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Dear Author(s):
Sanih Gholiyah, Achmad Lutfi

Warm Greetings!

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GEOMETRICHEM GAME TO IMPROVE STUDENT LEARNING AUTONOMY IN MOLECULAR SHAPE TOPIC

Comment [k1]: Pada dasarnya artikel ini sudah bagus. Dari sisi bahasa Inggrisnya, secara umum s bagus. Yang saya tuliskan hanya sekedar saran saj jadi tidak diubah tidak apa2.
Untuk konten, ada beberapa kalimat di hasil penelitian yang merupakan pengulangan apa yang ada di latar belakang, lebih baik di awal hasil dan pembahasan dituliskan seperti apa karakteristik da Geometrichem yang dikembangkan dan seperti ap gambarannya.

Sanih Gholiyah[1], Achmad Lutfi[2]
[1,2]Pendidikan Kimia, Universitas Negeri Surabaya
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Abstract

The aim of this research is to determine the feasibility of Geometrichem game as learning media to improve student learning autonomy in molecular shape topic according to validity, practicality, and effectiveness. Geometrichem game is expected to improve student learning autonomy. The research method applied was Research and Development: (1) preliminary study, (2) development of the product, (3) trial. The trial was conducted to 18 students of SMAN 1 Gresik. The result showed that Goemterichem game is feasible as learning media in molecular shape topic as (1) validity reached 89,29% or very valid, (2) practicality reached 84,03% or very practical according to response questionnaire, and 78,79% or good according to student activity observation, (3)

Comment [s2]: highly

Comment [s3]: highly

effectiveness reached 77,78% according to classical completeness. Geometrichem game improved student learning autonomy in student motivation, use of learning resource, self-evaluation, and environmental factor aspects, but not in learning strategy, planning, and self-monitoring aspects.

Keywords: Geometrichem; learning autonomy; molecular shape.

Abstrak

Penelitian ini bertujuan untuk mengetahui kelayakan permainan Geometrichem sebagai media pembelajaran untuk meningkatkan kemandirian belajar peserta didik pada materi Bentuk Molekul berdasarkan kriteria kevalidan, kepraktisan, dan keefektifan. Permainan Geometrichem diharapkan dapat meningktakan kemandirian belajar peserta didik. Jenis penelitian yang digunakan adalah penelitian dan pengembangan (R&D) dengan tiga langkah, yaitu (1) studi pendahuluan, (2) pengembangan permainan, dan (3) uji coba. Permainan Geometrichem diujicobakan pada 18 peserta didik SMAN 1 Gresik. Hasil yang diperoleh menunjukkan bahwa permainan Geometrichem layak digunakan sebagai media pembelajaran untuk meningkatkan kemandirian belajar peserta didik pada materi bentuk molekul dengan rincian: (1) kevalidan mendapatkan persentase 89,29% atau sangat valid, (2) kepraktisan mendapatkan persentase 84,03% atau sangat praktis berdasarkan angket respon peserta didik, dan 78,79% atau baik berdasarkan observasi aktivitas peserta didik, (3) keefektifan mendapatkan persentase 77,78% berdasarkan ketuntasan klasikal. Permainan Geometrichem meningkatkan kemandirian belajar peserta didik pada aspek penggunaan sumber belajar, evaluasi diri, dan faktor lingkungan, tetapi tidak berpengaruh pada aspek strategi belajar, perencanaan, dan pemantauan diri.

Kata kunci: bentuk molekul; Geometrichem; kemandirian belajar; permainan.

Introduction

Education is one of the most influential sector toward nation's quality. Through 2013 curriculum, the government attempts to increase education quality. The 2013 curriculum aims to prepare Indonesian as individuals and citizens capable of being people who are faithful, productive, creative, innovative, affective, and able to give contribution to social life, nation, and the state.

Education and Culture Ministerial Regulation of the Republic of Indonesia No. 65 of 2013 on Elementary and Middle Education Process Standards stated that the learning process in educational units is implemented in interactive way, inspiring, fun, challenging, motivating students to actively participate, also providing sufficient space for initiative, creativity, and independence in accordance with talent, interest, and physical and psychological development of students. Therefore, to achieve education outcomes, chemistry learning should be conducted in a fun way so that students do not get bored and they are able to develop their ability.

One of the goals of cultural education and national character is to develop the ability to become an independent human being. Through learning autonomy, students with their self-awareness undertake the learning activity independently. Students with learning autonomy tend to maximize their effort to get high learning achievement as they expected (Ningsih, 2016).

Learning autonomy is measured through various aspects, among them are motivation to study, the use of learning resource, learning strategy, study planning, self-monitoring, self-evaluation in learning process, and environmental factor (Islami, 2018).

