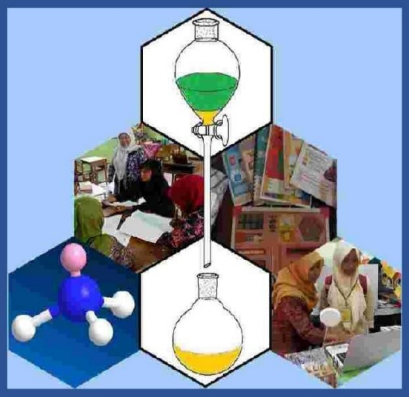
ISSN 2549-1644

JCER

JOURNAL OF CHEMISTRY EDUCATION RESEARCH

Volume 6 Number 1 Pages 1 – 92 June 2022



Publisher: Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. Email: jcer@unesa.ac.id

http://journal.unesa.ac.id/

DEVELOPMENT OF ASSEMBLR EDU-ASSISTED AUGMENTED REALITY LEARNING MEDIA ON THE TOPIC OF EFFECT OF SURFACE AREA AND TEMPERATURE ON REACTION RATE

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Abstract. *Understanding concepts at the submicroscopic and symbolic levels becomes challenge in studying subtopics of the effect of surface area and temperature because some parts are still abstract and difficult to understand. Creative and innovative learning media are needed to help learn concepts through visualization. This research aims to create product in the form of Augmented Reality assisted by Assemblr Edu that is valid, effective, and practical. This study is development research that adopts the modified Borg & Gall development model. The research subjects were 12 students of pre-service chemistry teachers. The research supporting instruments were validation sheets, test items, and response questionnaires. Data were analyzed using descriptive statistics and Aiken's V. The results showed that: (1) product fulfilled very valid criteria with average percentage of 91% with the results from the presentation and product use aspects of 90% (very valid), content aspect of 92% (very valid); language aspect by 92% (very valid); (2) the average test score of respondents after the trial is 75 which indicates that the results are good and the product is classified as effective; and (3) the average response to the product is 89% indicating that the product is very good and very practical for further use. This digital product is feasible to use and is recommended to support the understanding of the subtopic of the effect of surface area and temperature on the rate of chemical reactions.*

Keywords: *Augmented Reality, Assemblr Edu, Surface Area and Temperature, Reaction Rate*

INTRODUCTION

Chemistry is a branch of natural science that studies the properties, structure, and changes of a material along with their energy. The characteristic that distinguishes chemistry from other sciences is that most of the concepts of chemistry are abstract, simple, multilevel, and structured. Given this, it requires understanding and rational thinking to describe the facts and events that occur in the surrounding environment [1].

In fact, learning chemistry in high school is still not very attractive to students. Students assume that chemistry is a difficult subject to understand. In addition, the lack of students' interest in learning chemistry can affect the low learning outcomes of students, so it can be said that the learning objectives of chemistry subjects have not been achieved optimally [2].

Many factors cause students to not be able to achieve the Minimum Completeness Criteria (MCC) set by the school in chemistry learning, including a lack of understanding of the concept of chemistry and the occurrence of misconceptions in students. Misconceptions in chemistry learning often occur due to the lack of students' understanding of chemical concepts that are partially abstract, such as the concept of atoms, molecules, equilibrium, reaction rates, and so on. Students sometimes make their own interpretations of the concepts being studied as an effort to complete the learning they are going through. Sometimes the results of students' interpretations are not in accordance with chemical concepts that have been recognized by experts. This will have an impact on the emergence of misconceptions [3]. One of the materials that can be studied in chemistry and the most difficult at the high school level is the rate of reaction. The problem with this material

is that it takes time and effort to practice the effect of reaction rates [4].

Reaction rate is an abstract chemical concept. The nature of this abstraction is representative of the submicroscopic form, for example, the visualization of reacting molecules, collisions between molecules, and the speed of movement of molecules. This makes students have difficulty understanding the concept of this reaction rate [5]. Based on previous research conducted by Nazar et al. (2010), students experienced misconceptions about the material influencing the rate of reaction. Students often experience learning difficulties in the sub-topic of the influence of surface area and temperature on the reaction rate. On the temperature factor, students assume that an increase in temperature in a chemical reaction can affect the activation energy of the reactants. whereas the correct concept of temperature explains that the higher the temperature of a reaction, the faster the reaction of these substances will take place. On the factor of the surface area of the touch area, students assume that the smaller particle size has a smaller touch surface area in the same mass. The correct concept is that a substance that has a smaller size has a large surface area, so that a substance in the form of a fine powder will react faster than a compound whose shape is larger than a powder [6].

