DEVELOPMENT OF ASSEMBLR EDU-ASSISTED AUGMENTED REALITY LEARNING MEDIA ON THE TOPIC OF EFFECT OF REACTANT'S CONCENTRATION AND CATALYST ON REACTION RATE

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Abstract. *The level of submicroscopic representation can be cause of difficulty in learning chemistry, so that interest and understanding of chemistry concept is low. In overcoming this, innovative learning media are needed that are able to visualize and make it easier to understand abstract concepts, especially on the subtopic of the effect of reactant's concentration and catalyst on the chemical rate reactions. 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 Research and Development that uses ADDIE development model and involves 10 prospective chemistry teacher students. Research instruments include validation sheets, test items, and response questionnaire. Data were analyzed using Aiken's V and descriptive statistic. The results showed that: (1) product have fulfilled very valid criteria with average percentage of 92% with aspect of product presentation and use are 92% (very valid), content aspect of 94% (very valid); language aspect by 92% (very valid); (2)average test score of respondents after using the product is 70 which indicates that product is classified as effective; and (3)average response to the product is 90% indicating that the product is very good and classified as very practical. The product is feasible to use and can support the mastery of technology-based concept, especially in the subtopic of the effect of reactant's concentration and catalyst on chemical rate reactions.*

Keywords: *Augmented Reality, Assemblr Edu, Reactant's Concentration, Catalyst, Reaction Rate*

INTRODUCTION

Chemistry is an important part of the branch of natural science. In chemistry, it includes various abstract chemical concepts related to the nature, structure, changes, and energy that accompanies changes in material, both physical and chemical changes. Abstraction of chemical concepts starts from the simplest level to the more complex level. Facts that can be found in chemistry learning at high school are often weak students in interpreting the concepts that exist in chemistry subject, so that this has an impact on the level of understanding of students [1]. In addition, the lack of variety of learning models and methods applied by teachers in teaching chemistry also contributes to the low interest in learning of students. Learning that tends to be one-way and monotonous makes students easily bored. Students who tend to be passive in learning can affect the achievement of unsatisfactory learning outcomes [2].

The rate of reaction is one of the materials in chemistry subjects belonging to the field of physical chemistry studies. The scope of this reaction rate material relates to the theory of collisions and the factors that affect the rate of reactions. In studying the reaction rate material, some students have difficulty understanding the factors that affect the reaction rate, especially the effect of concentration and the effect of catalyst. Based on the research of Jusniar et al [3], students understand that the reaction rate changes with time because the concentration of products and reactants vary with time. Students understand that the rate is the reduction in the concentration of the product in each unit of time and the increase in the concentration of the reactants is affected by the length of the reaction time. Meanwhile, in the research of Nazar et al [4]. on the subtopic of the effect of catalysts on reaction rates, students understand that the addition of a catalyst causes the activation

energy of the reactants to increase and causes the reaction to take place faster.

There are three levels of representation in chemistry, namely macroscopic, submicroscopic, and symbolic levels. The facts found at high school chemistry learning, the submicroscopic level which tends to be abstract is not fully optimized [5]. The existence of abstraction at the submicroscopic level on the subtopic of the effect of concentration and catalyst on the reaction rate can cause learning difficulties for students. Students have difficulty visualizing the model of atomic arrangement in chemical reactions about the effect of concentration and catalyst. Lack of teaching on the concepts of reaction rates, especially on the subtopics of the influence of concentration and catalysts at the submicroscopic level can cause students to have difficulty in building more meaningful learning concepts [6].

Augmented Reality is a technology that combines two-dimensional and/or three-dimensional objects, which can then be displayed or visualized in the real world. Augmented Reality technology integrated into chemistry learning media is very interesting in its use to allow students to interact directly with the digital world [7]. In addition, learning media development using Augmented Reality can help increase student motivation in learning and make it easier for students to understand abstract objects [8]. Thus, in improving the understanding of concepts in the subtopics of the influence of concentration and catalysts, the help of learning media with Augmented Reality technology can be found in the Assemblr Edu application so that students can visualize each component of the material in the real world and make it easier for students to understand concepts with the presence of three objects, dimensions, and animations and their explanations.

