Chemmo Configuration Game As Learning Media On Periodic System Of Element Matter

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***Abstract*—The aim of the research is to get the feasibility of Chemmo Configuration game as learning media in chemistry material, periodic system of element based on validity, practicality, and effectiveness of the game. This research use a Research and Development (R&D) method which consist of three stages, 1) introduction, 2) development, and 3) trial. In this research only done until trial test. Ttrial test was conducted in 10th grade of MIA 1 in Senior High School 1 Manyar Gresik. Validity obtained from the assessment of the Chemmo Configuration game by the validator. Practicality obtained from the results of the questionnaire responses of students and observations of student activities while using the game as learning media. Effectiveness obtained from the learning outcomes of students and the results of student learning motivation questionnaire. Chemmo Configuration game obtained percentage of validity 80% until 93% from content validity and construct validity, the practicality of the game on attractiveness aspects obtained practical percentage 97.6%, on the aspect of easiness obtained practical percentage 97.8%, for the activities of students obtained percentage of 94.07%, while the effectiveness of the Chemmo Configuration game declared effective seen from the learning outcomes of students who get a percentage of classical completeness of learning outcomes 100% and the results of student learning motivation questionnaire get 95.30% with very good category. Based on the result, Chemmo Configuration game is feasible as a learning media in chemistry material, periodic system of element.**

Keywords—Game, Chemmo Configuration, Periodic System of Element.

I. INTRODUCTION

Chemistry is one of the subjects that taught in the senior high school level. Chemistry is part of natural science that studies the properties, structure of matter, composition of matter, changes and energy that accompany changes in matter [1]. Periodic system of element is one of the chemistry matter that taught in 10th grade of senior high school. In this material there are sub matter of electron configuration and periodic properties of elements, students are required to know the principles and rules for writing electron configuration, write electron configuration in the form of orbital diagram, determine an element in the periodic table of elements based on electron configuration, and analyze relationship between atomic number and periodic properties of elements. Thats matter make students still difficulty in learning periodic system of elements matter when determining the location of elements in the periodic table and determining the periodic properties of elements, its makes students understanding in the material still low [2]. Based on the result of questionnaire given to students in Senior High School 1 Manyar Gresik it is known that 70% of students consider periodic system of element as a difficult matter in chemistry. Based on the results of interview with chemistry teacher, most of students have difficulty when determining electron configurations because they often forget about the sequence of quantum energy level. While the use of learning media such as game in computer or android is still rarely applied.

The existence of good motivation in learning will show good result too. One of the motivation that can be given to students is extrinsic motivation through conditioning a conducive learning environment. Learning while playing using game media will challenge and motivate students to create active learning in the classroom [3]. The age of student in senior high school is classified as teenager where they still like to play, one of which is playing game. This phenomenon can use to make educational games as learning media [4]. Learning activities using educational games try to provide learning for players while entertaining them so as give an interesting and exciting educational experience [5]. In chemistry learning, the use of games as learning media is commonly used because it can involve students actively, focusing attention, influence motivation and can entertain students [6].

The development of science and technology also changes learning media. Game based computer as learning media can be used for transferring knowledge to students [7]. The use of games as learning media will be more interesting and beneficial because students tend to have greater memories about what they have learned before [2]. Learning chemistry using games can also motivate students, improve their ability to make decisions and make students use their knowledge that they have learned before [8].

Therefore, the researcher developed the Chemmo Configuration game as learning media in periodic system of element matter. The Chemmo Configuration game is an adventure game in the forest. In each of the level, the player must be able answer the questions to continue to the next level. The aim of the research is to get the feasibility of Chemmo Configuration game as learning media in periodic system of element matter based on validity, practicality, and effectiveness of the game. The use of this game is expected to make students more interested, motivated, and able to improve the learning outcomes of chemistry, especially for periodic system of element matter.

II. METHOD

This research use a Research and Development (R&D) method which consist of three stages, 1) introduction, 2) development, and 3) trial [9]. However, in this research only done until trial test. Validity obtained from the assessment of the Chemmo Configuration game by the validator. Practicality obtained from the results of the questionnaire responses of students and observations of student activities while using the game as learning media. Effectiveness obtained from the learning outcomes of students and the results of student learning motivation questionnaires.