Students who have difficulty learning about the material factors that influence the rate of reaction find that it is possible to create new learning difficulties for materials related to chemical reaction kinetics. This will result in the low ability of students and a failure to achieve the completeness of student learning outcomes [7].

During chemistry learning, students still use learning books or modules with a simple appearance. This can reduce students' interest in reading and learning. That feels boring for students. One solution that can be offered in overcoming these problems is to use learning media assisted by the Assemblr Edu application with Augmented Reality technology on the subtopic of the influence of the surface area of the touch area and temperature on the reaction rate. The two subtopics of the factors influencing the rate of reaction can be clearly visualized in three-dimensional form through the Augmented Reality application, so that it can make learning more interesting and provide its own motivation for students to study the material.

Augmented Reality is a technology for merging two-dimensional or three-dimensional virtual objects into a real environment, and these objects can be projected in real time. The advantages of using augmented reality are that learning can be more interactive, its use is effective, and it can be widely implemented in various types of media. Its manufacture does not involve a lot of ordinary things, and it is easy to operate [8]. The Assemblr Edu application is an application that supports the use of Augmented Reality media. According to Ryza (2017), this application has several advantages, namely that it can provide direct experience to students, can visualize objects as a whole, and can provide a clear picture of objects. This application is designed to help teachers and students use and develop two-or three-dimensional content that can be realized in the form of Augmented Reality.

The purpose of this research is to develop a valid, effective, and practical chemistry learning product assisted by Assemblr Edu on the subtopic of the influence of the surface area and temperature on the reaction rate, and to increase students' conceptual understanding influencing the rate of reaction, especially the subtopic of the surface area and temperature.

METHOD

This study is Research and Development (R & D), which refers to the Borg & Gall development model (9: 772) which has been modified into five stages, namely Research and Information Collection; Planning; Developing a Preliminary Form of Product; Preliminary Field Testing; and Revising Final Products. The product created in this research is an Augmented Reality learning product assisted by the Assemblr Edu application, which is used in subtopic: the influence of the surface area and temperature on the reaction rate of chemical reactions. Other instruments that were also used to support this research were items in the pretest and posttest as well as questionnaire for respondents in responding to the product. The

product and all research instruments were validated and assessed by three validators.

After revising the product and supporting instruments, an online product trial was conducted through Zoom Meetings with 12 prospective teacher students from the Chemistry Education Study Program who were selected using purposive sampling technique.

Data from the product and all instruments were analyzed descriptively, and the validity of the items was analyzed using Aiken's V statistic. Information on data analysis can be described as follows:

A. Result Validation Analysis of Product and Questionnaire

According to Sistyarini & Nurtjahyani (2017), the percentage of validation result based on the validator score can be calculated using the formula:

$$\text{Percentage} = \frac{\text{Obtained total score}}{\text{Maximum score}} \times 100\ \%$$

The criteria for product validity and respondents' questionnaires are shown in Table 1.

Table 1. Criteria for Product Validity and Respondents' Questionnaires [10]

No	Percentange (%)	Validity Category
1	81 – 100	Very Valid
2	61 – 80	Valid
3	41 – 60	Quite Valid
4	21 - 40	Less Valid
5	0 - 20	Invalid

B. Item Validity Analysis

The quality of the items from the validation results is shown through the magnitude of the item validity coefficient (V) obtained through the formula:

$$V = \frac{\Sigma s}{n\,(c-1)}$$

Description:

S = r – Lo

Lo = the lowest number of validity assessments

c = the highest number of validity assessments

r = the score given by the validator

n = number of validators

The criteria for the validity of the items are shown through the Aiken validity coefficient value and can be determined by referring to Table 2.

Table 2. Criteria for Validity of the Items [11]

No	Aiken Validty Coefficient	Validity Criteria
1	0,80 < V ≤ 1,00	Very High
2	0,60 < V ≤ 0,80	High
3	0,40 < V ≤ 0,60	Quite High
4	0,20 < V ≤ 0,40	Low
5	0,00 < V ≤ 0,20	Very Low

C. Test Result Analysis

The values obtained in the pretest and posttest can be calculated using the formula:

$$\text{Score} = \frac{\text{Obtained total score}}{\text{Maximum score}} \times 100\ \%$$

The ability of respondents to answer questions can be determined in certain categories according to Table 3.

Table 3. Category of Respondents' Ability Based on Values [12]

Score	Category
80-100	Very Good
70 – 79	Good
60 – 69	Quite Good
40 – 59	Poor
0 – 39	Very Poor

The average final score of the respondents during this trial determines the effectiveness of the product used. The criteria are shown in Table 4.