Based on the description of the background, this study aims to: a) to obtain a chemistry learning media assisted by Assemblr Edu on the subtopic of the effect of concentration and catalyst on reaction rates that are valid, practical, and effective; b) improve the understanding of the concept of the effect of concentration and catalyst on the reaction rate of students with the existence of learning media assisted by Assemblr Edu.

By developing of Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on reaction rates, it is hoped that it can support chemistry learning at high school, so that students' mastery of material concepts can be achieved well.

METHODS

This study is development research that refers to the ADDIE model [9]. This development model includes the stages of Analyze (Analysis of Product Development Needs), Design (Product Design), Develop (Product Development), Implementation (Product Trial), and Evaluation (Product Development Evaluation). The product developed is in the form of Augmented Reality learning media assisted by the Assemblr Edu application which is used on subtopic learning of the effect of reactant and catalyst concentration on the reaction rate of a chemical reaction. In addition to the product, other instruments are also needed to support the research, namely the items in the pretest and posttest related to the material in the product and respondents' questionnaire on the product. The product and all instruments were assessed by three validators.

After product and instruments were revised, limited trial was conducted involving 10 students as prospective chemistry teacher from Chemistry Education Study Program who were selected through purposive sampling technique. This technique is used based on certain considerations, namely the willingness of the sample to take part in the trial carried out [10].

The data obtained were analyzed descriptively and using Aiken's V statistics which can be described as follows:

A. Analysis of Product and Questionnaire's Validation Result

The scores obtained from the three validators were calculated and converted into percentages using the formula according to Sistyarini & Nurtjahyani [11], namely:

$$\text{Percentage} = \frac{\text{total score obtained}}{\text{maximum score}} \times 100\ \%$$

Based on these percentages, the criteria for product validity and questionnaires can be determined as shown in Table 1.

Table 1. Product Validity Criteria and Response Questionnaire [12]

No	Percentage (%)	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. Analysis of Item Validity

Specifically for analyzing items, calculations are used to determine the magnitude of the item validity coefficient (V) according to 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

After obtaining the value of V for each item, the criteria for the validity of the items can be determined in Table 2.

Table 2. Table of Item Validity Criteria [13]

No	aikens validity coefficient	Validity Criteria
1	0,80 < V ≤ 1,00	Very High
2	0,60 < V ≤ 0,80	High
3	0,40 < V ≤ 0,60	Enough
4	0,20 < V ≤ 0,40	Low
5	0,00 < V ≤ 0,20	Very Low

C. Analysis of Respondents' Questionnaire Results

After the trial was carried out, respondents were asked to fill out a questionnaire. The score obtained is calculated using the formula:

$$\text{Percentage} = \frac{\text{total score obtained}}{\text{maximum score}} \times 100\ \%$$

The average percentage of the questionnaire results obtained can be calculated and the response criteria determined by referring to Table 3.

Table 3. Criteria for Response to Products [14]

Percentage (%)	Category
75-100	Very High
50-75	High
25-50	Enough
0-25	Low

In addition, the average percentage of the results of the questionnaire also determines the practicality of the product developed. The product practicality criteria can be seen in Table 4.

Table 4. Product Practicality Criteria [15]

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

D. Analysis of Test Result in Product Trial

The test results were determined through the scores obtained from the pretest and posttest. The scores obtained from the respondents are converted into values using the formula:

$$\text{Value} = \frac{\text{total score obtained}}{\text{maximum score}} \times 100\ \%$$

After the score is obtained, the category of student ability can be determined by referring to Table 5.

Table 5. Category of Respondents' Ability Based on Values [16]

Value	Category
80-100	Very Good
70 – 79	Good
60 – 69	Enough
40 – 59	Not Good
0 – 39	Not Very Good

The scores and average scores of the respondents involved during the trial also determine the effectiveness of using the product. The interpretation of values as effectiveness criteria is shown in Table 6.