A. Preliminary Study

The preliminary study is the initial stage of preparation for development, this stage consists of three steps as follows.

1) Literature Study

The literature study discusses learning theory related with learning media using games, the characteristics of students, and studying the results of previous studies related with the media developed.

2) Field Survey

Conducted through interview with chemistry teacher and giving questionnaires to students to find out the learning media that have been used, difficulties in learning chemistry for students, and learning motivation in students.

3) Drafting The Product

Drafting the product is made based on the results of literature study and field survey that have been carried out, including determining the title of the media, arranging learning objectives, making storyboard to explain the storyline, and then compiling the games according to the storyboard.

After the game has been completed, the next steps is reviewed the game by experts like the activities below.

(1) Review of Game

The game that has been completed was reviewed by chemistry lecturer as expert in material and media to obtain suggestion and comment for the game.

(2) Repair of Game

Suggestion and comment from reviewer are used as a reference to repair the game.

(3) Validation

Validation was carried out by two chemistry lecturers and one chemistry teacher. Assessment uses calculations from the Likert scale [10].

TABLE I. LIKERT SCALE SCORE

Criteria	Score
Very Good	5
Good	4
Less	3
Bad	2
Very Bad	1

The percentage of validity is calculated using the following formula.

$$\text{Precentage of Validity} = \frac{\text{Total score}}{\text{Criterion score}} \times 100\%$$

The calculation results then interpreted as in the following table.

TABLE II. SCORE INTERPRETATION CRITERIA

Score (%)	Criteria
0-20	Invalid
21-40	Less Valid
41-60	Valid Enough
61-80	Valid
81-100	Very Valid

Chemmo Configuration game is said to be valid if get the percentage ≥61% [10]. If the game has not reached the criteria, the game must repaired again. After that the game enter the validation stage again until the game is declared valid.

B. Development

Trial test was conducted on 10th grade of Senior High School 1 Manyar Gresik to obtain data on the practicality and effectiveness of the game. The trial was conducted using the One Group Pretest-Posttest Design system. Pretest sheets are given to find out the students initial understanding of periodic system of element matter. Then students study use Chemmo Configuration game as learning media.

During study using Chemmo Configuration game the activities of students is observed by the observer. Activity observation results are used to determine practicality, calculated using the following formula.

$$\text{Precentage of Practicality} = \frac{\text{Total Score}}{\text{Total respondent}} \times 100\%$$

After using learning media, each students given a posttest sheet to find out the mastery of learning as an influence of the game as a learning media. Then students answer the response questionnaire related to the game and answer motivation questionnaire. The results of the response questionnaire used to determine the practicality of the game, calculated using the following formula.

$$\text{Precentage of Practicality} = \frac{\text{Total score every statement}}{\text{Number of respondent}} \times 100$$

Chemmo Configuration game is said to be practical if get a percentage of practicality from students responses of ≥61% [10].

Learning outcomes of students are used to determine the effectiveness of the game. Individual completeness is calculated using the following formula.

$$\text{Individual Completeness} = \frac{\text{Total score obtained}}{\text{Maximum number of score}} \times 100$$

For classical completeness is calculated using the following formula.

$$\text{Classical Completeness} = \frac{\text{Number of students who complete}}{\text{Total number of students}} \times 100\%$$

Individual learning completeness was set with a value of ≥78 according to the minimum school completeness criteria and classical completeness was set at ≥85% [11].

Learning motivation questionnaire results of students also used to determine the effectiveness of the game, calculated using the following formula.

$$\text{Percentage of Effectiveness} = \frac{\text{Total score every statement}}{\text{Number of respondent}} \times 100\%$$

The Chemmo Configuration game is said to be effective if it get a percentage of ≥61% with good criteria.

III. Result and Discussion

The following are results and discussion from preliminary study and development stage.

