Development of Innovative Learning Media Educational Game Periodic Chemistry Based on Scramble for Class X SMA Students

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Abstract. Chemistry is one of the subjects that is quite difficult for students to accept, especially in the introduction to the periodic table of elements, which are not small in number. So there is a need to develop interactive learning media to increase students' interest in learning. This study aims to create an educational game learning media based on the Scramble game that students can use to understand chemistry subjects, especially in introducing the chemical periodic table. The development method used is the Research and Development (R&D) method with a 4D development model (Define, Design, Develop, and Disseminate). In the testing phase, several data were obtained: validation by four experts, including validation by media experts & material experts, and questionnaires by 6 Class X high school students as respondents. Instrumentation validation is calculated using the System Usability Scale (SUS) instrument testing. The calculation of the data for filling out the questionnaire got good results, which means that the learning media of Scramble-based educational games with the introduction of the chemical periodic table material is very appropriate and can be easily understood by students. The calculation results show that making a Scramble-based educational game learning media about the chemical periodic table in Chemistry subjects at SMA Muhammadiyah 1 Surakarta is appropriate and feasible to be used as a learning medium.

Keywords: Educational Games · Learning Media · Scramble

1 Introduction

One of the problems often faced in the learning process is the limited support for learning media, teaching materials, and others that can help realize interactive learning [1]. Learning media is complementary tool teachers need to interact with students [2]. The purpose of using learning media lies in the essential competencies and indicators to be achieved, the domain of student development (cognitive, affective, & psychomotor), and the emphasis on using sensory stimuli [3]. This is under the statement [4] that utilizing learning media in the teaching and learning process can help foster student interest and motivation to learn. It can even have a psychological effect on students.

M. H. Hikmat et al. (Eds.): ICOLAE 2022, ASSEHR 757, pp. 1991–2008, 2023.
https://doi.org/10.2991/978-2-38476-086-2_160

Teachers can use learning media as a form of means of supporting creativity, namely by using game media or games. The game is an interaction between players following the rules set to achieve specific goals [5]. Various types of learning media can be used as a vehicle for teacher creativity in realizing interactive learning, so the selection of media types must also be adjusted to achieve learning objectives optimally [5].

Chemistry is a branch of natural science that is very complex from the many existing natural sciences. Chemistry consists of organic and inorganic chemistry, food science, medical science, biochemistry, and others [6]. The existence of in-depth knowledge of the chemical elements contained in everyday life is the basis for mastering these branches of chemistry [6]. Lessons on chemistry were first introduced when entering high school (SMA) grade 10, which began with an introduction to the basics of chemistry. However, the current learning process is still focused on teacher-centered, textbook-oriented, and teachers who still use improvised learning media, making it less effective and students find it challenging to explore in understanding the material [4].

In the current learning process, there are still many teachers who tend to use still learning methods that are only teacher-centered, thereby reducing student interest in learning and making students bored quickly in the teaching and learning process [7]. Factors that can cause a decrease in students' interest in learning in the learning process, especially in learning chemistry, are teachers who do not develop learning models and only explain without using interactive learning models [8].

According to Novianti et al. [9], The lack of interest in student learning in chemistry subjects resulted in a decrease in student learning outcomes. So, the influence of student interest in learning is very influential in student achievement. Most students who have a negative perspective on chemistry lessons tend to have no interest in problems involving chemistry. Students interested in a particular subject will give greater attention to the subject so that if the subject matter provided is outside the interests of students, it will result in students not learning well. It is this perception and sense of disinterest that results in a decrease in students' willingness to study chemistry.

Scramble game learning is a cooperative learning model that invites students to look for answers to questions or arrange letters randomly to form a correct answer [10]. Scramble is a translation from English that means struggle, struggle, or struggle. In the scramble learning model, students are required to find answers from an available clue, including arranging scrambled letters to form an answer word [11]. The Scramble learning model is very suitable for introduction to the periodic table of chemical compound element names [11]. Students are trained to arrange the names of chemical elements on the periodic table. Students will be given an easy way to guess the chemical element's name by arranging the letters that are scrambled on the scramble board.