Table 6. Effectiveness Criteria [17]

Value	Criteria
76 – 100	Very Effective
51 – 75	Effective

26 – 50	Less Effective
0 – 25	Ineffective

RESULTS AND DISCUSSION

The development of Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on the reaction rate was designed by adapting the ADDIE development model through five stages, namely Analysis, Design, Development, Implementation, and Evaluation [9]. The further description of the ADDIE development model is as follows:

A. Analysis

Augmented Reality learning media assisted by the Assemblr Edu application is designed to provide innovations in chemistry learning, especially in the subtopics of the effect of concentration and catalyst on reaction rates. The existence of technology-based Augmented Reality learning media can make it easier to understand abstract chemical concepts by visualizing each material component in the form of three-dimensional objects and animations along with their explanations. The concept of the effect of concentration and catalyst on the reaction rate requires visualization.

Learning difficulties experienced by students in the study of Sudria et al [6]. regarding the factors that affect the reaction rate, one of which is to distinguish effective collisions involving microscopic aspects on the effect of concentration. Students also have difficulty understanding the effect of increasing the concentration of reactants, especially on the number of molecules at each increase in the concentration of reactants. Therefore, Augmented Reality learning media on the subtopic of the effect of reactant concentration on the reaction rate requires visualization to explain the difference in the number of molecules at different concentrations of reactants and the difference in collisions which is more effective. Based on research by Sari et al [18]. Regarding the factors that affect the reaction rate, students also experience learning difficulties, one of which is understanding the relationship between catalysts and activation energy. Students have difficulty learning the role of catalysts in lowering the activation energy so that the reaction rate can increase. Therefore, Augmented Reality learning media on the subtopic of the effect of catalysts on the reaction rate in this study requires visualization to be able to explain the working mechanism of the catalyst in reducing the activation energy of the ethylene hydrogenation reaction.

The Augmented Reality learning media product assisted by the Assemblr Edu application, can increase mastery of concepts in the subtopic of the effect of concentration and catalyst on reaction rates.

B. Design

On the design stage of Augmented Reality learning media using the Assemblr Edu application, more emphasis is placed on product results that are valid, effective, and have practical value in their use. Augmented Reality technology that is integrated into the Assemblr Edu application is still relatively new and its use in Indonesia has not been maximized properly [19]. In designing Augmented Reality learning media completely using software in the form of Assemblr Edu and several other editing applications, such as Clara.io and Canva which act as supporting applications. According to Aulawi et al [20], the use of Augmented Reality media can facilitate users to integrate the real world with the virtual world from the same place in real time. The product design stage can be divided into two parts, namely the design of learning media on the subtopic of the effect of concentration on the reaction rate and the effect of the catalyst on the reaction rate.

Design of Learning Media: Effect of Reactant Concentration on Reaction Rate

The stages of designing Augmented Reality learning media on the subtopic of the effect of reactant concentration on the reaction rate start from making 3-dimensional (3D) objects with a supporting application, namely Clara.io. Objects made such as atoms, solution

illustrations, and beakers can be seen in Figure 1.

Figure 1. Creating 3D Objects with the Help of the Clara.io Application

After the 3D object is created, the file in .abx format is entered into Assemblr Studio to be colored, which can be seen in Figure 2. Objects created in Clara.io are not colored because of limitations in the Assemblr Studio application which cannot enter all data. Therefore, the coloring process is carried out in Assemblr Studio.

The atoms that are entered into Assemblr Studio and colored are Magnesium atoms (Mg), Chloride atoms (Cl), and Hydrogen atoms (H). The atoms are colored according to the CPK colors. The Magnesium atom has a CPK color code "8AFF00" with a lighter green color, the Cl atom has a CPK color code "1FF01F" with a slightly darker green color, and the H atom has a CPK color code "FFFFF" with a white color [21]. In addition to atoms, beakers and solution illustrations are also included in Assemblr Studio and are given coloring and transparent effects.

