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Development of Reaction Rate Animation Application (Alare) to Train Students' Critical Thinking Skills on Reaction Rate Material

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Abstract
The purpose of this research is to produce an Alare application that is feasible to use to train students' critical thinking skills in the sub-material of factors that affect the reaction rate. The feasibility of the Alare application is reviewed from three aspects, namely validity, practicality, and effectiveness. This research used the Research and Development (R&D) method with the Sukmadinata development model. The limited trial was conducted in class XI IPAS of Senior High School 20 Surabaya with 16 students. The research data shows that (1) Alare application is declared valid as indicated by the mode of content validity and construct validity of 4 with the valid category, (2) Alare application is declared practical as indicated by the average results of student response questionnaires, which are supported by student activity observations, amounting to 89.2% with very practical criteria, (3) Alare application is declared effective based on the increase in the acquisition of pretest and posttest scores of critical thinking skills and also the completeness of students' learning outcomes. The value of students' critical thinking skills based on the N-gain score increased because the medium-g and high-g criteria were obtained. The completeness of students' learning outcomes in both individual and classical completeness is significantly complete with a percentage of 100%. Based on this, it can be concluded that the Alare application is feasible to use to train students' critical thinking skills on reaction rate material.

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INTRODUCTION

Chemistry is a topic that is considered difficult by students (Sariati et al., 2020). The same thing to the results of pre-research data obtained at Senior High School 20 Surabaya on June 5, 2024, which took 22 students of class XI as samples, which has been carried out with 100% of students stating chemistry is a difficult lesson. As many as 67% of students considered chemistry difficult because of abstract material and interrelated concepts. Chemistry is the science that investigates the composition, structure, properties, and reactions of compounds, especially atoms and molecular systems. Chemistry is closely related to physics and biology (Warlina, 2013). Johnstone, (1993) divides chemistry into 3 levels of representation, are macroscopic, submicroscopic, and symbolic representations.

The three levels of representation are macroscopic level representation of the properties of substances, submicroscopic level representation of abstract particles of matter, and symbolic level representation of chemical formulas, reaction equations, mathematical equations, etc. During the learning process, these three levels of representation are used. During the learning process, these three levels of chemical representations are used. This will help students understand abstract chemistry (Johnstone, 1993).

Reaction rate is an example of chemical material that requires a deep understanding of the three levels of representation. The subject matter of reaction rate includes the notion of reaction rate, factors affecting reaction rate, reaction rate equation, order (reaction rate), and collision theory (Herawati et al., 2013). Studying reaction rate material involves many important chemical concepts (Kolomuç & Tekin, 2011). Thus, students can understand and relate chemical ideas correctly. A deep understanding of the three levels of chemical representation will help students when studying chemistry (Buket Yakmaci & Emine, 2013).

According to Ihsan, Ramdani, & Hadisaputra (2019) the three levels of representation in chemistry learning, students must have a higher level of thinking or HOTS (High Order Thinking Skill). One of the components of high-level thinking is critical thinking. Critical thinking allows students to truly understand complex information (Dwyer et al., 2012). In the world of education, science is very difficult for students to understand. So that learning in this science must emphasize the provision of direct experience so that students develop their competencies to improve their critical thinking skills (Hassan et al., 2020). Critical thinking in learning is also important so that it can construct students' knowledge so that it is even better (Astuti et al., 2018). Factors that affect the reaction rate, are one of the chemical sub-materials that can train critical thinking (Agustin et al., 2016).