Table 4. Product Effectiveness Criteria [13: 69]

Score	Criteria
76 – 100	Very Effective
51 – 75	Effective
26 – 50	Quite Effective
0 – 25	Ineffective

D. Analysis of Questionnaire Result

Questionnaire was given and filled out by all respondents at the end of the study. The percentage of the results of the questionnaire can be calculated using the formula:

$$\text{Percentage} = \frac{\text{Obtained total score}}{\text{Maximum score}} \times 100\ \%$$

The criteria for the response to the product being developed can be determined by referring to Table 5.

Table 5. Product Response Criteria [14]

Percentage (%)	Criteria
75-100	Very High
50-75	High
25-50	Medium
0-25	Low

Furthermore, the results of the average response questionnaire can determine the practicality of the product during the trial. The practicality criteria of the product developed are shown in Table 6.

Table 6. Product Practically Criteria [15: 89]

Percentage (%)	Criteria
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Quite Practical
21 – 40	Impractical
0 – 20	Very Impractical

RESULT AND DISCUSSION

The development of Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the influence of surface area and temperature on the reaction rate is designed using a development model by Borg & Gall [9: 772] which has been modified by researchers into five steps, namely Research and Information Collection, Planning, Developing Preliminary Form of Product, Preliminary Field Testing, and Revising Final Product. The following is description of the five steps:

A. Research and Information Collection

On the analysis stage, the researcher conducted an analysis of the previous research conducted by [5] regarding the misconceptions that occurred in the subtopics of the influence of the surface area and temperature. This study states that most students have misconceptions about the concept of the effect of surface area and temperature, with the largest percentage of misconceptions on the concept of the effect of temperature on the reaction rate. This encourages researchers to develop chemistry learning media with Augmented Reality technology based on the Assemblr Edu application on the subtopic of the influence of surface area and temperature on reaction rate. Augmented Reality is a technology that can combine two-or three-dimensional virtual objects into a real three-dimensional environment. Learning using Augmented Reality technology media can create interactive classes and is very effective for students because it can be used by various media [8].

The development of chemistry learning media with Augmented Reality technology assisted by the Assemblr Edu application, especially on the subtopic of the influence of surface area and temperature on the reaction rate, is needed in learning because the material is in harmony with the developed media. The material of the influence of surface area and temperature on the reaction rate explains the frequency of collisions between molecules and the speed of movement of molecules in collisions, thus affecting the rate of product formation. Reaction rate is an abstract material, so it requires visualization of the collision events between molecules that occur at the reaction rate, and visualization of the molecules involved in the reaction is also required. With the existence of chemistry learning media with Augmented Reality technology based on the Assemblr Edu application on the sub-topic of the influence of surface area and temperature on the reaction rate developed by the researchers, it is hoped that it can increase students' understanding of the concept of the material on the effect of surface area and temperature on the rate and create a learning atmosphere that is conducive to learning. It is interactive and fun so that it can motivate students during the learning process.

B. *Planning*

The Design of Augmented Reality Learning Media in Subtopics The Effect of Surface Area on Reaction Rate

The stages of designing Augmenterd Reality learning media on the subtopic of the influence of the touch surface area begin with creating 3D objects that are not available in the

Assemblr Edu application. The creation of these 3D objects is assisted by a helper application, namely Clara.io. The objects made in this application, namely Cl atoms and Na atoms, can be seen in Figure 1.

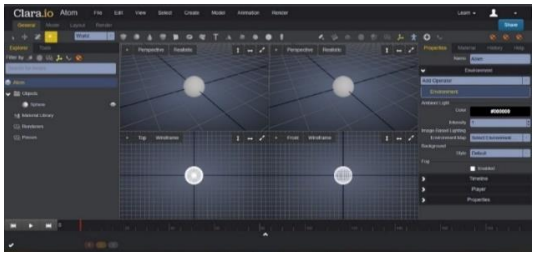

Figure 1. Designing Atoms in 3D Using the Clara.io App

After the 3D object is created and saved, the file in.abx format is inserted into Assemblr Studio for coloring. The coloring of Na atoms needs to follow the CPK coloring format with the hexadecimal number "AB5CF2" with a light purple color, while the Cl atom has a hexadecimal number "1FF01F" with a light green color [16: 123]. Atomic staining can be seen in Figure 2.