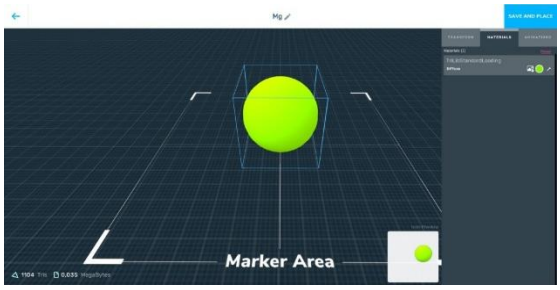

Figure 2. The Coloring Process of One of the 3D Objects in Assemblr Studio

Product creation can be done by creating a new project and there will be a marker area to design and design the product. In making a product, several features that can be used such as 3D objects, text, images, videos, and notes. Objects that have been previously entered will be in the 3D object feature. The product is created using several 3D objects, pictures, supporting videos, and explanatory notes, which can be seen in Figure 3.

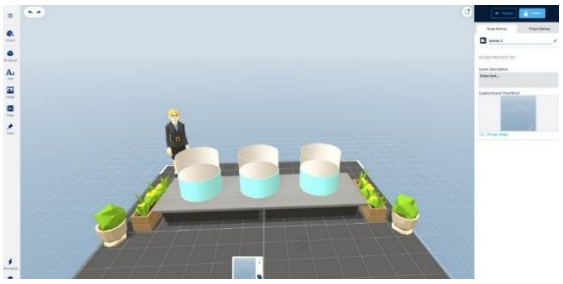

Figure 3. Features in Assemblr Studio and Using 3D Objects

In designing this Augmented Reality learning media product, another supporting application, namely Canva, is needed to design the description of the molecular name of the product which can be seen in Figure 4.

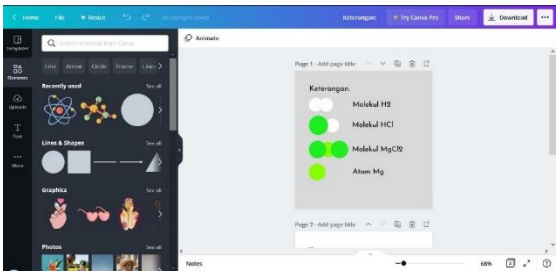

Figure 4. Making of Molecular Name Description

Using features and 3D objects that have been created, the atoms are arranged into molecules that have reacted in the beaker. The product also added 2 explanatory videos obtained from credible youtube sources. In making it easier to use the media, a note number is given that contains a brief explanation from a credible source. After designing the Augmented Reality learning media product on the subtopic the effect of reactant concentration on the reaction rate can be used as a chemistry learning medium. The result of this product is in the form of a barcode card that can be scanned by the user using the Assemblr Edu application or a scan feature on devices and classes that can be accessed using a class code. In the use of media, users can visualize each media component in a “3D view” or an “AR view”. The display of visualization of learning media on the sub-topics of reactant concentration on reaction rates and barcodes can be seen in Figures 5 and 6.

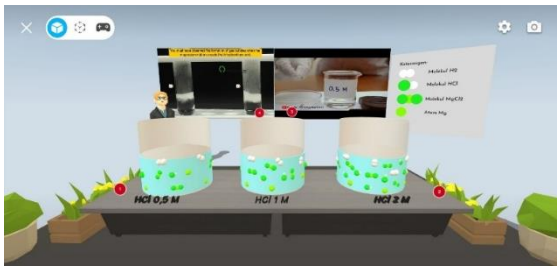

Figure 5. Learning Media Product Results Effect of React Concentration on Reaction Rate

Figure 6 . Barcode Learning Media Effect of React Concentration on Reaction Rate

Design of Learning Media: The Effect of Catalyst on Reaction Rate

The stages of designing Augmented Reality learning media on the subtopic of the effect of catalysts on the reaction rate start from downloading the Assemblr Edu application which can be downloaded via the Play Store on Android or the App Store on iOS. The following is a display of the Assemblr Edu application which can be seen in Figure 7.