According to the preliminary research conducted to students of grade 10

Comment [s4]: improve

Comment [s5]: dihilangkan saja

science at SMAN 1 Gresik, 88,89% students stated that they have an interest in chemistry lesson. It means that students are quite intrinsically motivated to learn chemistry. Specialized in molecular shape topic, 55,56% students found molecular shape topic is relatively easy. However, 72,22% of students stated that they were not able to do the exercise on their own without the help of others. 50% of students did not perform learning evaluation, such as correcting errors or rework the exercises given by the teacher.

The difficulties experienced by students can be overcome by utilizing learning media in the learning activity. Learning media can help and ease teacher to deliver the lesson to students. One of learning media that can be utilized is games. Games have the potential to be useful tools for learning(Welbers et al., 2019). Games as a learning media can help students to be autonomic learner that study independently. Also, games conduct recreational atmosphere that can reduce students' stress and increase students' learning motivation. Through educational games, students are no longer knowledge passive receivers. They will achieve meaningful learning because they are active knowledge constructers(Huang, 2019). The feedback contained in a game will increase student engagement in the learning process. Through games, students will not feel burdened while learning chemistry. Students find it a motivating and enjoyable activity(Welbers et al., 2019).There are still very few teaching materials designed to stimulate the development of students' critical and creative thinking skills in constructing their knowledge independently(Sofiana & Wibowo, 2019).

Based on interviews conducted with chemistry teacher in the preliminary study, chemistry learning, especially molecular shape topic, is easier to be delivered by utilizing learning media. The learning media used so far is conventional media, such as Molymod model and simple objects that are all around us. The teacher utilizes ICT-learning media in molecular shape learning activity but only for presenting slides and videos to students. According to preliminary study questionnaire given to the students, 94,44% students wanted to learn molecular shape topic utilized by computer-based game as the learning media. 100% students agreed that teacher need to develop a game as learning media to ease their understanding in molecular shape topic.

Therefore, game as a learning media for molecular geometry chapter featured with text, music, that is fun and adventurous, utilizes computer technology that gain student interest and learning autonomy is needed to be developed. Games with those descriptions according to author's study do not exist, so it should be developed. Based on the background explained, author developed Geometrichem game, a computer-based game in molecular shape topic. The purpose of this research is to find out the feasibility of Geometrichem game as a learning media in molecular shape topic in terms of validity, practicality, and effectiveness. The utilization of Geometrichem game in learning activity is expected to improve student learning autonomy.

Research Method

Research method conducted in this game development was Research and Development (R&D). R&D method is carried out in creating certain product and testing the effectiveness of it(Sugiyono, 2017). The method carried out was R&D by Sukmadinata, which consists of three stage: 1) Preliminary study, 2) Development of the product, and 3) Trial(Sukmadinata, 2016). In this research, the research method used was only conducted until limited trial.Each stage of research and development can be described as follows.

1. Preliminary study
   Preliminary study is the first step for development preparation. This stage consisted of three steps, which were literature study, field survey, and preparation of the product draft. These three steps were carried out continuously.
   a. Literature study
      Concepts or theories related to games which would be developed were studied. Specifically about the characteristics of students and

previous researches regarding the learning media that would be developed.

b. Field study
Data pertaining to the planning and implementation of chemistry learning, especially in molecular shape topic were collected in this step. In the field study, questionnaire of preliminary study was distributed to 18 students of grade 10 science at SMAN 1 Gresik, and an interview to chemistry teacher was conducted. The questionnaire and the interview content was perception, motivation, and teacher's skill to develop learning media for molecular shape topic, factors affecting learning activity such as learning media, learning resources, and students' learning autonomy. The interview result supported the results of preliminary study questionnaire that had been given to students. The results obtained were used as the background of the development of Geometrichem game.

c. Game planning
Geometrichem game was designed in the form of storyboard to be developed next.

2. Development of the product

a. Preparation of the product draft
The storyboard obtained from game planning step was then compiled into the initial draft of Geometrichem game.

b. Game review
The initial game was reviewed by the experts of material, learning, and media. The experts were two chemistry lecturers and one chemistry teacher. Game review step aimed to acquire suggestions and feedback for the improvement of Geometrichem game.

c. Game revision
Geoemtrichem game was getting revised according to the result of the game review from the experts.

d. Game validation
The validity of Geometrichem game as a learning media for molecular shape topic was determined by game validation. The validation process was conducted by three experts of material, learning, and media who were two chemistry education lecturers and one chemistry teacher. The validation involved content and construct validity. Content validity represents the correctness of molecular shape concept and the appropriateness of the topic to the learning outcomes and indicator. Construct validity represents several aspect that were encourages developing specific skill, suitability with students' characteristics, having rules, guiding students, having requirement, obstacle, and strategy in playing, challenging and actively engaging students, having success standard, giving feedback, having aspect of decision-making, game display as a learning media, audio visual communication, and engineering aspect of the software. The validity was measured by Likert 5 rating scale. The result of the game validity was calculated as follows.

$$\%\ Validity = \frac{the\ number\ of\ scores\ obtained}{criterion\ score} \times 100\%$$

Criterion score = highest score x number of validators.