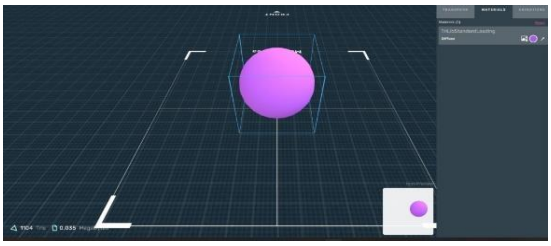

Figure 2. Na atom staining in Assemblr Studio

Product creation can be done by selecting a simple editor menu, after which a marker area display will appear for designing and designing products. In product preparation, there are several features that can be used, such as 3D objects, text, images, videos, and notes. Atomic objects that have been created with the inserted clara.io application will be in the 3D object feature in the custom component option. Products can be designed using several 3D objects, pictures, learning support videos, and explanatory notes, which can be seen in Figures 3, 4, and 5.

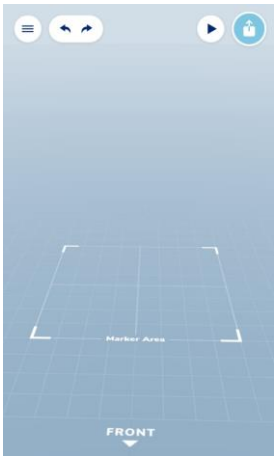

Figure 3. Marker Area Display

Figure 4. Display of Custom Component Menu Options

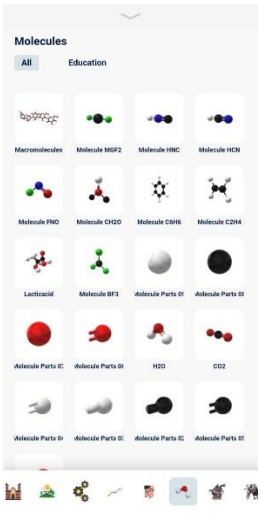

Figure 5. Molecules Assemblr Edu Menu Display

In the process of making Augmented Reality learning media, other additional applications are needed, such as the Canva

application, which is used to create images of the solvation process in NaCl salt. The appearance of the worksheet in Canva can be seen in Figure 6.

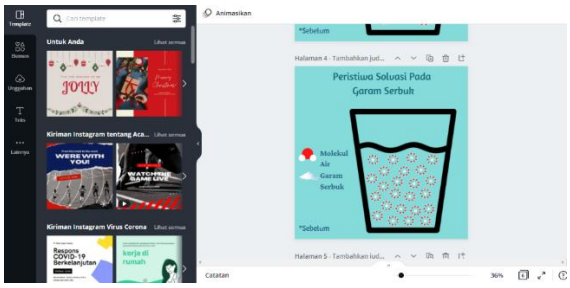

Figure 6. Solvation Event Visualization Design Display on NaCl

After designing products for the manufacture of products, Augmented Reality learning media on the subtopic of the effect of catalysts on reaction rates can be applied in chemistry learning. Visualization of the media can be observed through the "3D view" or "AR view" menu. In addition, there are three ways to be able to view media visualizations; namely, 1) it can be done using a barcode scan; 2) it can be done by clicking on the link on the following link, http://asblr.com/GAKjJ ; 3) visiting the class contained in the application Assemblr Edu, with class code: xsyyy. The visualization display of Augmented Reality learning media on the subtopic of the effect of surface area on the reaction rate and the barcode of the media

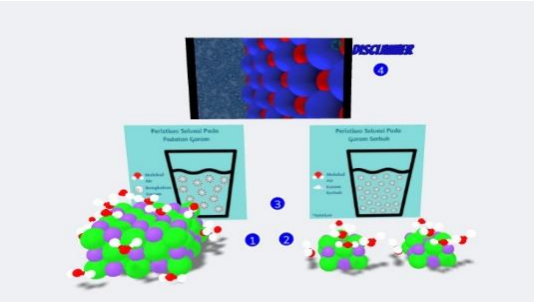

Figure 7. Product Display: Augmented Reality Media Effect of Surface Area on Reaction Rate

Figure 8. Product Barcode Display Augmented Reality Media Effect of Surface Area on Reaction Rate

Figure 9. Class Display Learning Media Factors Influence Assemblr Edu Application Reaction Rate

The Design of Augmented Reality Learning Media on the Subtopic Effect of Temperture on Reaction Rate

When making designs, there are several stages in developing this Augmented Reality-based learning medium. The main application that will be used to visualize learning media is Assemblr Edu. The Assemblr Edu application is an application that is used to visualize objects around you in 2D and 3D.

The first step is to make the sulfur element, then make a beaker, the water element in the beaker, and a thermometer. The elements are created because Assemblr Edu is still limited in the elements it can contain. For the manufacture of elements and tools created using Clara.io.