Figure 7. Display of the Edu Assemblr Application

After the Assemblr Edu application is downloaded on Android or iOS, the main application page will appear. Then the user can select the desired language and can proceed with account creation. After the account creation process is complete, users can directly access and use the Assemblr Edu application. The initial preparation before using the application can be seen in Figures 8 and 9

Figure 8. Display of Language Selection on the Assemblr Edu Application

Figure 9. Account Creation Page Display on the Assemblr Edu Application

After the account creation process is complete, the user now has an account that can be used to design and design learning media. In the account menu, users can directly create a new project. The initial appearance of this new project is in the form of a marker area that can be used to design and design products. Several features that can be used in the product manufacturing process, such as 3D objects, text, images, videos, and notes. Through these various features, users can be creative using various three-dimensional objects, and add text, images, videos, and notes. The following is a display of the marker area and one of the features, namely 3D objects which can be seen in Figures 10 and 11.

Figure 10. Marker Area Field Display in the Assemblr Edu Application

Figure 11. Display of 3D Object Features in the Assemblr Edu Application

The process of designing Augmented Reality learning media, it also requires other supporting applications, such as Canva, which plays a role in the process of designing the description of the name of each molecule in the media product. An overview of Canva's design of molecular captions can be seen in Figure 12.

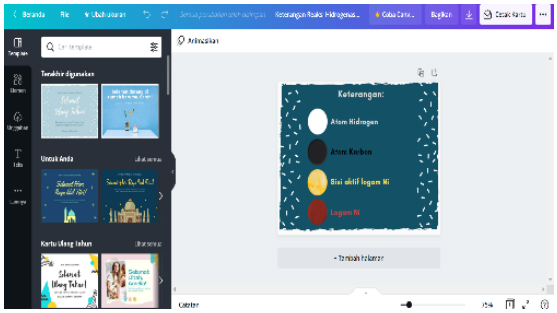

Figure 12. Molecular Caption Name Design Using Canva

After designing the product, Augmented Reality learning media on the subtopic of the effect of catalysts on reaction rates can be used in chemistry learning. There are two alternative ways that users can use to observe media products, namely by joining through a class code or scanning the barcode to view media products. By joining a class, each user can share and observe each media product developed in the class. Meanwhile, the alternative method of scanning the barcode can provide practicality for users to be able to directly view and observe media products without having to join a class. Alternative ways to use class code and barcode can be seen in Figures 13 and 14.

Figure 13. Display of Class Code Usage of Subtopic Learning Media The Effect of Catalyst on Reaction Rate

Figure 14. Barcode Display of Learning Media Products Subtopic Effect of Catalyst on Reaction Rate

After the user joins through the class code or scans the barcode, the visualization of each media product can be viewed in two alternative ways, namely "3D views" or "AR display". Through the 3D display, users can display media products in three dimensions to facilitate the observation of objects from various points of view. Meanwhile, through the AR display, users can display media products in three-dimensional form that can be applied to the surrounding environment. The visualization display of media products on the 3D display and AR display can be seen in Figures 15 and 16.

Figure 15. Subtopic Learning Media Products Effect of Catalysts on Reaction Rates in 3D Display

Figure 16. Subtopic Learning Media Products Effect of Catalysts on Reaction Rates in AR Tampilan Display

C. Development

After designing the product, the product is then developed to be validated by three validators. The validator subject in this study involved 2 chemistry teachers and 1 chemistry education lecturer. The purpose of the validation activity in this study is to prove that the product is valid and suitable for use in chemistry learning [22]. Aspects that are validated in the development of this learning media are aspects of the product presentation and use, content aspects, and language aspects. The results of the validation of media products involving 3 validators are shown in Table 7.

Table 7. Media Product Validation Results

No	Rated Aspect	Average Percentage	Category
1.	Aspects of product presentation and use	92	Very Valid
2.	Content aspect	94	Very Valid
3.	Language aspect	92	Very Valid
	Average	92	Very Valid

Based on data analysis of product validation results involving 3 validators, the average percentage value obtained is 92% with very valid category. The three validators provide good and constructive comments so that the quality of the product can be improved. Judging from the aspect of product presentation and use with an average percentage of 92% which is categorized as very valid, Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on reaction rates has met the indicators: 1) Presentation of attractive and systematic products; 2) The product has text, color, and image compatibility; 3) The product contains complete information; 4) the product is easy to use in learning. The use of learning media can help students in growing interest and motivation in learning chemistry. In addition, the existence of learning media can also make it easier for students to understand chemical concepts.