According to Kurnia et al., [11], This learning model is also referred to as a learning process while playing because it requires thinking and focusing students in solving problems in games. Therefore, this learning model can foster enthusiasm, as evidenced by students' achievements in improving learning outcomes. According to Robert B. Taylor, as quoted by Miftahul Huda, one of the learning methods that can improve students' concentration and speed of thinking is using the Scramble model [12].

Research on learning models with the Scramble game that has been carried out by [13] has succeeded in improving the chemistry learning outcomes of class XI DG 1 students

at SMK Negeri 1 Pallangga Kab. Gowa on colloidal system materials. Moreover, it has also been supported by research conducted by [14], which also applies the Scramble game learning model by utilizing video media for sixth-grade students. In this study, the learning outcomes obtained by students in classes that apply Scramble learning are higher than students who follow conventional classroom learning. Based on the background stated above, the researcher is interested in developing a scramble-based educational game media innovation learning chemistry periodic table for students of SMA Muhammadiyah 1 Surakarta Class X.

This study aimed to develop an educational game based on Scramble on the Periodic Table of Chemical Elements in Chemistry subjects and to determine the feasibility of the Scramble learning media on the material of the Periodic Table of Chemical Elements.

2 Methodology Study

2.1 Research and Development (R&D) Methods

According to [15], the Research and Development (R&D) research method is used to test a product's effectiveness and produce a particular product. This research method is carried out intentionally and systematically to find, develop, produce, and even test the effectiveness of a product, model, or method/strategy that is superior, new, efficient, and meaningful. Based on the definition stated above, the Research and Development (R & D) method is used to produce a particular product and test its effectiveness of a particular product which is carried out systematically.

2.2 Data Collection Techniques

According to [15], the data collection technique is critical because it aims to obtain accurate data that produces valuable information.

Interview Technique. Interview technique is a series of data collection carried out directly through communication between investigators and respondents. This interview was conducted with SMA Muhammadiyah 1 Surakarta teacher who teaches Chemistry. The interview was conducted on November 8, 2022. The essence of the interview is about what learning media are used and the obstacles in the learning process.

Observation. Observation is a data collection technique carried out by direct observation to get to know the physical environment of the research subject [16]. Researchers conducted direct observations of how SMA Muhammadiyah 1 Surakarta teachers used the learning model and learning media. Observations were made on November 8, 2022.

From the results of interviews and observations, it is necessary to add learning models that utilize technology to realize interactive learning to increase student interest in learning.

Documentation. Documentation, a technique carried out by recording, documenting events, or collecting monumental works from someone, is also known as a technique of recording events that have occurred [15]. The document generated from this data collection technique contains materials taken from the teachers of SMA Muhammadiyah 1 Surakarta, which will be developed into an interactive learning media form.

2.3 Development Model

This study uses a 4D model (Define, Design, Develop, Disseminate) (Fig. 1).

The stages in the 4D method include the following:

Define. At this stage, the researcher analyzes the needs, analyzes the research, and collects information on the learning media used.

Design. The following stage, designs, begins with selecting appropriate designs for the subject's theme and topic of infographics, then illustrated using flowcharts and interface designs. In this study, the author uses Canva Pro to create image designs for the developed application.

Develop. The next stage is to implement until the final form. This stage produces product development through two stages, namely expert appraisal and developmental testing.

Disseminate. At the last stage of development, this application is used to distribute products that have been developed to be accepted by users (individuals or groups).

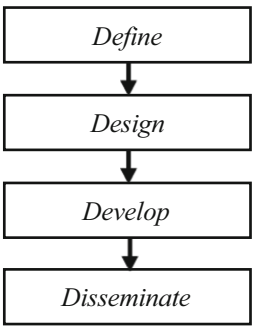

Fig. 1. 4D (Define, Design, Develop, Disseminate)

2.4 Data Analysis Techniques

The data analysis technique is used to analyze data obtained from validators and from students who act as respondents.