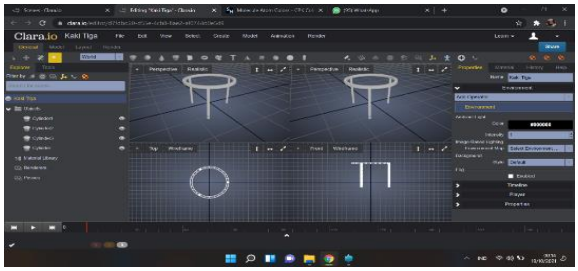

Figure 10. Creating Elements and Tools Using Clara.io

After creating these elements, we entered the sulfur element and tools such as tripods and thermometers into Assemblr Studio before being put into Assemblr Edu. Assemblr Studio is an application for editing these elements used in Assemblr Edu. Assemblr Studio is used to enter the color of elemental sulfur and also the tools used. After the color is entered, the elements and tools are uploaded and integrated into the details contained in Assemblr Studio. The S atom coloring needs to follow the CPK coloring format with yellow [17].

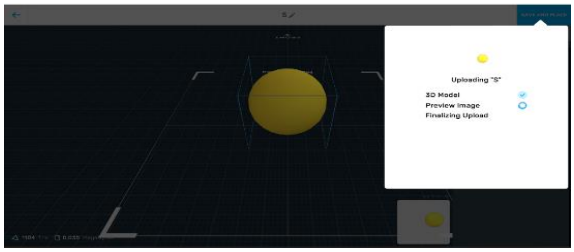

Figure 11. Adding Color to the Sulfur Element in the Assemblr Studio Application

After uploading, the learning media is ready to be developed using Assemblr Edu. Android and iOS users can use this application, so students can easily download this application on the Playstore and Appstore.

Figure 12. Assemblr Edu Aplication

Editing of media development can also be done after the required elements are complete.

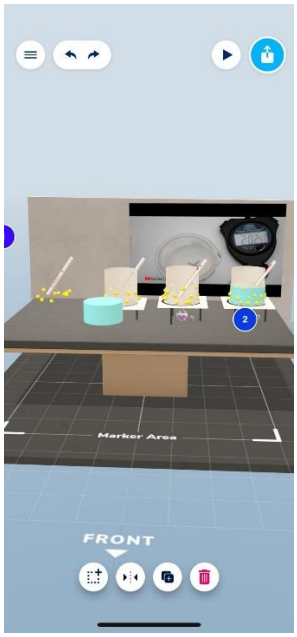

Figure 13. The Display of Augmented Reality Media Products, The Effect of Temperature on the Reaction Rate being Developed

In the developed learning media, there is an explanation related to the reaction of the developed media, namely the reaction between hydrochloric acid and sodium thiosulfate, which later, at a certain temperature, will produce solid sulfur elements as part of the product of this reaction.

The reaction of 0.1 M HCl with 0.1 M Na2S2O3 will produce a yellow sulfur precipitate. This sulfur precipitate is formed more and more as the temperature of the mixture increases. The reactions that occur are: $2HCl(aq) + Na_2S_2O_3(aq) \rightarrow S(s) + 2NaCl(aq) + H_2O(l)$ [18].

This explanation was edited using another application, namely Canva.

Figure 14. The Design of Chemical Reaction Description Using Canva

After completion, the explanation is inserted into the learning media so that students can find out the reactions that occur in the beaker. In addition to this explanation, an audio-visual-based explanation was also given in the form of a Practicum Video link from Youtube into the learning media so that students better understand the material regarding the factors of temperature that affect the rate of reaction. The higher the temperature in the reaction, the faster the reaction occurs.

When the temperature is raised, the molecules will move faster (the kinetic energy of the particles increases) so that the collisions between the particles are more effective. This causes the reaction rate to be faster [19].

Figure 15. Product Result Display

To enter the class that has been created, you can read the section on the design of Augmented Reality learning media on the subtopic of the influence of the surface area of the touch area on the reaction rate. The QR code for the Augmented Reality learning media subtopic, the effect of temperature on the reaction rate, is shown in Figure 16.

Figure 16. Product Display Barcode Augmented Reality Media Effect of Temperature on Reaction Rate

C. Developing Preliminary Form of Product (Validation Results)

Product Validation Result

Before being tested on users, namely prospective chemistry teacher students, Augmented Reality learning media assisted by the Assemblr Edu application on the sub-topic of the influence of surface area and temperature on the reaction rate has been validated first by three validators, namely two high school chemistry teachers and one expert lecturer. This validation was carried out to test the feasibility level of Augmented Reality learning media assisted by the Assembrl Edu application. Assessment in validation includes aspects of the product presentation and use, content aspects, and language aspects.