A. *Preliminary Study*

Learning theory related to the game developed are constructivist learning theory which states that teachers do not just provide knowledge to students, but students must active in building their own knowledge. Behaviorism learning theory emphasizes behavior change that appears as an indicator of the learning process, the existence of pleasant consequences will strengthen behavior while unpleasant consequences will weaken behavior. Information processing theory studies how a knowledge or information is managed in the brain, both in the form of processing, storing, and recalling knowledge from the brain. Based on the learning theory, the game is considered capable of maximizing teaching and learning activities in the form of interactions between students and subject matter in a game.

The age of students in Senior High School between 14 years old and over who cognitively have entered the formal operation stage where they are able to think abstract but not yet thoroughly, so they need learning media that help them to understand abstract learning materials. At that age students also still like to play, one of them is playing games. This can be used to make educational games as learning media.

Research conducted by Mukaromah & Lutfi which states that student learning outcomes increased after using the game as a learning media [12].

1) Field Survey

The results of the pre-research activities show that most of students have difficulty determining electron configurations because they often forget about the order of energy levels from quantum numbers, 70% of students choose periodic system of element as difficult chemistry matter. For the use of learning media, it still just use powerpoint and whiteboard, while the use of learning media such as game based computer is still rarely applied. Students consider learning chemistry boring and ultimately difficult to understand because the learning is monotonous and the material is difficult and abstract.

Based on the explanation, it is necessary to develop the game as a learning media in the periodic system of element which are expected to help students to be more motivated so that they have a positive impact on student learning outcomes.

2) Drafting The Product

In preparation of the product begins with determining the title of the media and arranging the learning objectives. Basic competence taken are basic competence 3.3, 3.4 and 4.3. From basic competences also determine the indicators and learning objectives. The finished storyboard then realized in the form of a game through the unity program.

The Chemmo Configuration game that was completed then reviewed by lecturer as a expert in material and media. Steps that conduct after the game is finished is explain like the following below.

(1) Review of Game.

Suggestions and comments that received from the lecturer are about the display must be appropriate with the theme of the game, the display of matter must clearly, narrative information and the level of the game must be presented, and the total score at the end of the game must be displayed. Music can be added to the audio section when the player is wrong or correct.

(2) Repair of Game.

Repair are carried out according to the all suggestions and comments from the reviewer.

(3) Validation.

Validator consist of two chemistry lecturers and one chemistry teacher. The following are the results of the validation with the explanation.

TABLE III. Results of Content Validuty

Aspect	Assessment Indicator	Validity (%)
Content Validity		
Truth of concept	The chemistry concept in the game is correct.	80
Have Goals	Questions in the game appropriate with learning objectives.	87
Construct Validity		
Characteristics of Science	There are an investigation activity.	80
Encourage developing special skills	Develop basic science process skills, namely: classification, applying concepts.	93
Appropriate with the characteristics of students	Appropriate with learning style of students.	80
	Appropriate with the age of students.	80
	Give motivation for students to study.	87
Have Rule	There are guidelines or rules for playing.	80
Guiding	There are instructions for completing the game (narration).	87

Aspect	Assessment Indicator	Validity (%)
There are competition, requirements and strategies in playing	Encourage competition from players when playing. There are requirements to complete the game. Train players to apply the right strategy to complete the game.	80
There are standards for the success of students	There are standards that must be achieved in the game.	80
Challenging and actively involving students	Challenging students to play while learning.	87
Give feedback	There are punishment when the player fail.	87
	There are gift when the player success.	87
There are aspects of making decision	There are options to answer the question or to continue play the game.	87
Display of color, graphic size and animation	The colors used are appropriate with the theme.	80
	Animations used appropriate with the content.	80
	The font size used is clear.	80
Audio visual communica-tion	There are connection between narration, sound effects, backsound, and music.	80
	The background design and the placement of text and color is appropriate.	80

The first indicator in content validity is the concept of chemistry in the game is right, obtaining 80% of percentage validity with valid criteria. One of the important things in chemistry learning is to increase students understanding of material concepts, the use of games as learning media is considered capable of motivating students and facilitate students in learning chemical concepts, so the game as a learning media must be adapted to the concept of chemistry material, because each material has its own characteristics [6]. Based on the validator's assessment and existing theories, the chemistry concepts in Chemmo Configuration game is correct so that the aspect truth of concept in content validity have been fulfilled.