Black Box Testing. Black box testing is a test that focuses on the functional specifications of the application by testing the application's functional specifications to define a set of input conditions [17].

Android Smartphone Portability Testing. Android smartphone portability testing is done by running applications on devices with different Android operating systems to determine whether a system can run well.

SUS Instrument Testing. This test was conducted to determine the performance of the scramble application based on user opinions. System Usability Scale (SUS) is a usability evaluation method that provides results based on consideration of small sample size, time, and cost. Then the results of the calculation of this method are converted into a value that can be considered in determining whether or not an application is feasible [18] (Table 1 and Fig. 2).

Table 1. SUS Instrument Testing

No	Statement
1	I will use this system again.
2	This system is complicated to use.
3	This system is easy to use.
4	I need help from other people or technicians in using this system.
5	The features of this system work properly.
6	I feel many things are inconsistent (not compatible with this system)
7	I feel others will understand how to use this system quickly.
8	This system is confusing.
9	There are no obstacles to using this system.
10	I need to get used to it first before using this system.

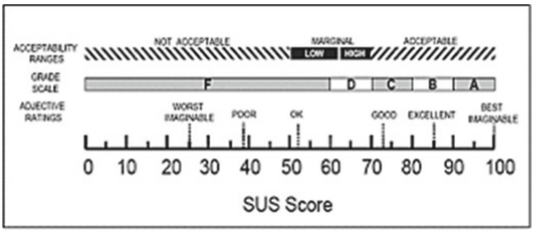

Fig. 2. Score on SUS

Product Development Validation. A product's feasibility data is based on several experts' assessments. This test includes media experts, material experts, and practitioner experts. This validation analysis technique is used to get the value in the form of conversion as a reference in the quality of research product development. The calculation of the score refers to the rumpus that has been proposed by [19].

$$X'' = \frac{\sum fx}{N} \tag{1}$$

Information:
X'': Average score
$\sum fx$: Total Score
N: Number of components

Then the average score obtained is converted into qualitative data with the formula proposed by [20] (Table 2).

$$\text{X} = \text{Score obtained}$$

$$\text{Xi} = \frac{1}{2}(Max\ Score + Min\ Score) \tag{2}$$

$$\text{Sbi} = \frac{1}{6}(Max\ Score + Min\ Score) \tag{3}$$

Then the Score obtained is also converted in percentage in the following way.

$$p = \frac{\sum x}{\sum xi} \times 100\% \tag{4}$$

Information:
$\sum x$ = scoring acquisition score
$\sum xi$ = maximum score

Table 2. Conversion of the Interval Mean Score into criteria for the Development of Learning Media Educational Games for Scramble-Based Chemistry Periodic Tables for Class X High School students

Score	Score Interval	Criteria
A	X > X i + 1,8 Sbi	Excellent
B	Xi + 0,6 Sbi < X ≤ Xi + 1,8 Sbi	Good
C	Xi - 0,6 Sbi < X ≤ Xi + 0,6 Sbi	Fair
D	Xi - 1,8 Sbi < X ≤ Xi - 0,6 Sbi	Weak
E	X ≤ Xi – 1,8 Sbi	Fail

3 Result and Discussion

3.1 Define

Define is a stage in analyzing needs and defining learning requirements consisting of five steps, including the following:

Front End Analysis. At this stage, an initial diagnosis is made of the learning media used in SMA Muhammadiyah 1 Surakarta in increasing the efficiency and effectiveness of chemistry learning in schools.

Learner Analysis. At this stage, the researcher studied the characteristics of class X students of SMA Muhammadiyah 1 Surakarta in Chemistry subject, based on background knowledge, abilities, motivation in learning, and others.

Task Analysis. At this stage, is an analysis of all the main tasks that must be mastered by class X students of SMA Muhammadiyah 1 Surakarta to achieve minimum competence.