According to Facione & Gittens (2016), critical thinking in cognitive skills includes interpretation, analysis, evaluation, inference, explanation, and self-regulation. These analyzing skills are closely related to learning materials, especially in interpretation, analysis, evaluation, inference, and explanation. Meanwhile, self-regulation is not directly related to learning materials, but rather to self-monitoring and self-correction (Facione & Gittens, 2016). This research is also supported through pre-research data obtained at Senior High School 20 Surabaya on June 5, 2024, which took 22 students of class XI as samples, the results obtained from students about critical thinking skills in each component, namely, (1) The interpretation component gets a percentage of 42.86%, (2) The analysis component gets a percentage of 38.10%, (3) The evaluation component gets a percentage of 42.06%, (4) The inference component gets a percentage of 42.86, (5) The explanation component gets a percentage of 53.17. A question and answer/interview conducted with a chemistry teacher at SMAN 20 Surabaya stated that the majority of students have moderate critical thinking skills.

In addition, along with human growth, science, and technology also continue to develop, resulting in significant transformations for humans. One example is the media used as a learning container or learning media (Anshori, 2018). However, in fact, the teaching and learning process refers to traditional learning tools, and does not attract students' interest in learning (Khaeruman et al., 2015). This is in accordance with the results of pre-research, where the learning process still uses student worksheets as the main learning media.

In this study, researchers want to offer one type of learning media. One type of learning media is multimedia (Yaumi, 2017). Animation is one of the parts of multimedia. The word "Animation" comes from the English word "to animate", which means "to move" to move something still, such as an image or object (Ramadhona et al., 2017). Animation can be utilized by teachers as an engaging and fun learning media for students that makes learning not boring (Novita et al., 2020). Animation can also foster critical thinking skills (Falah et al., 2016).

Based on previous research, several media have been used and influence critical thinking skills. Among them, the media used by Subhan & Danial (2018) in their research shows that animation media can help improve the critical thinking skills of students in class XI IPA Senior High School 21 Makassar. Then in his research, Majora (2022) developed animated learning video media in which there are 3 levels of chemical representation, namely macroscopic, microscopic, and symbolic. Because the 3 levels of representation are contained

in animated learning videos, the learning atmosphere is more exciting, and more fun. So that it can increase the motivation and learning outcomes of students of class XI MIA Senior High School 1 Bolaang. Therefore, because there is still no application related to the Android operating system that is equipped with animation on the reaction rate material in it, it is necessary to develop the application.

Therefore, critical thinking skills are very important, not only in learning, but also in problem solving as adults (Mashami et al., 2021). In addition, the results of pre-research also show that the critical thinking skills of students are still relatively low. With the help of the use of animation media, it is expected to make learning more interesting and fun, and also help students improve their critical thinking skills.

Based on the previous information, a learning media that can be designed to display three levels of representation is needed to help students learn chemistry., especially reaction rate material, and also to train their critical thinking skills. So, the researcher is impressed to carry out research through the title "Development of Reaction Rate Animation Application (Alare) to Train Students' Critical Thinking Skills on Reaction Rate Material".

METHOD

The research design used in this study is research and development proposed by Borg and Gall and modified by Sukmadinata. The ten stages of research and development proposed by Borg and Gall were modified into three stages, namely preliminary studies, model development, and research model testing (Sukmadinata, 2015). This research was only conducted until the trial stage so it only focused on the level of feasibility in terms of validity, practicality, and effectiveness of the results. This research was carried out for 3 months, in April-June 2024.

The preliminary study stage consists of 3 stages, there are literature study, field survey, and product preparation/initial draft. The literature study focused on concepts and theories related to the developed media, and previous research on this topic was also studied. A field survey was conducted to obtain information about how learning is carried out in schools. Product development/initial draft, at this stage, based on the findings obtained from the literature study and field survey, an initial draft was prepared to be taken to the next stage.

The result of the model development stage is media that can be used as learning media based on the results of the review. This review consists of a review and validation process carried out by experts. The review was conducted by one lecturer, while the validation was conducted by two lecturers and one chemistry teacher. Then revisions were made according to the validator's suggestions and comments. This stage has the aim of producing media that is suitable for use in the trial stage.

The trial stage can be carried out after the developed media application is declared valid at the previous stage. The trial used in this study was a limited trial. This trial aims to obtain data on the practicality and effectiveness of the developed media. Data on the practicality of the learning media developed is obtained from the student response questionnaire which is supported by the student activity observation sheet. Then the effectiveness data in this research was taken from the analysis of pre-test and post-test scores, this test was given before and after using the developed learning media.

