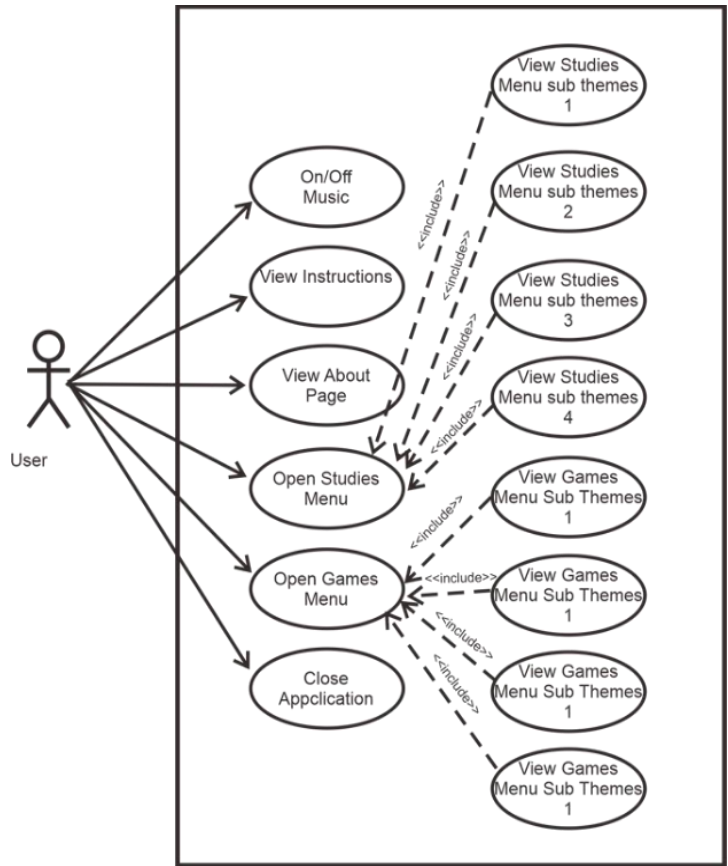
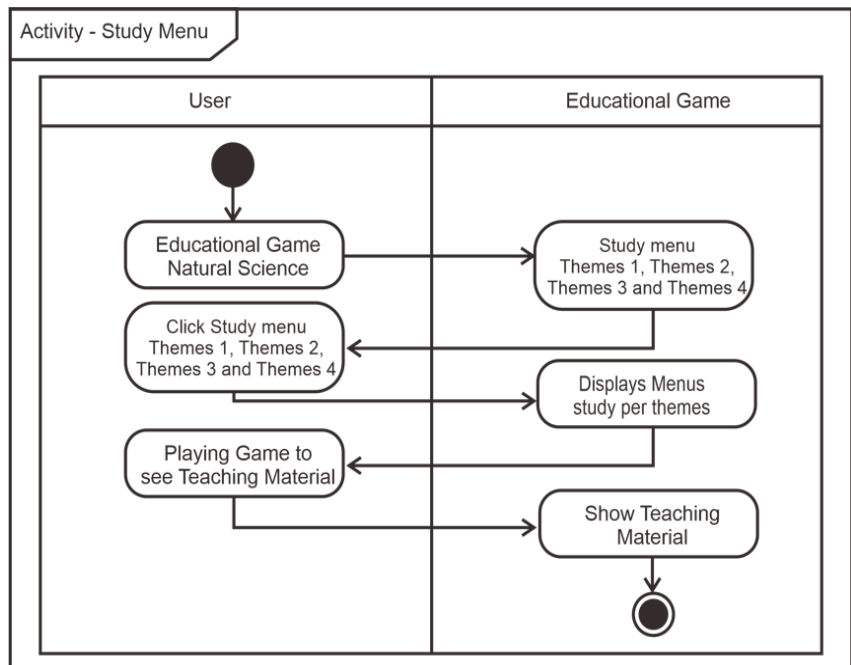Figure 2. Use Case Diagram of Science Education Game