Geometrichem game is valid if it reaches≥ 61% validity percentage or is in the valid or very valid category(Riduwan, 2015).

3. Trial
The feasibility of Geometrichem game was measured through the game trial. In the trial stage had been discovered students learning outcomes, result of student response questionnaire, result of students learning autonomy questionnaire, and result of student activity observation. The effectiveness of Geometrichem game as a learning media for molecular shape topic was

determined by students learning outcomes. The practicality of Geometrichem game as a learning media for molecular shape topic was determined by the results of student response questionnaire and student activity observation. The effect of Geometrichem game to students learning autonomy was determined by the result of student learning autonomy questionnaire.

This research was carried out until limited trial that was conducted to 18 students of grade 10 science at SMAN 1 Gresik. The trial conducted was "One Group Pretest-Posttest Design". This research is carried out to a group that is given pretest before treatment, and posttest after the treatment(Sugiyono, 2017). This design can be described as follows.

$$O_1 \; X \; O_2$$

Figure 1. One Group Pretest-Posttest Design.

O_1 = pretest(before given Gemetrichem game as learning media)

X = learning process utilized by Geometrichem game as learning media

O_2 = posttest (after given Geometrichem game as learning media)

Normality test was conducted in advance to identify the normality of data distribution. Through SPSS, normality test was carried out by Shapiro-Wilk Test as the sample size is less than 50. If the significance value is > 0,05 the data is normally distributed and statistical analysis conducted is parametric statistic model, in this research was Paired Samples T-Test(Mishra et al., 2019; Razali & Yap, 2014). If the t statistic is > t table, or significance value is ≤ 0,05, it is stated that there is significant difference between students' pretest and posttest score. Geometrichem game is effective if student outcomes improved, as evidenced by Paired Samples T-Test on the pretest and posttest results.

The percentage of classical completeness was used to determine the effectiveness of Geometrichem game classically. Classical completeness was calculated using the formula.

$$Classical\ completeness\ (\%) = \frac{number\ of\ students\ who\ completed}{number\ of\ students} \times 100\%$$

The game is effective if the percentage of classical completeness reaches 75% (Kurniasih, 2019).

The practicality of Geometrichem game was measured through response questionnaire by Likert 4 rating scaleand student activity observation measured by Guttman scale. The result of the game practicality from response questionnaire was calculated as follows.

$$\%\ Practicality = \frac{the\ number\ of\ score\ each\ indicator}{the\ maximum\ number\ of\ scores} \times 100\%$$

The Guttman scale for student activity observation is described as follows.

Table 1. Guttman Scale Score for Student Activity Observation

Answer	Score for positive statement	Score for negative statement
Yes	1	0
No	0	1

The result of the game practicality from student activity observation was calculated as follows.

$$\%\ Practicality = \frac{the\ number\ of\ score\ each\ indicator}{the\ maximum\ number\ of\ scores} \times 100\%$$

Geometrichemgame is practical if the percentage of students responses and activity observation reach≥50% or is in the practical or very practical category(Riduwan, 2015).

The effectiveness of Geometrichem game in increasing students learning autonomy was determined by the result of learning autonomy questionnaire before and after using Geometrichem game as learning media. The questionnaire for students' learning autonomy was analyzed using descriptive statistics in the form of mode calculations, which is the most common phenomenon.

Result and DIscussion

The result and discussion of the development of Geometrichem game through research and development method is described as follows.

1. Preliminary study
   a. Literature study

Senior high school students commonly have difficulty in understanding chemistry. Many chemical concepts are abstract, making it difficult for students to understand chemistry, so that chemistry is considered a difficult subject(Khulliyah & Fadhlan, 2019).

One of indicators that has been studied is the low learning outcomes, since chemistry subject needs high thinking and reasoning skill. While studying molecular shape topic, students feel bored because they only learn it through books and teacher's explanation(Supriono & Rozi, 2018).

Student-centered learning will be optimal if students have the learning autonomy(Sandi, 2012). Learning autonomy is the ability of student to supervise and manage their own learning activity(Merç, 2015). Motivation, organizing and planning, self-management, self-evaluation are some of the indicators of learning autonomy(Firat, 2016; Merç, 2015). Self-evaluation helps students to improve their learning outcomes(Andrade, 2019).