The product developed in this research is learning media in the form of reaction rate animation applications (ALARE) that run on devices with the Android operating system to train critical thinking skills on reaction rate material. This study used the One Group Pretest-Posttest Design method. The research design is presented in Table 1.

Table 1. One-group pretest-posttest research design

Group	Pretest	Treatment	Posttest
Experimental group	O_1	X	O_2

Description:
O_1 : Pretest score (before treatment)
O_2 : Posttest score (after given treatment)
X : Treatment using the Alare Application

The subject of this research is the reaction rate animation application (Alare) on the material of the reaction rate which was tested on students in class XI Senior High School 20 Surabaya who had received the material.

The data collection method in this research is a questionnaire method including a review questionnaire assessed by one chemistry lecturer to get suggestions and comments, then a validation questionnaire assessed by three validators to determine the validity of the Alare application in terms of content validity and construct validity, there is also a student response questionnaire given to students at the end of the activity to determine the practicality of the Alare application based on student responses, After the questionnaire method there is also an observation method carried out by observers, namely fellow students to observe student activities during the trial process to support the results of the student response questionnaire, and finally the test method which is divided into two, namely pretest and posttest to determine the initial ability of students before and after using the Alare application based on the results of the critical thinking skills test.

Validation Data Analysis Technique for Alare Application

Data from validation results were analyzed descriptively and quantitatively. Scoring is based on a Likert scale as shown in table 2.

Table 2. Likert scale

Scores	Criteria
1	Invalid
2	Less Valid
3	Valid Enough
4	Valid
5	Very Valid

(Riduwan Adaptation, 2015)

The data obtained in the validation is in the form of ordinal data which has the nature that mathematical operations cannot be performed (added, subtracted, multiplied, and divided), so the determination is done by mode. In this study, the criteria were applied: the minimum score obtained was 3 or the category is quite valid.

Analysis of Student Response Questionnaire for Alare Application

Data on the results of students' responses were analyzed descriptively and quantitatively. In the student response questionnaire in the form of positive and negative statements. Scoring is based on the Guttman scale score in Table 3.

Table 3. Guttman Scale Score

Response	Answer	Score
Negative	Yes	0
	No	1
Positive	Yes	1
	No	0

(Riduwan Adaptation, 2015)

The data obtained will be analyzed using the following formula.

$$\%\, response\ of\ student = \frac{\sum Score\ obtained}{\sum maximum\ score}\ x\ 100\%$$

The results of the response questionnaire will be used to determine the practicality of the Alare application, using the score interpretation shown in Table 4.

Table 4. Percentage of practically criteria

Percentage (%)	Criteria
0 - 20	Not Practical
21 – 40	Less Practical
41 – 60	Practical Enough
61 – 80	Practical
81 – 100	Very Practical

(Riduwan Adaptation, 2015)

Based on Table 4, the Alare application is said to be practical to very practical if a practicality percentage of ≥ 61% is obtained. The results of the student response questionnaire analysis are also supported by the student activity observation sheet.

Analysis of Student Activity Observation Sheet for Alare Application

The results of the observation of students' activities are used to support the data of the students' response questionnaire by seeing whether the results of the analysis of the student's response questionnaire data are in line with the results of the observations made. Observations were made by observers who were chemistry students. Scoring is based on the Guttman scale score in Table 3. The data obtained will be analyzed using the following formula.

$$\%\, response\ of\ student = \frac{\sum Score\ obtained}{\sum maximum\ score}\ x\ 100\%$$

The results of the response questionnaire will be used to determine the practicality of the Alare application, using the score interpretation shown in Table 5.

Table 5. Percentage of practically criteria

Percentage (%)	Criteria
0 - 20	Not Support
21 – 40	Less Support
41 – 60	Support Enough
61 – 80	Support
81 – 100	Very Support

(Riduwan Adaptation, 2015)

Based on Table 5, the student observation sheet is declared supportive if the percentage of support is ≤61%.