Concept Analysis. At this stage, perform a concept analysis that will be developed in the learning media.

Specifying Instructional Objectives. At this stage, showing the expected learning and behavioral changes. Facilitate students in the learning process and can increase students' interest in learning chemistry learning materials.

3.2 Design

The design of the learning media application flow process is described by the use case and the flowchart (Figs. 3 and 4).

The initial design of the application consists of the "Material", "Play Game", and "Credits" menus (Fig. 5).

After the initial design was continued designing the primary material, introduction to the Periodic Table of Chemical Elements (Figs. 6, 7 and 8).

Then make a Scramble Game menu design that is used to hone students' skills in introducing the Chemical Elements Periodic Table (Figs. 9, 10 and 11).

Next, design the Credits menu to function as a media developer identity (Fig. 12).

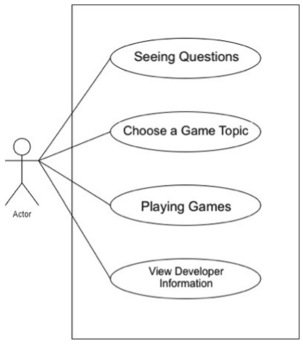

Fig. 3. Usecase diagram

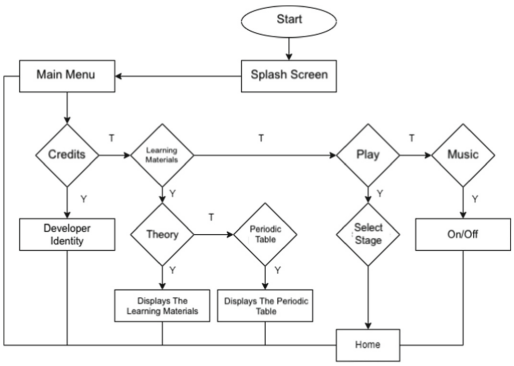

Fig. 4. Flowchart

Fig. 5. Media Preview Design

Fig. 6. Material menu display design

3.3 Develop

The design of the learning media application flow process is described by the use case and the flowchart.

Index Start Menu. The index menu interface is the initial display of this application. There is a button to access the material, a game start button, a developer identity button, and a button for on/off game music (Fig. 13).

Fig. 7. Material menu display design

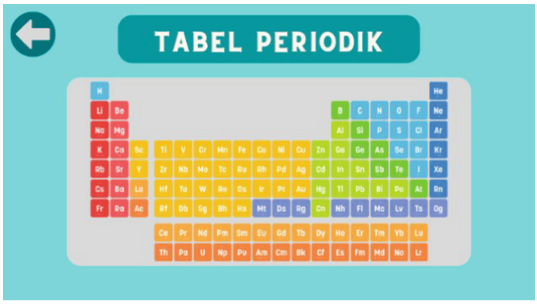

Fig. 8. Material menu display design

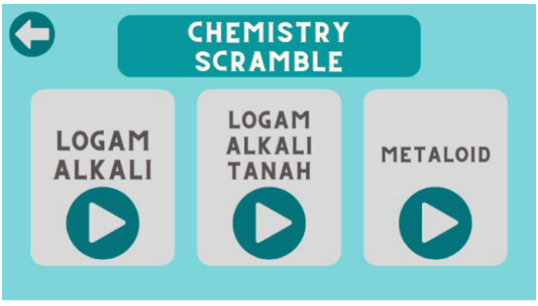

Fig. 9. Scramble Game Play menu display design

Material Index. The material index interface in this application is divided into two parts. The first is a sub-material of the basic theory of the Periodic Table of Chemical Elements; then, the second sub-material displays the Periodic Table of Elements (Figs. 14, 15 and 16).

Index Scramble Game. Index scramble game is a game menu from the media that hone students' thinking skills and train students' focus in solving a problem (Figs. 17, 18 and 19).