Figure 3. Learning Menu Diagram Activity

The activity diagram of the game menu illustrates the user's workflow in opening the game menu. User activities differ significantly from those in the Activity Diagram Learning menu. Activity Diagram of the game menu can be seen in Figure 4.
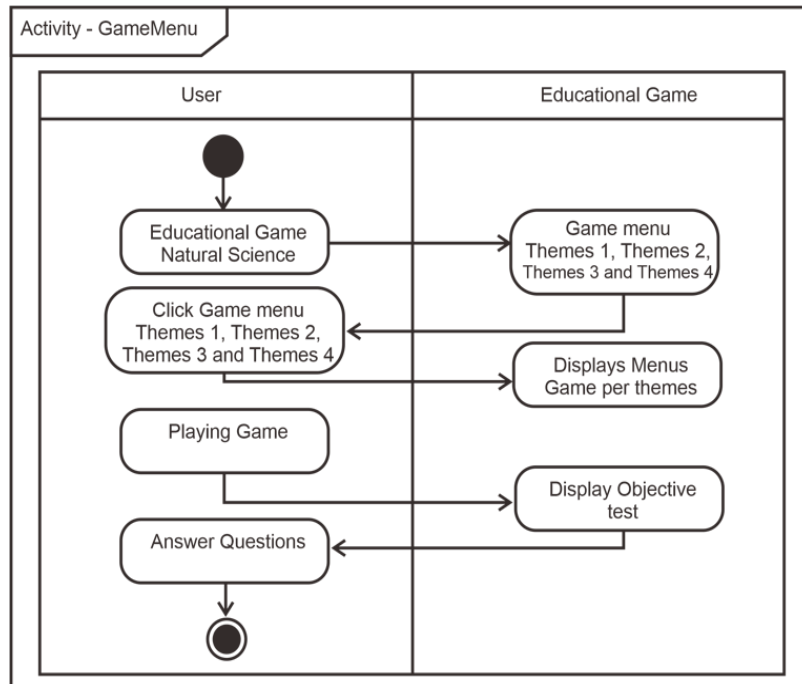
Figure 4. Activity Diagram Learning Menu

The third stage of Develop is done by developing a game using Construct 2. The slides and questions displayed in the game are designed using Adobe Photoshop and saved in *.png format. Slides and questions already in .png format are imported into Construct 2 and arranged according to their themes. The development of this science learning educational game produced a game with HTML 5 format. The HTML 5 format of this science learning educational game can be opened offline and online. Offline games can be activated through a local host by first activating the local web server software Xampp version 3.3.0. The results educational game can be seen in Figure 5.
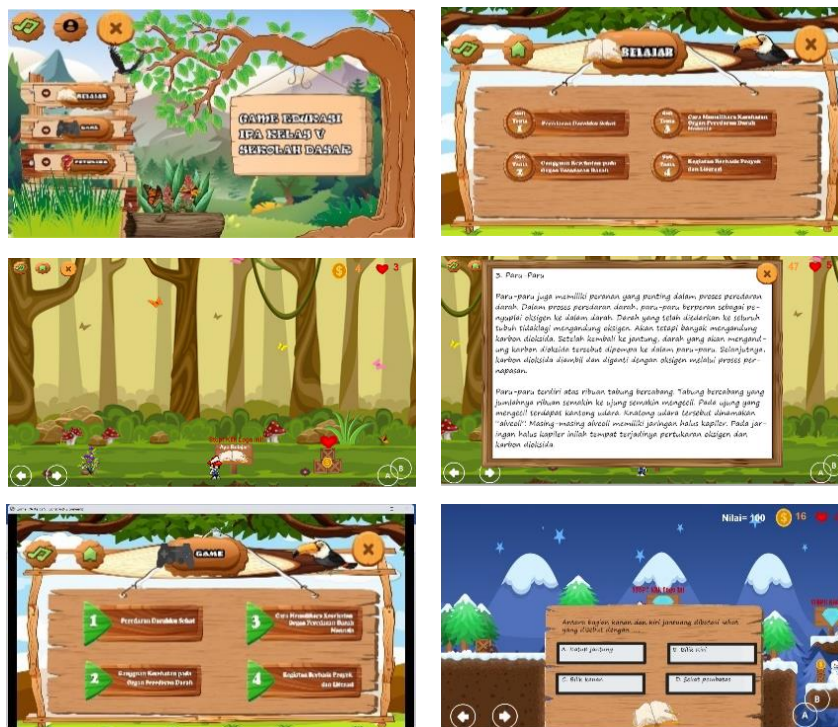