Data Analysis of Critical Thinking Skills and Student Learning Outcomes

On critical thinking skills. The achievement of an increase in students' critical thinking skills is reviewed through normalized gain (N-gain) with the following formula.

$$N - gain = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score}$$

The normalized gain score obtained is interpreted in Table 6. Improvement in critical thinking skills is achieved if the N-Gain score ≥ 0.3 with a minimum category of medium-g.

Tabel 6. N-gain criteria

Score N-Gain	Criteria
$N - gain \geq 0{,}7$	High-g
$0{,}7 > N - gain \geq 0{,}3$	Medium-g
$N - gain < 0{,}3$	Low-g

(Sukarelawan et al., 2024)

The learning outcomes of students are used to determine the effectiveness of the Alare application used to train students' critical thinking on reaction rate material, with individual learning completeness set at a score of ≥75 according to the school's criteria for achievement of learning objectives (KKTP) and classical completeness set at ≥85% (Anwari & Kusumadani, 2022). Classical completeness can be calculated using the following formula.

$$Classical\ completeness = \frac{Number\ of\ students\ who\ are\ complete}{Number\ of\ all\ student}\ x\ 100\%$$

RESULTS AND DISCUSSION

The development of this Alare application is based on the research and development (R&D) method by Sukmadinata (2015) which is the result of a modification of the 10 steps of Borg and Gall research and development. This research consists of 3 stages, namely, preliminary studies, model development stages, and model testing stages.

Preliminary Study Stage

This stage consists of 3 stages, namely, literature study, field survey, and product preparation/initial draft.

Literature Study

The literature study focused on related concepts and theories through the Alare application. In addition, previous research on this topic was also studied. From the results of the study conducted, it was found that based on the learning theory of cognitive development according to Jean Piaget, senior high school students are in the internal formal stage, where children can think abstractly and logically, and are also able to overcome situations using hypotheses (Nurlina et al., 2021). In the context of constructivism, teachers can assist in the learning process, so that students achieve their goals (Herliani et al., 2021). The assistance provided can be in the form of media that supports the learning process, such as the Alare application developed. Based on the stages of information processing learning theory, namely the sensing stage, processing stage, and output stage (Haqi et al., 2023). The animation in the Alare application is designed to attract the attention of students so that it makes it easier for students to achieve these three stages. In dual coding theory, it is said that if information is included with images, the text will be easier to remember (Mariana et al., 2011). In the video in the Alare application, some texts are complemented by images, so it is hoped that students can be more efficient in learning.

Based on a review of previous relevant research. There are some articles related to this investigation. The research shows that in the first article, animation media can support chemistry learning on reaction rate material. Then in the second article, animation media can support the improvement of students' critical thinking skills. Then in the third article, animation media also has a significant impact on the growth of students' critical thinking skills. Based on some of these articles, there is still no research related to animated media that can train students' critical thinking skills on reaction rate material, so researcher are interested in research on this topic.

Field Survey

The field survey was conducted to obtain information about how learning is carried out in schools (Sukmadinata, 2015). The field survey was conducted at Senior High School 20 Surabaya. At this stage, data were collected through teacher interviews, pre-research questionnaires of students, and tests on students to determine their critical thinking skills. This critical thinking skills tracking test aims to see the critical thinking skills possessed by students before conducting a limited trial for the development of Alare application learning media.

The results of the chemistry teacher interview show that the minimum passing criteria value in chemistry learning is 75, then, for critical thinking skills, the majority of students are still in the middle category.

The results of the pre-research showed that students stated that all students agreed that the lesson that was difficult to understand was chemistry, and as many as 71% of students agreed that the material that was difficult to learn was the reaction rate. Then the results of the tracking test of students' critical thinking skills on reaction rate material indicated by percentage in each critical thinking component of interpretation, analysis, evaluation, inference, and explanation are 43%, 38%, 42%, 43%, and 53%. As a finding of the critical thinking skills tracking test, it appears that students do not have sufficient ability in their critical thinking skills.