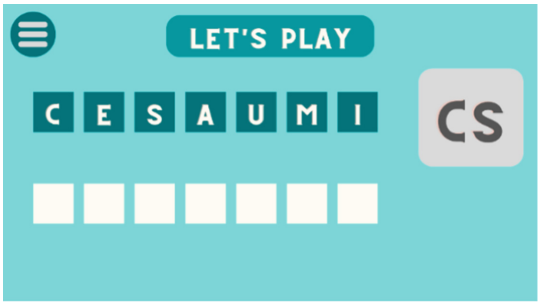

Fig. 10. Scramble Game Play menu display design

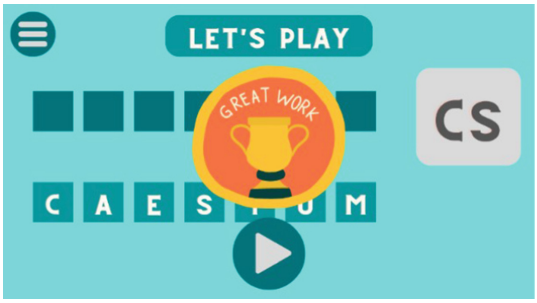

Fig. 11. Scramble Game Play menu display design

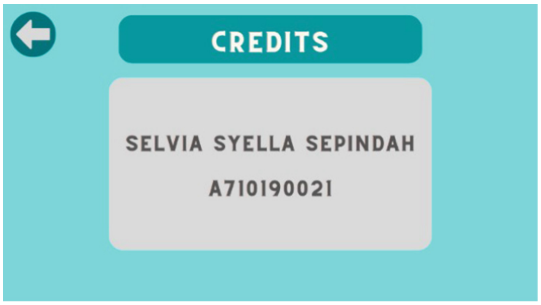

Fig. 12. Credits menu display design

Index Credits. Index Credits is located on this application's initial display, which contains personal data from the Scramble Game media developer (Figs. 20).

3.4 Disseminate

At the dissemination stage, it was carried out on class X students of SMA Muhammadiyah 1 Surakarta by providing questionnaires and training on the use of scramble applications. The purpose of the training on the use of the scramble application is that students know

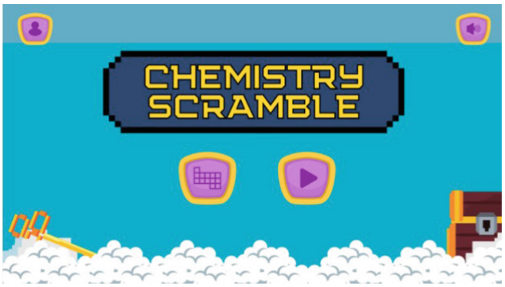

Fig. 13. Display of the initial menu index

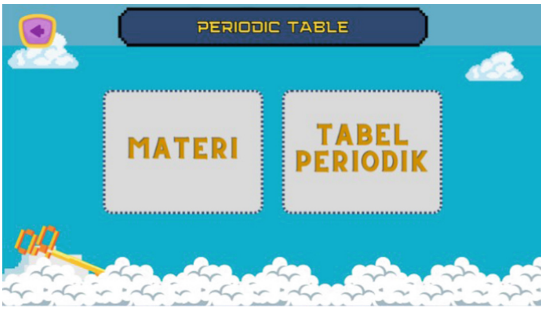

Fig. 14. Display material menu

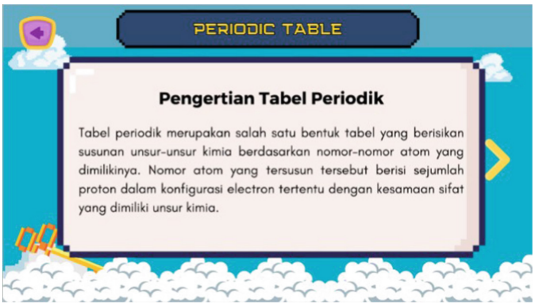

Fig. 15. Display material menu

how to use the application and can feel the benefits of using this scramble application so that this application can be used optimally. The result of this scramble application training is that students can easily use this scramble application because it can be accessed via smartphones, so that it can be accessed anywhere (Table 3).