The second indicator in content validity is the question in the game appropriate with the learning objectives, obtain a validity percentage of 87% with very valid criteria. A game can be called learning process if there are learning goal that must be achieved by students. Based on the validator's assessment and existing theories, the questions of the Chemmo Configuration game are appropriate with the learning objectives so that the aspects has a purpose in content validity have been fulfilled.

The first indicator in construct validity is there are investigation activity, obtaining a percentage of validity 80% with valid criteria. The indicator appears when players must answer the question about periodic properties of element. On the question, several elements are presented with their atomic number and students are asked to determine the periodic properties of the elements. To be able to answer these question students must process and analyze existing data and determine whether these elements exist in one group or one period, after knowing these elements exist in one group or one period then students can determine the periodic properties of the elements by relating them to existing theories. Based on the explanation above, Chemmo Configuration game as a learning media has fulfilled the characteristic aspects of science.

The second assessment indicator is developing basic science process skills, classifying and applying concepts, these indicators obtain validity percentage of 93% with very valid criteria. An educational game must encourage the development of special skills, and can help teach a variety of different skills [13]. Based on the explanation above, Chemmo Configuration game as a learning media has fulfilled the aspect of encouraging developing special skills.

First indicator in aspect three is appropriate with learning style of the students, obtain validity percentage of 80% with valid criteria. Not all students have the same learning styles, there are students who tend to have auditory learning styles, visual learning styles, or kinesthetic learning styles, so in the Chemmo Configuration game presents material and questions that are packaged in a game both visually, audio and audio visual. The second indicator is appropriate with the age of students obtain validity percentage of 80% with valid criteria. The age of students in senior high school is classified as teenager, they can think abstractly but not yet thoroughly so that in the learning process they need media to help them understand the material. Students in senior high school still like to play, one of them is playing games [4]. The third indicator, motivate students to learn, obtains a percentage of validity of 87% with very valid criteria. The use of media can add positive motivation to students to learn so that their attention to learning material increases [6]. Based on the validator's assessment and the existing theory, Chemmo Configuration game as a learning media has fulfilled the aspect "appropriate with the characteristics of students" in construct validity.

The fourth indicator is has guidelines or rules for playing. From the table above it is known that the indicator get validity percentage of 80% with valid criteria. One characteristic of the game is that there are guidelines or rules in playing that must be obeyed by the players . Based on the validator's assessment and existing theories, Chemmo Configuration game has good guidelines or rules of play so that aspects of having rules in construct validity are fulfilled.

The fifth indicator, the game can guide the player, obtain validity percentage of 87% with very valid criteria. These results indicate that the Chemmo Configuration game as a learning media can guide students to learn independently because in the game provided learning materials, practice questions, and discussion of questions.

The sixth aspect is encourage competition, requirements and strategies in playing, obtain validity percentage of 80% validity with valid criteria. The existence of competition appear when player compete in obtaining scores with other players. Requirement in a game appear when player want to advance to the next level they must be able to answer questions. Strategy in this game appear when player face the enemy. Based on these description, Chemmo Configuration game has fulfilled the aspect of encouraging competition, requirements and strategies in play.

The seventh indicator is there are standard that must be achieved in the game, obtain validity percentage of 80% with valid criteria. These results show that the Chemmo Configuration game as a learning media has a standard of success that must be achieved by students. The standard of success in the game can make students motivated to play the game until finish.

The eighth indicator is challenges students to play while learning, obtain validity percentage of 87% with very valid criteria. To make learning chemistry more fun and interesting can use the game as a learning media, students can actively participate learning, so they tend to have better memories of what they have learned [2]. Based on the validator's assessment, the Chemmo Configuration game as a learning media has fulfilled the aspect of challenging and active involving students in construct validity.