Table 7. Validation Result of Product

No	Rated Components	%	Validity Criteria
1	Aspects of Product Presentation and Use	90	Very Valid
2	Content Aspect	92	Very Valid
3	Language Aspect	92	Very Valid
	Average	91	Very Valid

Based on Table 7, the average final score percentage is 91% with very valid criteria. Judging from the product presentation and use aspect, the average ratio is 90%, with very valid standards. Based on these results and criteria, it is known that the Augmented Reality learning

media assisted by the Assemblr Edu application on the sub-topic of the influence of surface area and temperature on the reaction rate has fulfilled the requirements, namely, 1) attractive and systematic product presentation; 2) color compatibility, writing, and images in the product; 3) the product contains complete information; and 4) the product is easy to use in learning. The use of media in learning is an inherent part of the education process in high school to help achieve effective and efficient learning objectives. The existence of the media in the learning process is quite important for students. Learning media helps in explaining material that is abstract and difficult for students to understand. In addition, learning media can foster good will and interest in students and motivate students during the learning process [20].

Augmented Reality learning media products, assisted by the Assemblr Edu application, are designed with audio-visual features that can help convey material in the learning process to students in an interesting and interactive way. According to [21], audio-visual media has an important role in the educational process, especially for educators and students, because of the nature of audio-visual/sound-images that can encourage many stimuli to students. In addition, audio-visual media can expand the learning environment, support exploration, experimentation, and discovery, and help students develop their ability to express their thoughts. When students use audio-visual media in learning, it will directly provide experience and create a learning atmosphere that will feel more fun.

In the aspect of the feasibility of the content of the material, an average percentage of 92% is obtained with very valid criteria because the material presented in the media has met: 1) the suitability of the material in the product with KD and GPA, 2) the suitability of visualization in the product with KD and GPA, 3) the material in the product can motivate and provide a stimulus during learning, 4) the material in the product is effectively used and supports learning. The material presented with interesting visualizations for students can affect the effectiveness of the chemistry learning process in the classroom. The material provided will be more explicit, making it easy for students to understand and enabling them to achieve learning objectives. Learning media facilitates communication between educators and students. So that it can minimize difficulties in conveying verbal language and misperceptions in giving messages [22].

In the language aspect, an average percentage of 91% is obtained with very valid criteria because the presentation of the language used in the delivery of material in the media has met: The standard language used in the product is in accordance with PUEBI, and 2) the language used in the product is simple and easy to understand. The use of clear, concise, and easy-to-understand language can clarify and complete the information provided, making it easier for students to digest the material provided in this learning medium. During the learning process, the use of communicative language really needs to be applied so that it can be understood by both parties, namely educators and students, so that they can avoid misunderstandings and minimize communication gaps so that learning goals or objectives can be achieved [23].

Item Validation Result

Analysis of the validity test on the items needs to be done to find out whether the questions used have met the criteria for a good test. The item test analysis is related to the preparation of the questions in the test that have been prepared well, the instructions for working on the questions are clear and easy to understand, the coverage of the material being tested is representative, the multiple choice options given are homogeneous, and so on [24]. In the test of the validity of the pretest and posttest items, the researcher tested the logical validity based on the results of the reasoning carried out by the validator. For the validity of each item, the validator tested the pretest and posttest questions, which consisted of 6 questions. The results of the validity of each item by the three validators are:

Table 8. The Results of the Validity of Each Item Pretest and Posttest

No	Question Points	Validity Coefficient Average	Validity Criteria
1	Number 1	0,81	Very High
2	Number 2	0,87	Very High
3	Number 3	0,91	Very High

4	Number 4	0,91	Very High
5	Number 5	0,87	Very High
6	Number 6	0,81	Very High
Average		0,86	Very High

Based on Table 8, the average validity coefficient of Aiken's V was obtained, namely item number 1, obtained an average validity coefficient of 0.81 with very high validity criteria; item number 2 obtained an average validity coefficient of 0.87 with very high criteria; item number 3 obtained an average validity coefficient of 0.91 with very high validity criteria; item number 4 obtained an average validity coefficient of 0.91 with very high validity criteria; item number 5 obtained an average validity coefficient of 0.87 with very high validity criteria; and item number 6 obtained an average validity coefficient of 0.81 with very high criteria.