3.5 Data Analysis

At the dissemination stage, it was carried out on class X students of SMA Muhammadiyah 1 Surakarta by providing questionnaires and training on the use of scramble applications.

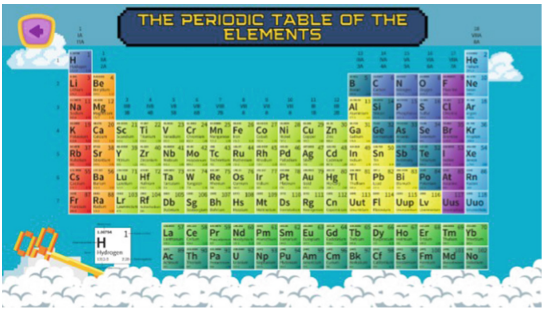

Fig. 16. Display material menu

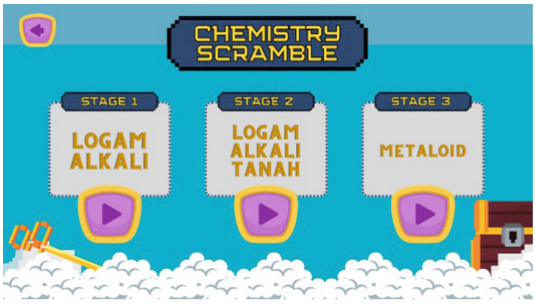

Fig. 17. Display game play

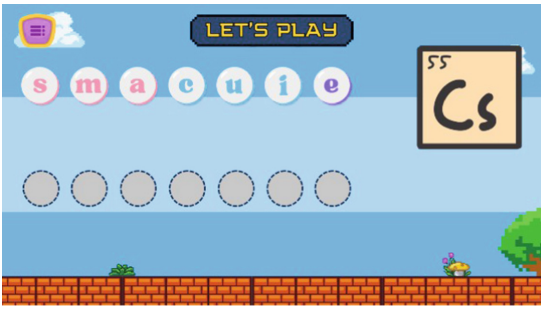

Fig. 18. Display game play

The purpose of the training on the use of the scramble application is that students know how to use the application and can feel the benefits of using this scramble application so that this application can be used optimally. The result of this scramble application training

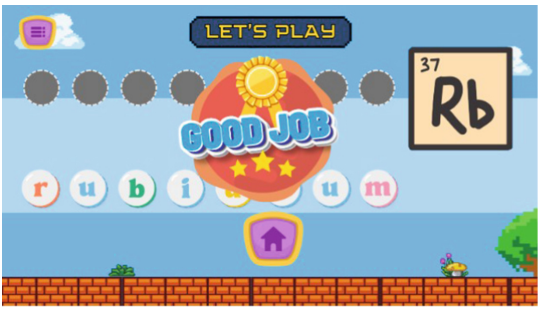

Fig. 19. Display game play

Fig. 20. Display of index credits

Table 3. The results of the black box testing on this scramble application

Testing	Result
The interface displays the material	The material appears when the user runs the application and selects the material, and the conclusion of the test results is accepted.
The interface controls the application music	The application background music can be activated and deactivated by the user, and the conclusion of the test results is accepted.
The interface for running scramble games	The user can run the game well, and the conclusion of the test results is accepted.
The interface displays the developer page	Can display the developer page when the user presses the credits button on the initial screen of the application, and the conclusion of the test results is accepted.

is that students can easily use this scramble application because it can be accessed via smartphones, so that it can be accessed anywhere.

Blackbox Testing. Testing the Scramble application interface using a black box.

Android Smartphone Portability Testing. We tested the scramble application on android smartphone devices and got good results. The application can operate and run well, so this scramble application is feasible to use.

SUS Instrument Testing. Testing the SUS instrument was conducted by taking data from class X students of SMA Muhammadiyah 1 Surakarta, who acted as respondents (Table 5).