In the ninth aspect have two indicators. First indicator is there are punishment for fail and the second indicator there are gift when success. Both indicators obtain validity percentage of 87% with valid criteria. According to the behaviorism learning theory, reinforcement is an important element in the learning process, individual behavior that followed by pleasant consequences makes the individual will repeat the behavior as often as possible, while unpleasant consequences (punishment) will weaken behavior. In the Chemmo Configuration game feedback in the form of punishment appear when a player is caught by an enemy so that his life is reduced, feedback in the form of gift appear when the player is given a score when successfully determining the correct quantum number. Based on the assessment of the validator and the description above, Chemmo Configuration game as a learning media has fulfilled the aspect of providing feedback on construct validity.

In the tenth indicator "available choices to answer the questions or continue to play the game", get a percentage of validity 87% with very valid criteria. These results show that Chemmo Configuration game as learning media has been good in providing making decision choices. Its appear on the main menu, there are several alternative choices, players can open the material before playing or can choose to directly play.

In the eleventh aspect there are three indicators, the colors used in game appropriate with the theme, the animation used appropriate with the content, and the font size used is clear. The three indicators obtain a validity percentage of 80% with valid criteria. Computer-based interactive learning that is able to present display of text, images, videos, sounds, and animations that can motivate students to learn because their enthusiasm for multimedia systems is presented [14]. Based on the assessment of the validator and the description above, Chemmo Configuration game has fulfilled the aspects in color display, graphic size and good animation on construct validity.

In the twelfth aspect have two indicators, there are connection between narration, sound effects, backsound, and music, and there are harmony between the background design and the placement of text and color. Both indicators obtain a validity percentage of 80% with valid criteria. The first assessment indicators appear in the game when the music that used in game is fun adventure-themed music so that it can attract the attention of students, there are also sound effects at levels 1 and 2 that is when players are wrong or correct in determine quantum numbers or orbital diagrams. The harmony between the background design and the text and color placement is good. This can be seen in the game where the text that appears is clearly appropriate with the background design.

Based on the results of the validator's assessment, Chemmo Configuration game as a learning media classified valid because on each indicator get a percentage of validity ≥61% with valid criteria until very valid criteria.

B. *Development*

At the development stage, a trial test was conducted in 10th grade of MIA 1 in Senior High School 1 Manyar Gresik. Trial activities are carried out to determine the practicality and effectiveness of the game. The practicality of the game is seen from the results of the students' responses to the game and the observations of students activities, while the effectiveness of the game is seen from the learning outcomes of students and the results of the learning motivation questionnaire.

1) Result of Observation Student Activity

Observation of student activities conducted by 4 observers. The number of students in one class is 28 people. One observer observed 7 students. Some things are observed when the play process is, the installation process of Chemmo Configuratiojn game shows if all students are able to open applications without difficulty. In the process of operating the game, students can also use the game well, but there are students whose laptops are not responding when playing but its not make the students repeat the game from the initial.

There are increasing activity that is appear when students playing game, which is the activity of seeing material when students difficult in answer questions. At level 1 students who see material when having difficulty in answer questions as much as 86%, at level 2 89%, at level 3 93% and at level 4 as much as 100%. This happens because the difficult material in this game is increase from level 1 to level 4. This results also show that there are efforts made by students to be able to answer questions in the game as evidenced by their effort to read the material. The

observations activities of students are used to determine the practicality of the Chemmo Configuration game as learning media.

Based on the observations of student activities, the average percentage that get is 94.07%, the results showed that Chemmo Configuration game was classified very practice.

2) Results of Student's Questionnaire Responses

After using the Chemmo Configuration game as learning media, students were given questionnaire response to find out the practicality of the game. The following are the results of the response questionnaire given to students.

TABLE IV. RESULT OF QUESTIONNAIRE RESPONSES

Indicator	Practicality
The level of students's interest about the game	97.6%
The level of ease to understanding the material and using the game	97.8%

Based on table 4, it can be seen if the student's interest in the game is high. Chemmo Configuration game makes students enthusiastic and interested in learning chemistry, especially in periodic system of element, they like learning chemistry using games and they want to learning chemistry again using games, it is an indicator that shows their interest in the Chemmo Configuration game. Game based on computer display good multimedia that make students interested in playing game so that in the end they can learn chemistry from the games they have played [15].