Based on the description above, a learning media is needed that can make students interested in learning and practicing their critical thinking skills on reaction rates. From the pre-research, it was seen that they were impressed to use animation-based learning media because it could facilitate learning chemistry.

Product Development/Initial Draft

Based on the findings obtained from the literature study and field surveys that have been carried out, an initial draft of the Alare application was prepared. The Alare application was created using the Kodular website and the animation was created using the Alight Motion application. Some views of the Alare application at this stage are presented below.

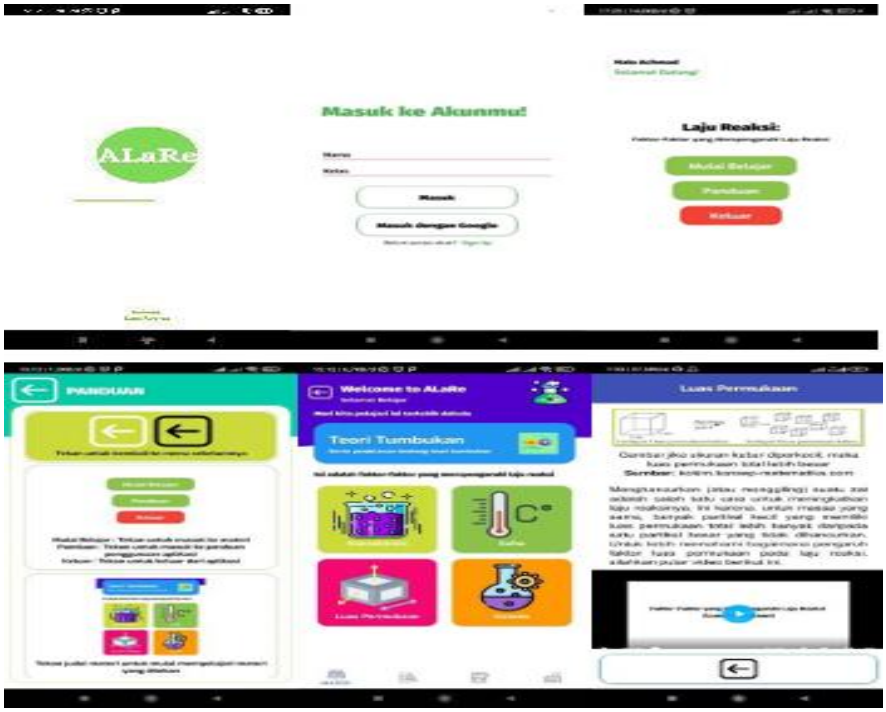

Figure 1. Some views of the initial draft Alare application

Furthermore, pretest and posttest questions were also made, totaling 15 questions about the theory of reaction rate, especially the sub-theory of factors that affect the reaction rate. The questions were divided into 2 parts, namely, the first 5 questions to test understanding of the reaction rate, while the remaining 10 questions were to test students' critical thinking skills.

Development Stage

This stage consists of 2 stages, namely, learning media review, and learning media validation.

Learning Media Review

Media review has several steps, namely, media draft 1, media review, improvement, and media draft 2. In the preparation of the initial draft, draft 1 media was produced. Then draft 1 media was reviewed by one chemistry lecturer to provide constructive criticism and direction on the media improved by the researcher. The criticism and direction were then used as a reference for media improvement. After the improvement, the media draft 2 was produced.