The average validity coefficient of Aiken's V for all items is 0.86, with very high validity criteria, so each pretest and posttest item has fulfilled the material aspect, which consists of three components, namely: 1) the items are developed in accordance with KD and GPA; 2) the questions were developed according to the content of the material in the product; and 3) the questions and answer keys developed were in accordance with the concepts in the subtopics. Each pretest and posttest item has fulfilled the construction aspect, which consists of two components, namely, 1) the formulation of the sentence in the item is good and 2) the item contains clear instructions for working. In addition, each of the pretest and posttest items has also fulfilled the language aspect, which consists of two components, namely, 1) the language used in the items is in accordance with the PUEBI rules and 2) the items are arranged using communicative sentences.

Based on Table 8, the average item validity coefficient is at a very high criterion, but revisions are still needed to improve some questions. The revision of the questions follows the suggestions and input from the validator. The results of the overall analysis of the items showed good results, so these items can be directly used as a tool to measure student learning outcomes [24].

Questionnaire Validation Result

Table 9. Questionnaire Validation Result

No	Rated components	%	Validity Criteria
1	Relevance Aspect	92	Very Valid
2	Construction Aspect	94	Very Valid
3	Language Aspect	96	Very Valid
Average		94	Very Valid

Based on Table 9, we obtained an average percentage of 94% with very valid criteria. Judging from the aspect of relevance, the average percentage obtained is 92% with very valid criteria, and this shows that the results of the validation of student questionnaires on the product have met the research objectives. The average percentage obtained is 94% with very valid criteria, meaning that the results of the validation of the student response questionnaires to the product have met: 1) clarity of instructions for filling out the questionnaire, 2) clarity of question items, 3) questions written briefly and congested. The average percentage obtained in the language aspect is 96%, with very valid criteria, meaning that the results of the validation of the student response questionnaires to the product have met: 1) the use of language in accordance with PUEBI and 2) the language used is simple and easy to understand.

Product Trial Result

The product feasibility trial involved 12 prospective chemistry teacher students as respondents in using the product. These twelve students are representatives of the population of prospective teachers who are expected to later teach chemistry with the topic of discussing factors that affect reaction rates, especially temperature factors and the surface area of the touch area. First of all, students are given pretest questions as an introduction to find out the extent to which students' initial abilities are related to the topics in the product. After doing the pretest, the product was introduced, and the student studied the product to learn the factors that affect the reaction rate, especially the temperature factor and the surface area of the touch area. Students were very enthusiastic and

asked a lot of questions about this product. Students get some new knowledge about the reaction rate factor, especially on the temperature factor and the outer surface of the touch area, while using the product. Next, students take a posttest to measure their abilities after learning to use the product. After the trial ended, students were asked to fill out a response questionnaire regarding the product.

After the experiment was carried out, the following results were obtained.

Test Result Analysis

Analysis of Pretest and Posttest Result

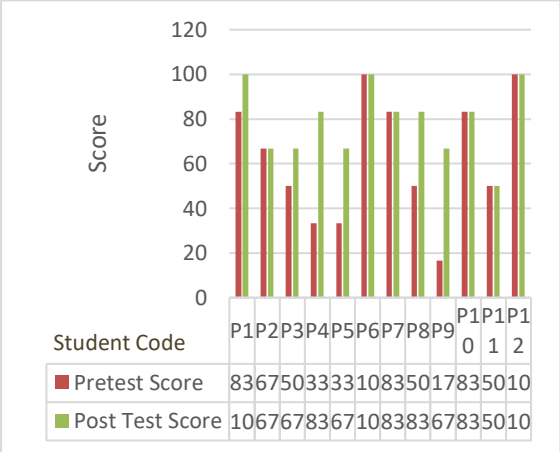

Figure 17. Pretest and Posttest Result of Prospective Chemistry Teachers

Based on Figure 17, the average result for the student pretest is 63, which is included in the category of quite good in understanding the material factors that affect the reaction rate, especially the temperature factor and the surface area of the touch area. After the students used the product, the average posttest score rose to 79, and the score was in the good category. The data from the pretest and posttest results for the prospective chemistry teacher showed that some students who had poor grades turned out to be quite good; some even became very good. This is due to the visualization of the reaction rate seen by students through the developed product. The concept of chemistry can be easily understood by students and students when they can imagine the shape of a reaction in a macroscopic, submacroscopic, and symbolic form [25].

Based on Figure 17, the level of achievement obtained is 79, and this product is categorized as reasonably practical. This product explains the effect of the surface area and temperature on the reaction rate to increase students' conceptual understanding.