The insertion of the character can be conveyed to students directly or indirectly. Direct insertion can be in the form of a direct instruction.Indirect insertion of character values can be in the form of learning material content(Aeni, 2019).

The right learning media will facilitate students' understanding, especially in understanding chemical concepts that are considered difficult and abstract by students (Sulistyani & Nirwana, 2019).

One of learning media that can be used is games. Games as learning media also can help students to study independently and create recreational atmosphere. Many researches about gamification found that by motivating students through reward-based learning, such as giving compliments and scoring system in a game, their learning skill improved and eventually gain their learning outcomes(Alomari et al., 2019).

Students' curiosity increase by the desire to finish the game. The feedback contained in a game has the potential to be useful for increasing student engagement in the learning process because it makes student feel they are improving and toward the goal(Welbers et al., 2019).

   b. Field study

Preliminary study questionnaire distributed to students shows that 88,89% students are interested to chemistry subject. 83,33% students are interested to molecular shape topic. 88,89% students are interested to ICT-based learning in molecular shape topic. 100% students agreed that teacher need to develop computer-based game as a learning media to ease the understanding on molecular shape topic. 94,44% students desired to understand molecular shape topic utilized by computer-based game as the learning media. 100% students are interested to know computer-based game as a learning media, especially in molecular shape topic. 55,56% students felt that molecular shape topic is easy to understand. 88,89% students agreed that material provided by the teacher was complete. 83,33% students used additional learning resources other than those provided by the teacher. 27,78% students admitted that they were not able to do exercises on their own. 50% students performed evaluation on their learning outcomes, such as correcting errors or rework the exercises given by the

Comment [k6]: sdh ada di latar belakang

teacher. 77,78% students agreed that the teacher uses ICT-based learning media in the learning activity.

The result of interview to chemistry teacher shows that students were happy while learning chemistry, especially molecular shape topic. Students did evaluation after the teacher reviewed their work. Learning resources used in learning activity were Unit Kegiatan Belajar Mandiri (UKBM), module, textbook provided by the government, and power point slides. Besides, students are free to use additional books. The teacher used computer-based learning media in the learning activity, but only limited to the use of laptops and LCD projectors. The teacher stated that it would be great if there was learning media in the form of games.

According to the field survey, it can be concluded that a computer-based game as learning media in molecular shape topic does not exist. It is necessary to develop Geometrichem, a computer-based game as learning media in molecular shape topic that is expected to help student to improve their learning outcomes and learning autonomy.

c. Preparation of draft product

The product draft was prepared in a storyboard. Materials in form of text and videos, also questions for molecular shape topic according to the learning outcomes were prepared.

The storyboard contained design, features and specifications, learning outcomes, and the gameplay of Geometrichem game. Geometrichem is a computer-based game with the theme of endless run. Geometrichem consists of five menu, those are *Kompetensi, Petunjuk, Materi, Main,* and *Pengembang*. *Kompetensi* contains of Basic Competence and learning outcomes of molecular shape topic. *Petunjuk* contains player guidance and game rules. *Materi* contains material of molecular shape topic. *Main* is menu to start playing. *Pengembang* contains information about the developer of Geometrichem game. Players are provided with five lives at each level and are reduced each time the player falls or hits the enemy.Geometrichem game consists of three levels. Players must score at least 30 to advance to the next level. There are five questions that must be answered in order to advance to the next level. Players are given two chances to answer the same question. If players give correct answers in the first chance, they will get 10 score and can immediately continue the game. If they give incorrect answers in the first chance, they will be given a material in the form of text and video about the clue to answer the question, and the second chance to answer the same question is provided. Pretest and posttest are 11 multiple choices questions with different score each question and 100 score in total.

2. Development of the product

a. Development of the game product

All components prepared in the previous stage were the materials used to create Geometrichem game. Geometrichem game was developed using Construct 2 game editor. The product was exported to .exe format which is compatible for computer with 32-bit or 64-bit versions of Windows operation system.

b. Game review

The result of the review step was suggestions and feedback for Geometrichem game in accordance with the criteria that have been determined using the review sheet. The criteria assessed include content and construct validity. One of the review result was the suggestion to add the device specification that Geometrichem game compatible on.

c. Game revision

The suggestion and feedback obtained from game review step was analyzed and the revision was then conducted. The following is one of

Comment [k7]: ada sebagian yang sdh ada di belakang

Comment [s8]: ...in the...

the example of game revision after being reviewed.

Figure 2 displays Geometrichem *Petunjuk* menu before being revised. The layoutwas a little messy and confusing. The revision was conducted by changing it into bullet points as appeared in Figure 3.