Learning Media Validation

A media is declared valid if it meets content validity and construct validity. Content validity assesses that the media can answer the needs, and each component must be based on the latest knowledge. Meanwhile, construct validity assesses if all media components must be consistently linked to each other (Plomp & Nieveen, 2013). Validation of learning media in this study was carried out by 3 validators, namely, 2 chemistry lecturers and 1 chemistry teacher on content validity and construct validity in the Alare application. The data from the validation assessment were then analyzed on each indicator using the mode. In this study, it is said to be valid if it gets a minimum mode value of 3 or with a fairly valid category. Validators can also provide comments and suggestions if needed. Based on Table 7, shows that the alare application has a mode 4 in the content and construct aspects, so it is included in the valid category.

Table 7. Alare application validation scores

Validity	Aspect of validation	Mode	Criteria
Content	Suitability with criteria related to the material	4	Valid
	Suitability of media with criteria related to illustrations	4	Valid
Construct	Characteristics of chemistry	4	Valid
	Media can facilitate students in learning	4	Valid
	The existence of rules/guidelines	5	Very Valid
	Encourage the development of student’s critical thinking skills	4	Valid
	The Media uses good and correct Indonesian language	5	Very Valid
	Media display as learning media	4	Valid

So, it can be concluded that the entire validity of the Alare application gets a mode score of 4 with a valid category when analyzed from content validity and construct validity. Thus, stating that the Alare application that has been developed can be declared valid as learning media.

Testing Stages

The test conducted in this research is a limited trial. Limited trials were carried out after the Alare application was declared valid. This limited trial was conducted at Senior High School 20 Surabaya class XI IPAS with 16 students. This trial aims to obtain data on the practicality and effectiveness of the Alare application developed. Practicality is a condition in which the media can be used in situations that have been designed and developed (Plomp & Nieveen, 2013). Data regarding the practicality of the Alare application was obtained from a questionnaire of students' responses supported by an observation sheet. The response questionnaire was given after the media trial was conducted. The overall score obtained in the

student response questionnaire received a percentage of 89.2% with a very practical category. Analysis of student response questionnaires shows the practical aspects of using the Alare application in training students' critical thinking skills on reaction rate material. The result for each aspect percentage of the student response questionnaire is presented in Table 8.

Table 8. Student response score

Assessment Aspects	Score	Criteria
Students' interest in the developed application	93,7%	Very Practical
Ease of students to use the application developed	84,5%	Very Practical
The usefulness of the Alare application on student learning outcomes	89,6%	Very Practical

This is shown when students use the Alare application, students look happy when they see the animation contained in the application. They understand better how factors affect the reaction rate based on the animation presented by the application. This makes students easier to do the posttest. Students also become more understand about the correct critical thinking process based on the exercises presented in the Alare application.

The student activity observation sheet was used to support the data obtained in the student response questionnaire. Observation of students' activities was carried out by 4 observers with each observer observing 4 students in the use of the Alare application individually. Thus, it can be concluded that the practicality of the Alare application is reviewed from the results of the questionnaire with a percentage of 89.2% in the very practical category and supported by the results of the observation of students' activities which get a percentage of 96.3% in the very support category, the result for each aspect percentage of the student response questionnaire is presented in Table 9. thus, stating that the Alare application that has been developed can be declared practical as a learning media.

Table 9. Student activity score

Assessment Aspects	Score	Criteria
Students' interest in the developed application	89%	Very Support
Ease of students to use the application developed	100%	Very Support
The usefulness of the Alare application on student learning outcomes	100%	Very Support

Data on the effectiveness of the Alare application is obtained from the pretest and posttest scores of students, the pretest is given at the beginning of the activity to determine the initial score, while the posttest is given at the end of the activity to assess learning outcomes. Effectiveness itself is a condition where the media can produce the desired results (Plomp & Nieveen, 2013). There are 2 tests used to measure the effectiveness of the Alare application. First, a test to measure the improvement students' critical thinking skills, and the second is a test to determine students' learning completeness about reaction rate material. The test was given before and after using the Alare application. First, the improvement of students' critical thinking skills was analyzed using the n-gain formula and was declared achieved when getting an N-gain score ≥ 0.3 with a minimum category of medium-g. The N-gain score of each student can be seen in Table 10.