In the section on the influence of the surface area of the contact area on the reaction rate, it was stated that the event of dissolving NaCl salt into water In the process of dissolving the NaCl salt, two conditions are given, namely the NaCl salt particles in the form of one whole lump and the NaCl salt particles that have been broken into two small pieces. This condition explains why the NaCl salt particles that have been broken into small pieces can cause an increase in the collision frequency. This is because the smaller particles have a larger surface area of contact than one large particle of NaCl salt. The greater the surface area available for the particles to collide, the more the frequency of collisions increases so that the reaction will be faster [26].

On the effect of temperature on the reaction rate, it was found that the chemical reaction between $Na_2S_2O_3$ (Sodium Thiosulfate) solution and HCl solution has different temperature variations, namely at temperatures of 10°C, 20°C, 30°C, and 40°C. The following is an equation for the reaction between a solution of $Na_2S_2O_3$ (sodium thiosulfate) and a solution of HCl:

$$2\ HCl\ (aq) + Na_2S_2O_3\ (aq) \rightarrow S\ (s) + SO_2\ (g) + 2\ NaCl\ (aq) + H_2O\ (l)$$

Based on the equation of the reaction, the phenomenon that can be observed changing is the rate of formation of sulfur deposits and SO2 gas. The effect of a higher temperature on the reaction rate causes the kinetic energy of the molecules to be greater and the motion of the reactant molecules to collide and break bonds will be faster, so the faster the formation of products (27). Thus, it can be concluded that the temperature variation in the reaction between $Na_2S_2O_3$ (Sodium Thiosulfate) solution and HCl solution, the rate of formation of sulfur precipitates, and SO_2 gas will occur faster at a temperature of 40°C.

Analysis of Questionnaire Result

In the questionnaire section, there are several types of aspects that are assessed by students as respondents, namely: 1) The products developed are attractive; 2) The letters and numbers used in the product are clear; 3) The product is easy to use in learning; 4) The material in the product is clear to understand; 5)

Augmented Reality visualization in the product is able to clarify the concepts and examples provided; 6) The language in the product is in accordance with PUEBI; and 7) The language used in the product is simple and easy to understand. Based on the results of the questionnaire contained in Figure 18, an average percentage of 89% was obtained. This product received a very high response from prospective chemistry teaching students. The percentage of student response questionnaire data is shown in Figure 18.

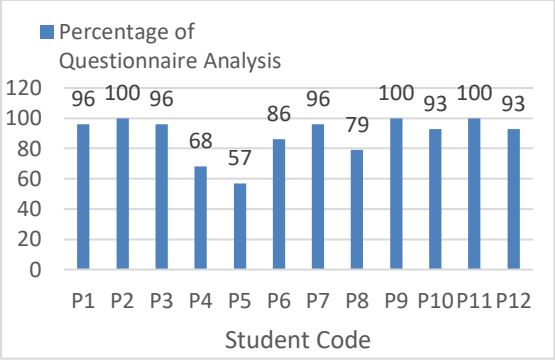

Figure 18. Student Questionnaire Results

Based on Figure 18, the products developed get an average percentage of 89%, so this product is included in the category that is very practical to use. The students gave a positive response and stated that the product was very interesting because it was colorful; the concept was simple, so it was easy to understand; the product was very educational and creative; and this product could be applied as a learning medium used in schools later.

CONCLUSIONS AND SUGGESTIONS

Based on research on Augmented Reality-based learning products that was developed on the subtopics of the influence of the surface area of the touch area and temperature on the reaction rate, it can be concluded that: (1) the type of research used is R & D with the Borg & Gall development model, so that the resulting product is in the form of media. Augmented Reality-based learning using Assemblr Edu on the subtopics of the influence of the surface area of the touch area and temperature on the reaction rate (2) The average percentage of product validation is 91%, which indicates the product is very valid to use; (3) The average coefficient of item validity obtained is 0.86, and these results indicate very high criteria; (4) The average result of the response questionnaire validation on the product is 94%, which indicates that the product is very valid to use; (5) The product was tested on 12 prospective chemistry teacher students and obtained information that the average pretest score was 63, which showed good results, increasing to an average posttest score of 79, indicating good results after using the product; and (6) The product developed is quite effective and the average percentage of student responses to the product is 89%, which shows very high criteria and is very practical to use in learning.

Suggestions that can be given for the next product development include: (1) further products can be tested on students at the senior high schools level or equivalent to be analyzed regarding concept understanding after using the product; and (2) the features in Assemblr Edu are still limited, making it possible to add other applications and modify them to support product development on other chemistry topics.

ACKNOWLEDGEMENT

We would like to say thanks to the Chemistry Education Study Program, Faculty of Teacher Training and Education, Sanata Dharma University, for allowing the author to participate in the 2021 National Seminar on Chemistry and assist in financing the publication of journal article.

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