Figure 5. Display of Science Learning Educational Games

Figure 5 illustrates the appearance of the main menu, the display of subject matter, the game menu, and the display of learning evaluation questions. The main menu has 6 (six) buttons that users can use. Music button, about button, close button, Learn button, game button, and hint button. Material that learns science Sub-theme 1, sub-theme 2, sub-theme 3, and sub-theme 4 can be displayed after pressing the learning button. The game button contains evaluation questions from sub-theme 1, sub-theme 2, sub-theme 3, and 4.

The learning menu of this science learning educational game has four menus, each for sub-theme 1, sub-theme 2, sub-theme 3, and sub-theme 4. In addition, it also features a button to turn on/off the music, a home button to return to the main menu, and a close button to close the game.

Learning sub-theme 1 display, the user must move the player forward, backward, or jump to pass the existing challenges. If the player reaches the Let's Learn icon, the user can click on the icon to display the subject matter.

The game menu activates the learning evaluation game for each sub-theme. The user continues to play in the game as in the learning menu. The user must move the player forward, backward, or jump to reach the diamond icon. An objective test question matches each theme if the diamond icon is clicked.

A media validation process is carried out before entering the fourth research stage or dissemination stage. Media validation involves validation from media experts and grade V elementary school students. Eleven experts validate this media, and the results of expert validation are as follows in Table 2.

Table 2. Media Expert Validation Results

No.	Aspect	Average	Category
1	Game name appears in the intro section	0.96	Valid
2	Game Audio can be active or inactive	0.98	Valid
3	Displays game creator information	0.95	Valid
4	Exit the game application	0.87	Valid
5	Displays the Study Menu	0.98	Valid
6	Displays the Game Menu	0.96	Valid
7	Displays the game guide page	0.93	Valid
8	Displays the learning menu to learn Sub-theme 1	1.00	Valid
9	Displays the learning menu to learn Sub-theme 2	0.98	Valid
10	Displays the learning menu to learn Sub-theme 3	1.00	Valid
11	Displays the learning menu to learn Sub-themes 4	0.98	Valid
12	Displays the sub-theme game menu 1	1.00	Valid
13	Displays the sub-theme game menu 2	0.98	Valid
14	Displays the sub-theme game menu 3	1.00	Valid
15	Displays the sub-theme game menu 4	1.00	Valid
16	Players in the learning sub-theme move in the direction of the arrow	0.98	Valid
17	The subject matter appears in the learning sub-theme	0.95	Valid
18	The player in the game moves in the direction of the arrow	0.98	Valid
19	Objective Test appears in the Game sub-theme	1.00	Valid
Average		**0.97**	**Valid**

Based on the validation results from 11 experts, it can be concluded that the science learning educational game is valid with a validation value of 0.97. Furthermore, validation was carried out to users consisting of 21 grade V students of SDN 13 Sungai Sariak, Baso District, Agam Regency. Of the 21 respondents who conducted the game trial, the following results were obtained in Table 3.