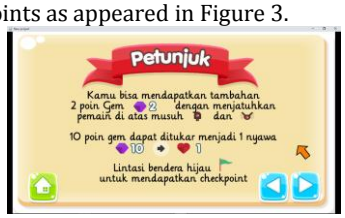

Figure 2. Display of Geometrichem *Petunjuk* menu before Revision

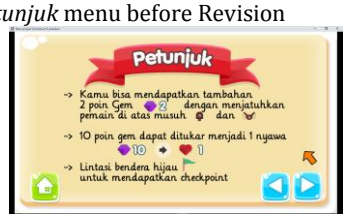

Figure 3. Display of Geometrichem *Petunjuk* menu after Revision

d. Game validation

Validity of Geometrichem game according to validation result by the validators is described as follows.

Table 2. Content Validity of Geometrichem Game

No.	Aspect	Percentage (%)	Category
1.	Concept correctness	79,16	Valid
2.	Appropriateness of material with learning objectives	66,66	Valid
	Average of validation result	72,91	Valid

According to Table 2, concept correctness of Geometrichem game was rated 79,16% and categorized as valid. It means that every material and questions in Geometrichem game related to molecular shape topic is correct according to chemical scientific principles. The appropriateness of the topic to the learning outcomes and indicator aspect was rated 66,6% and categorized as valid. It means that every material and questions in Geometrichem game is appropriate with the learning outcomes planned in the first stage. This is in accordance with the theory that an educational game must have goals according to the prepared learning objectives(Lutfi et al., 2014). This content validity also applied to questions in the pretest and posttest that have been prepared.

Table 2. Content Validity of Geometrichem Game

No.	Aspect	Percentage (%)	Category
1.	Encourage developing specific skill	83,33	Very valid
2.	Conformity with the characteristics of students	91,66	Very valid
3.	Having rules	91,66	Very valid
4.	Having a guiding aspect	100	Very valid
5.	Having competition, requirements, and strategies	95,83	Very valid
6.	Challenging and actively engaging students	83,33	Very valid
7.	Having a standard of success	91,66	Very valid
8.	Provide feedback	100	Very valid
9.	Having aspects of decision making	100	Very valid
10.	Quality of display	91,66	Very valid
11.	Audio visual communication	83,33	Very valid
12.	Software engineering	91,66	Very valid
	Average of validation result	92,01	Very valid

According to Table 3, Geometrichem game was rated 83,33% and categorized as very valid in the first aspect of construct

Comment [s9]: highly valid

Comment [s10]: highly

validity, which is encourage developing specific skill, in this research is learning autonomy. By using Geometrichem game, students can perform evaluation in studying because of the special feature of Geometrichem game which gives a second chance to answer the same question after answering questions incorrectly. Also, students are given explanation in each questions in the game. This is in accordance with the theory that students' learning autonomy is manifested primarily in planning, monitoring and evaluating learning process(Jácome, 2012). Geometrichem game utilizes students to do their self-evaluation by the features provided to make them engaged in reflection on their learning process. Instant feedback gives good effect to students because they get what they have attempted(Welbers et al., 2019).

Geometrichem game engaged students to actively participate in learning. Geometrichem game has being a supporting learning resource other than those provided by the teacher. Preparing learning resources is included in planning of learning process as a manifestation of student learning autonomy.

Geometrichem game has met the second aspect in construct validity, which is conformity with the characteristics of students, as rated 91,66% or categorized as very valid. Geometrichem is an endless run game with molecular shape topic. Geometrichem appropriates students of senior high school who are 15 years old in average, or categorized as teenagers. According to cognitive development theory of Piagiet, intellectual skill of teenagers reaches formal operational stage, indicated by logical thinking skill of abstract idea(Ahmad et al., 2016).

Geometrichem game was rated 91,66% or categorized as very valid for having rules aspect. Geometrichem game has met the having a guiding aspect as it was rated 100% or categorized as very valid. If players answer questions in Geometrichem game incorrectly, they are required to take a review on the material, in the form of text or video. After that the information about the presence of a second chance to answer the same question will be displayed. Educational game must have a guide for the players to achieve the expected goal.

Geometrichem game was rated 95,83% or categorized as very valid for having competition, requirements, and strategies aspect, 83,33% or categorized as very valid for challenging and actively engaging students aspect, also 91,66% for having a standard of success. There are requirements for players to proceed to the next level in Geometrichem game. To unlock the next level the player must answer the minimum score that has been determined. To finish the game the player must complete all three levels. There is a strategy in running the game. The player can maximize the score obtained by always answering correctly the first chance. Learners as players must faced with competition, challenges, and strategies to achieve goals and victory expected in the game(Lutfi et al., 2014).