Description: P= Statement R= Respondent 5 = Strongly Agree
4 = Agree
3 = Neutral
2 = Disagree

Table 4. Testing from Android Smartphones

No	Android Brand	Operating System & RAM	Application Test Results
1	Oppo A83	Android 7.1, RAM 2GB	It can be operated and run well
2	Xiaomi Redmi Note 9	Android 11, MIUI 12.5 RAM 6GB	It can be operated and run well
3	Xiaomi MI 6	Android 9, MIUI 10.9 RAM 6GB	It can be operated and run well
4	Xiaomi Redmi 9A	Android 10, MIUI 12 RAM 3GB	It can be operated and run well

Table 5. Results of the System Usability Score (SUS) test

Respondent	**Original score**										**Amount Calculate SUS**	**Value (sum x 2.5)**
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10		
R1	5	3	4	3	5	3	3	3	5	3	37	93
R2	5	2	5	2	5	2	5	1	5	2	34	85
R3	5	1	5	1	4	2	3	1	4	2	28	70
R4	4	2	4	1	5	3	4	2	5	3	33	83
R5	5	1	5	3	5	3	5	1	5	3	36	90
R6	5	1	5	1	5	3	5	1	5	2	30	75
SUS Calculation Average Score												83

Table 6. Media expert validation results

Media Aspect			
Media Expert	Average Score	Percentage	Category
1	83	97,64%	Excellent
2	84	98,82%	Excellent

1 = Strongly Disagree

The data from the SUS test calculation results from the Scramble-based Educational Game Learning Media application in Table 4 obtained the total SUS test results from all respondents, namely 496, with an average SUS score of 83. Excellent".

Product Development Validation. The media validation aspect of learning media is validated by media experts 1 and 2 as experts in the media field. The validation questionnaire consists of 17 assessment items, with the preparation using a scale of 5 and then in percentage (Table 6).

The categories are obtained from the calculations proposed by [19]. The following results from the calculation of the media expert assessment scores category (Table 7).

Aspects of material validation of learning media were validated by media experts 1 and 2 as experts in the field of chemistry. The validation questionnaire consists of 16 assessment items using a scale of 5 and then converted into percentages (Table 8).

Table 7. Category of assessment of media experts on the draft of scramble-based educational game learning media

Aspect	Score Interval	Score	Category
Media	$X > 71{,}34$	A	Excellent
	$57{,}78 < X \leq 71{,}34$	B	Good
	$44{,}22 < X \leq 57{,}78$	C	Fair
	$30{,}66 < X \leq 44{,}22$	D	Weak
	$X \leq 30{,}66$	E	Fail

Table 8. Results of material expert validation

Material Aspect			
Media Expert	Average Score	Percentage	Category
1	79	98,75%	Excellent
2	80	100%	Excellent

Table 9. Category of assessment of media experts on the draft of scramble-based educational game learning media

Aspect	Score Interval	Score	Category
Material	$X > 67{,}08$	A	Excellent
	$54{,}36 < X \leq 67{,}08$	B	Good
	$41{,}64 < X \leq 54{,}36$	C	Fair
	$28{,}92 < X \leq 41{,}64$	D	Weak
	$X \leq 28{,}92$	E	Fail

The categories are obtained from the calculations proposed by [19]. The following are the results of calculating the category score for the material expert assessment (Table 9).

4 Conclusion

Based on the results of research and development of scramble-based educational game learning media in chemistry subjects, the introduction of the periodic table of chemical elements at SMA Muhammadiyah 1 Surakarta that has been carried out, it can be concluded that this learning media is designed using a 4D development model (define, design, develop), and disseminate) using four stages of development. From the results of product feasibility testing by media experts and material experts, the scramble-based educational game learning media is suitable for class X high school students. The results of the calculation of the validity of media experts and material experts who are included in the appropriate category and the calculation of the validity of respondents 83, which is included in the "Excellent" category and can be easily understood by students.

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