Meanwhile on the second indicator also gets a high percentage. Chemmo Configuration game makes students understand chemistry material and makes students easier to answer posttest questions, Chemmo Configuration game is easy to operate, instructions in the game are not difficult to understand is an indicator that shows if the Chemmo Configuration game makes students easier in understand the material and easy to operate the game. The results of student's response are used to determine the practicality of the Chemmo Configuration game as learning media.

Based on the results of the students' responses, it shows that the Chemmo Configuration game as learning media is classified practical because get percentage of practicality

3) Student's Learning Outcomes

Student's learning outcomes data were obtained through the pretest and posttest sheets. There are 15 questions in pretest and posttest. The pretest question sheet is given before students use Chemmo Configuration game as learning media, while the posttest question sheet is given after students use Chemmo Configuration game as learning media. Students are declared complete when their score is ≥78 appropriate with minimal completeness criteria. The following are the results of the students' pretest and posttest.

TABLE V. RESULT OF PRETEST AND POSTTEST

	Pretest	Posttest
Number of individual completeness	4	28
Classical completeness	14.28%	100%

Based on the table above, it is known that there are 4 students whose pretest scores ≥78 or complete, while 24 other students have pretest scores under the minimal completeness criteria and declared incomplete, for the pretest stage the classical completeness scores obtained 14.28%. Meanwhile at the posttest stage shows a positive result which is 28 students value ≥78 or is declared complete so that the classical completeness value becomes 100%. The existence of students who did not complete because many of them forgot about the periodic system of element material and they also not understand about the material. This result is appropriate with research by Mukaromah & Lutfi which states that student learning outcomes increased after using the game as a learning media [12].

Based on the learning outcomes of the students it can be said if the Chemmo Configuration game as chemistry learning media in the periodic system of element is effective.

4) Result of Motivation Questionnaire of Students

The results of motivation questionnaire of students are used to determine the effectiveness of Chemmo Configuration game as learning media towards the motivation of students learning in the periodic system of element. The following are the results of students' learning motivation questionnaires.

TABLE VI. RESULT OF MOTIVATION QUESTIONNAIRE

Indicator	Precentage (%)
Motivation competitive	91.71
Motivation in works hard	100
Motivation to move forward	96

The first indicator aims to find out the competitive motivation of students with their friends in playing, obtained percentage 91.7%, this result shows if the average student has the motivation to compete with their friends when playing games. Because of the motivation to compete, indirectly they will learn periodic system of element material through the Chemmo Configuration game.

The second indicator aims to find out the motivation to work hard of students in completing the tasks during playing the game, obtained percentage 100%. These results show if there are effort made by students in getting something. Based on the results described above, the Chemmo Configuration game makes the motivation to work hard from the students appear, in this case they want to read the material in the game to be able to answer the questions so that they are able to advance to the next level.

The third indicator aims to find out the desire of students to move forward, obtained percentage 96%. The function of motivation is to make person do the best to achieve something, the existence of good motivation in

learning will also show good results [6]. Based on the explanation, the Chemmo Configuration game influence motivation to move forward for student, the desire of students to play Chemmo Configuration game outside of lesson hours shows that they want to more understand about periodic system of element.

Based on the results of the motivation questionnaire above obtained percentage of 95.30% with good criteria, with these results and learning outcomes of students who have reached the standard classical completeness, then the Chemmo Configuration game is declared effective as learning media in periodic system of element matter.

IV. Conclusion

1. Chemmo Configuration game as learning media on periodic system of elements matter declared valid by the validator and obtain a percentage of validity 80% to 93% for content validity and construct validity with valid criteria to very valid.
2. Chemmo Configuration games as learning media on periodic system of elements matter declared practice in terms of student responses and activities. The practicality of the game on the attractiveness aspect obtained 97.6% with a very practice category, in the aspect of ease of understanding the material and usage it obtained 97.8% with a very practice category, and the activities of students get 94.07% with very practice category.
3. Chemmo Configuration game as a learning media in periodic system of elements matter is declared effective in terms of learning outcomes of students that get a percentage of classical completeness of learning outcomes as 100% and the results of student learning motivation questionnaire get 95.30% with very good category.

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