Geometrichem game has met the provide feedback aspect as it was rated 100% or categorized as very valid. When the player answers the question incorrectly, the player gets feedback in the form of video or text material that can help students to answer the question. When the player answers the question correctly, the player gets score that has been determined. The explanation of the correct answer eventually displays in each question.

In having aspects of decision making, Geometrichem game was rated 100% or categorized as very valid. The player is given five answer choices for each question.

Geometrichem game was rated 91,66% or categorized as very valid

Comment [s12]: highly

Comment [s13]: highly

Comment [s14]: highly

Comment [s15]: highly

Comment [s11]: highly

Comment [s16]: highly

for quality of display aspect. The colors used in Geometrichem game are compatible. Road animations are in line with the theme of the game which is endless run. The letter types and sizes are legible and appropriate to the game.

Geometrichem game was rated 83,33% or categorized as very valid for audio visual communication aspect. There is a harmony between image, backsound, and sound effects. Also there is a harmony of the colors with the background given on the game.

Geometrichem game has met the software engineering aspect as it was rated 91,66% or categorized as very valid. Geometrichem as a software has met the maintainable, usable, and compatible aspects. Geometrichem game is easy to maintain, easy to use, easy to install on the device, and does not require additional applications to operate it. Also on installation window, information about the specification of computer device that adequate the installation of the program is available. Geometrichem is compatible for computer with 32-bit or 64-bit versions of Windows operation system.

Geometrichem game as computer-based learning media on molecular shape topic is declared very valid based on expert judgment as the average of the validity percentage is 89,29%.

3. Trial

Geometrichem game trial was conducted to 18 students of grade 10 science at SMAN 1 Gresik. The result of trial stage is described as follows.

a. Student learning outcomes

Student learning outcomes were obtained from pretest and posttest results. This learning outcomes result determined the effectiveness of Geometrichem game as learning media for molecular shape topic. The result of pretest and posttest is described in Figure 6.

Comment [s17]: highly

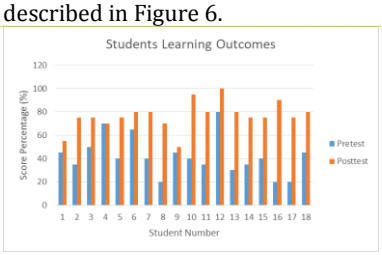

Figure 6. Students Learning Outcomes

Before the learning activity was conducted using Geometrichem as learning media, pretest was carried out to the students. The pretest results showed that 17 out of 18 students scored < 75 or categorized as incomplete. The classical completeness determined from the pretest score was 5,56%.

After using Geometrichem game as learning media, posttest was carried out to the students. The posttest results showed that 14 out of 18 students scored > 75 or categorized as complete. The classical completeness determined from the posttest score was 77,78% or > 75 and Geometrichem is effective according to the classical completeness.

Comment [s18]: highly

The result of normality test through Shapiro-Wilk Test by SPSS is described in Table 4.

Table 4. Normality Test Result

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.204	18	.046	.910	18	.084

Posttest	.223	18	.018	.906	18	.074

a. Lilliefors Significance Correction

The result of Shapiro-Wilk Test by SPSS was, the significance value of pretest = 0,084 or > 0,05 which means the pretest data is normally distributed. The significance value of posttest = 0,074 or > 0,05 which means the posttest data is normally distributed. According to the normality test, it can be concluded that students learning outcomes data is normally distributed. The statistical analysis used to determine the effectiveness of Geometrichem game was parametric statistical model, in this research was the T-Test(Mishra et al., 2019; Razali & Yap, 2014).

The T-Test conducted in this research was Paired Samples T-Test. The hypothesis of the test were:
H_0: there is no significant difference between pretest and posttest scores.
H_a: there is significant difference between pretest and posttest scores.

The result of Paired Samples T-Test by SPSS is described in Table 5.

Table 5. Paired Samples T-Test Result

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Posttest - Pretest	34.72222	18.97926	4.47346	25.28406	44.16039	7.762	17	.000

According to Table 5, the t score = 7,762 or > t table (2,110) and the significance value = 0,000 or < 0,05. According to the result, it can be concluded that H_0 is rejected and H_a is accepted. It means that there is significant difference between pretest and posttest scores. Based on the students learning outcomes, Geometrichem game as learning media in the molecular shape topic is effective.

b. Result of student response questionnaire

The result of student response questionnaire was used to determine the practicality of Geometrichem game as learning media for molecular shape topic. The questionnaire was distributed to the students after Geometrichem game trial. The result of student response is described in Figure 7.