Table 3. User Validation Results

No.	Aspect	Avg	Category
1	Are Educational Games Easily Accessible	95.24	Very good
2	Educational Games can be used without the guidance of another person	88.57	Very good
3	Educational Games can be accessed anytime and anywhere	93.33	Very good
4	Clarity of instructions in the use of educational games	93.33	Very good
5	Educational Games can be used over and over again	96.19	Very good
6	Educational Games have an attractive appearance	93.33	Very good
7	Educational Game Display Makes it easy for students to play games	95.24	Very good
8	Educational Games make learning more fun	98.10	Very good
9	Educational Games are equipped with tasks	93.33	Very good
10	Educational Games make it easier for students to understand the subject matter	95.24	Very good
Average		**94.19**	**Very good**

Based on users' test results, the test results of educational games for learning science are very good, with an average score of 94.19. The fourth stage of Disseminate is deployment. The spread of this educational game is carried out in 2 ways, namely online and offline. Online game dissemination is carried out by uploading the game to www.itch.io site. Educational games to learn science can be accessed through the address https://riri-okra.itch.io/game-edukasi-ipa. Offline deployment is carried out by copying a copy of the game to the teacher's laptop to be displayed during the learning activity.

Discussion

This science learning educational game is developed in 4 stages: define, design, develop and disseminate. At the define stage, literature studies and field surveys are carried out. The learning materials for grade V elementary school students are sourced from the 2013 Revised 2017 Curriculum Integrated Thematic book for grade V elementary school. Researchers conduct student analysis to find out the needs of students and analyze media that matches the characteristics of students. Grade V elementary school children or children aged 7-11 years enter the concrete operational stage. At this stage, children begin to understand abstract concepts and develop the ability to think logically (Rawi et al., 2023). The child at this stage of concrete operations tends to be more interested in concrete and tangible activities, such as manipulating physical objects, drawing, and counting. Thus, using concrete educational games that can stimulate logic and problem-solving skills can help children at this stage learn more effectively and have fun (Kusuma et al., 2022).

At the material design stage, obtained from the 2013 Revised 2017 Curriculum Integrated Thematic book for grade V elementary school began to be compiled into a collection of materials using Adobe Photoshop CS6. Game modeling is designed using use case diagrams and activity diagrams. Use case diagrams illustrate the interaction between one or more actors and the information system to be created (Ester, 2023). Use case diagrams are very suitable to demonstrate user interaction and each part of this science learning educational game. An activity Diagram illustrates user activities in learning menus, sub-menus, and menus in science learning educational games (Voutama, 2022). Activity Diagrams define a system's dynamic structure (behavior) by describing a workflow or process's activities, choices, interactions, and concurrency. The main advantage of the activity diagram is its simplicity and ease of understanding the logical flow of the modeled system (Rahmoune & Chaoui, 2022). The activity diagram will illustrate students' activities using this science learning educational game.

At the development stage, all material summarized and stored in .jpeg format is used to build games using Construct 2—development of educational games to learn science using Unified Modeling Language modeling. Unified Modeling Language (UML) is a standard modeling language used to describe and document software design, including games (Jurgelaitis et al., 2019). UML has

eight diagrams: Use Case Diagram, Class Diagram, State Diagram, Sequence Diagram, Collaboration Diagram, Activity Diagram, Component Diagram, and Deployment Diagram. The development of this science learning educational game uses two diagrams: Use case diagrams and Activity Diagrams. In game development with UML, UML is used as a tool to design and organize game structures by describing elements in the game, such as classes, objects, state machines, use cases, and sequence diagrams. Good game design with UML can help the game development team estimate the critical resource needs and ensure that the necessary game features are included.

The validity test of media experts and material experts determines the feasibility of this science-learning educational game. Validation is an assessment activity of the media to prove that the media is worthy of its use (Hidayat & Mulyawati, 2022). The validation result from experts on this educational learning game is 0.97. User validation was done by testing the game on 21 grade V students of SDN 13 Sungai Sariak, Baso District, Agam Regency. The user validation test got an average score of 94.19.

CONCLUSION

This science learning educational game developed using Construct2 has met the demands and needs of students. This science-teaching educational game has also completed the feasibility of media display and material, as shown by the results of expert testing with a value of 0.97, which means it is very valid. This science learning educational game can be operated online or offline and accessed using laptops and smartphones. This science teaching educational game can be well received by grade V elementary school students, as shown by the results of user examiners who get 94.19. This science learning educational game can arouse students' embeds in learning science.

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