Table 10. Student N-gain score of critical thinking skills

Student Number	Pre-Test	Post-Test	N-gain	Criteria
1	47	77	0,56	Medium-g
2	43	100	1,00	High-g
3	50	100	1,00	High-g
4	33	67	0,50	Medium-g
5	33	73	0,60	Medium-g
6	40	80	0,67	Medium-g

Student Number	Pre-Test	Post-Test	N-gain	Criteria
7	43	97	0,94	High-g
8	33	77	0,65	Medium-g
9	47	77	0,56	Medium-g
10	50	93	0,87	High-g
11	60	97	0,92	High-g
12	30	73	0,62	Medium-g
13	43	87	0,76	High-g
14	43	100	1,00	High-g
15	47	100	1,00	High-g
16	53	87	0,71	High-g
Average	**43,44**	**86,56**	**0,77**	**High-g**

Based on Table 10, it can be seen that 7 students get an increase in the ability of students in the medium-g category, and 9 students in the high-g category, so it can be concluded that the improvement of students' critical thinking skills can be said to have been achieved. This increase in students' critical thinking skills can also be seen when students do the critical thinking skills posttest which looks easier to do, and the results show that there is an increase in students' critical thinking skills test scores.

Then, in the learning outcomes test given during the prestest and posttest to test the individual completeness and classical completeness of students on reaction rate material. Individual learning completeness set at a score of ≥75 according to the school's criteria for achievement of learning objectives (KKTP) and classical completeness set at ≥85% (Anwari & Kusumadani, 2022). Test consisting of 5 questions, the scores can be seen in Table 11.

Table 11. Pretest and posttest scores of students on the learning outcomes test

Student Number	Pretest		Posttest	
	Score	Completeness	Score	Completeness
1	40	Incomplete	100	Complete
2	40	Incomplete	100	Complete
3	40	Incomplete	100	Complete
4	40	Incomplete	100	Complete
5	60	Incomplete	100	Complete
6	60	Incomplete	100	Complete
7	60	Incomplete	100	Complete
8	40	Incomplete	100	Complete
9	40	Incomplete	100	Complete
10	60	Incomplete	100	Complete
11	100	Complete	100	Complete
12	40	Incomplete	100	Complete
13	40	Incomplete	100	Complete
14	60	Incomplete	100	Complete
15	60	Incomplete	100	Complete
16	100	Complete	100	Complete
Average	**55**	**Incomplete**	**100**	**Complete**

Based on Table 11, it can be seen that the pretest scores obtained by students before using the Alare application in terms of individual completeness, 14 students were not complete because they had not reached a score ≥75, with details of 8 students scoring 40 and 6 students scoring 60. In addition, 2 students were obtained who had passed individual completeness because they had received the maximum score of 100. Then, the posttest score obtained by all students after using the Alare application exceeded the individual completeness score, with

details of 16 students scoring 100. This shows that there are significant increase in the students' learning outcomes test. So it can be concluded that 16 students have obtained completeness when viewed from individual completeness. Then in classical completeness after using the Alare application, it can be declared complete because it gets a percentage of 100%.

CONCLUSION

The development of the Alare application to train students' critical thinking skills on reaction rate material has been carried out. The validity of the Alare application obtained mode 4 in the aspects of content and construct validity, so it was categorized as very valid. The students' response questionnaire to the Alare application showed a very good response in the trial process. This is evidenced by the student response questionnaire which gets an overall average percentage score of 89.2% positive response. The application of Alare was declared effective based on the increase in the acquisition of pretest and posttest scores of critical thinking skills and also the completeness of student learning outcomes. The value of students' critical thinking skills based on the N-gain score has increased because it obtained medium-g and high-g criteria. The completeness of student learning outcomes both individual and classical completeness is significantly complete with a percentage of 100%.

RECOMMENDATIONS

Based on the results of this study, it is recommended that the Alare application to train students' critical thinking skills on reaction rate material be developed on devices with other operating systems such as iOS.

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