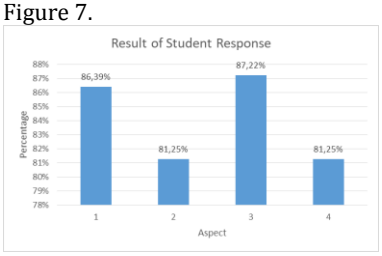

Figure 7. Result of Student Response

Legend:
1 = clarity of content and language
2 = convenience
3 = attractiveness
4 = usefulness

Clarity of content and language aspect was rated 86,39% or categorized as very practical. This is supported by the results of each indicators of the aspect. The ease of

understanding the material was rated 84,72%. Legibility and simplicity of letter used in Geometrichem game was rated 86,11%. The ease of language used was rated 86,11%. Appropriateness of pictures in Geometrichem game with molecular shape topic was rated 86,11%. The clarity of pictures and videos in Geometrichem game was rated 88,89%.

Convenience aspect was rated 81,25% or categorized as very practical. This is supported by the results of each indicators of the aspect. The ease of use indicator was rated 72,22%. The ease of understanding the guidance and instruction was rated 90,28%.

Attractiveness was rated 87,22% or categorized as very practical. This is supported by the results of each indicators of the aspect. The attractiveness of the display was rated 90,28%. The color selection was rated 86,11%. The neatness of the design was rated 80,56%. The appropriateness of layout and letters arrangement was rated 91,67%. Attractiveness of the material content was rated 97,50%.

Usefulness was rated 81,25% or categorized as very practical. This is supported by the results of each indicators of the aspect. 79,17% students stated that after using Geometrichem game, they are interested more to study chemistry, especially in molecular shape topic. 86,11% students stated that by using Geometrichem game, learning activities become more fun. 81,94% students stated that they understood molecular shape topic better after using Geometrichem game. 77,78% students stated that after using Geometrichem game, their learning autonomy in molecular shape topic was improved.

According to the student response in overall aspect, Geometrichem game as learning media in molecular shape topic is categorized as very practical as rated 84,03%.

c. Result of student learning autonomy questionnaire

The results of student learning autonomy questionnaire were used to determine the effectiveness of Geometrichem game as learning media for students learning autonomy in molecular shape topic. The questionnaire was distributed to the students twice, before and after using Geometrichem game as learning media in molecular shape topic. Figure 8 describes the result of student learning autonomy.

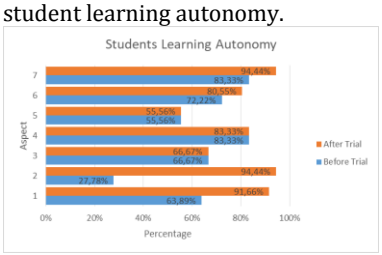

Figure 8. Students Learning Autonomy

Legend:
1 = student motivation
2 = use of learning resource
3 = learning strategy
4 = planning
5 = self-monitoring
6 = self-evaluation
7 = environmental factor

According to students learning autonomy data, before the trial of Geometrichem game, 83,33% students had their motivation to learn chemistry especially in molecular shape topic. After using Geometrichem in molecular shape topic, 94,44% students had their motivation to learn chemistry especially in molecular shape topic. This is supported by the result of student learning autonomy questionnaire which shows that before the trial, 77,78% students stated that the learning activity carried out by the teacher could improve their learning motivation. After the trial, 88,89% students admitted that their motivation to study was improved because of the

use of Geometrichem game as learning media. Before the trial, 50% students admitted that they study chemistry, especially in molecular shape topic on their own, without being told by their parents or teacher. After the trial, 94,44% students stated that they can study molecular shape topic on their own, without being told by their parents or teacher, utilized by Geometrichem game. It can be concluded that Geometrichem game improved students learning motivation in learning chemistry, especially in molecular shape topic.

Geometrichem game can be used as a learning resource. This is supported by the result of students learning autonomy questionnaire. Before the trial, 27,78% students stated that they were not able to do their exercise without any help of others. After the trial, 94,44% students stated that after using Geometrichem game, they are able to do their exercises without any help of others.

Geometrichem has no influence in students learning strategy aspect, as supported by the result of student learning autonomy questionnaire which showed that before the trial, 66,67% students asked the teacher when experiencing difficulties, and the remaining 33,33% did not. The same results were found after Geometrichem trial.

Geometrichem has no influence in planning aspect, as supported by the result of student learning autonomy questionnaire which showed that before the trial, 83,33% students prepared everything needed in learning activity such as learning resources, and the remaining 16,67% did not. The same results were found after Geometrichem trial.

Geometrichem has no influence in self-monitoring aspect, as supported by the result of student learning autonomy questionnaire which showed that before the trial, 55,56% students studied even though the teacher was not present, and the remaining 44,44% did not. The same results were found after Geometrichem trial.

Geometrichem improved student self-evaluation. Before the trial, 72,22% students performed self-evaluation in molecular shape learning activity. This is supported by the result of student learning autonomy questionnaire which shows that before the trial, 50% students correct their errors or rework the exercises given by the teacher. 94,44% students always do their homework given by the teacher. After Geometrichem trial, 80,55% students perform their self-evaluation. This is supported by the result of student learning autonomy questionnaire which shows that after using Geometrichem game, 66,67% students correct their errors or rework the exercises as they did when playing Geometrichem. 94,44% students always do their homework given by the teacher.

Environmental factor in this research associated with the use of Geometrichem game as learning media in molecular shape topic. Before the trial, 83,33% students agreed that if learning activity in molecular shape topic is carried out using game as learning media, it will improve their learning autonomy. After using Geometrichem game as learning media, 94,44% students admitted that Geometrichem game improved their learning autonomy in studying molecular shape topic.

According to the student learning autonomy in overall aspect, Geometrichem game improves student learning autonomy in molecular shape topic in student motivation, use of learning resource, self-evaluation, and environmental factor aspects, but not in learning strategy, planning, and self-monitoring aspects.

d. Result of student activity observation

Student activitiy observation involved the installation process of

Geometrichem game, the practice of playing Geometrichem game in each level, the time needed by students to play each level, student playing completeness and student learning autonomy. The result of student activity observation is described in Figure 9.

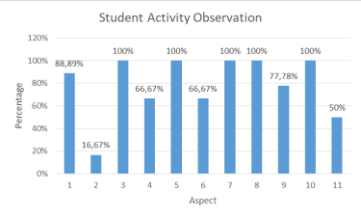

Figure 9. Student Activity Observation

Legend:

1 = Have no difficulty installing Geometrichem
2 = Have no difficulty playing level 1
3 = Finish level 1 less than 45 minutes
4 = Have no difficulty playing level 2
5 = Finish level 2 less than 45 minutes
6 = Have no difficulty playing level 3
7 = Finish level 3 less than 45 minutes
8 = Play the game until level 3
9 = Repeat the game level if have not reached the minimum score
10 = Do the exercise by themselves
11 = Use books or other learning resources to help answer the question

The observation result shows that 11,11% students had difficulty installing Geometrichem game in their computer, and the rest 88,89% did not. The difficulty was caused by the device error and the incomplete download of Geometrichem installer. The solution of this problem was deleting and re-downloading the Geometrichem installer, also refreshing the computer and reinstalling Geometrichem program.

83,33% students had difficulty playing Geometrichem in level 1, and the rest 16,67% did not. The difficulty they had was because they were trying to play it for the first time. When playing level 2 and 3, 66,67% students had no trouble because they had tried it at level 1.

Time needed by 100% students to finish each level was less than 45 minutes. 100% students played the game until level 3. 77,78% students repeat the game level if they have not reached the minimum score. While the remaining 22,22% students get less than the minimum score in level 3 and did not repeat the level. 100% students did the exercise in Geometrichem game by themselves. 50% students used their books or other learning resources to help them answer questions in Geometrichem game.

The practicality percentage of student activity observation in Geometrichem game in average was rated 78,79% or categorized as good. According to the result of student activity observation, Geometrichem game as a learning media to improve student learning autonomy in molecular shape topic is practical.

Conclusion

Geometrichem game have been declared feasible for the use as a learning media in molecular shape topic with the following details.

1. The validity of Geometrichem game in the term of content and construct validity has been rated 89,29% or categorized as very valid by the validators. The content validity of Geometrichem game has been rated 72,91% or categorized as valid, and the construct validity has been rated 92,01% or categorized as very valid.

2. The practicality of Geometrichem game according to students response and activity observation has been declared practical as the result of students response has been rated 84,03% or categorized as very good, and students activity observation has been rated 78,79% or categorized as good.
3. The effectiveness of Geometrichem game according to students learning outcomes through pretest and posttest has been declared effective as the T-test result showed that t score = 7,762 is higher than the t table = 2,110 and the significance value = 0,000 is lower than 0,05, which can be concluded that there is significant different between pretest and posttest score. Geometrichem game has been declared effective according to the classical completeness determined from the posttest score as rated 77,78%.
4. Geometrichem game has improved student learning autonomy in molecular shape topic according to students learning autonomy questionnaire in student motivation, use of learning resource, self-evaluation, and environmental factor aspects, but not in learning strategy, planning, and self-monitoring aspects.

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