Judging from the content aspect with an average percentage of 94% with a very valid category, Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the influence of concentration and catalyst on the reaction rate has met the indicators: 1) The suitability of the material in the product with KD and GPA; 2) Conformity 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 essence of the material and product visualization in this learning media can determine the effectiveness in the chemistry learning process, especially in the subtopic of the effect of concentration and catalyst on the reaction rate.

Judging from the language aspect with an average percentage of 92% with a very valid category, Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on the reaction rate has met the indicators: 1) Standard language used in the product is following PUEBI; 2) The language used in the product is simple and easy to understand. The use of language that is clear and easy to understand has a significant influence on understanding the concept of chemistry. A good and easy-to-understand language aspect in the development of this learning media can help students clarify or provide additional information regarding the visualization of existing products.

In the validation of several 6 pretest and posttest questions involving 3 aspects of assessment, namely material, construction, and language aspects. The results of the validation

of several six questions involving 3 validators are presented in Figure 17.

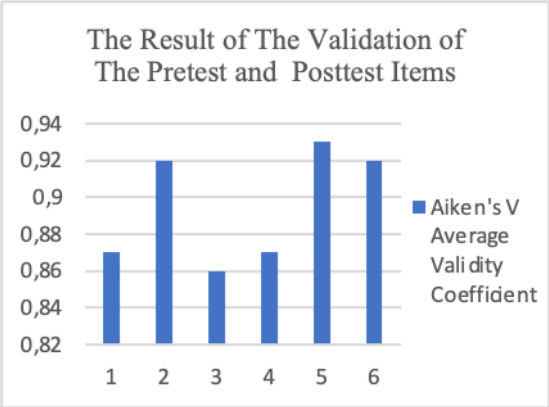

Figure 17. Results of Validation of Pretest and Posttest Items

Based on the data analysis of the validation results of the pretest and posttest items involving 3 validators, the average validity coefficient of Aiken's V obtained in item number 1 is 0.87 with a very high category; item number 2 is 0.92 with a very high category; item number 3 is 0.86 with a very high category; item number 4 is 0.87 with a very high category; item number 5 is 0.93 with a very high category; and item number 6 is 0.92 with a very high category. From the average Aiken's V validity coefficient on each of the existing items, it can be obtained that the average Aiken's V validity coefficient of the six pretest and posttest items is 0.895 with a very high category.

Judging from the average validity coefficient of Aiken's V obtained from the six questions, which is 0.895 with a very high category, the pretest and posttest items have met the material aspects with the fulfillment of indicators: 1) The questions are following KD and GPA; 2) Questions that are developed according to the content of the product; 3) The truth of the concept in the questions and answers. Then the pretest and posttest items have met the construction aspects with the fulfillment of indicators: 1) The formulation of sentences in the items is good; 2) Instructions for working on clear questions. Furthermore, the pretest and posttest items have also met the language aspect by fulfilling the indicators: 1) The language used is following the PUEBI rules; 2) Problems using communicative sentences. The fulfillment of 3 important aspects in the form of material, construction, and language aspects in the validation results of the pretest and posttest items shows the achievement of the validity and quality values of the existing items so that they are feasible to use.

In the validation of the questionnaire response to the product, three important aspects need to be assessed, namely aspects of relevance, construction, and language. The results of the validation of the student response questionnaire to the product involving 3 validators are shown in Table 8.

Table 8. Results of Validation of Response Questionnaires on Products

No	Rated Aspect	Average Percentage	Category
1.	Aspect of Relevance	92	Very Valid
2.	Construction Aspect	94	Very Valid
3.	Language Aspect	96	Very Valid
	Average	94	Very Valid

Based on the data analysis of the results of the questionnaire validation involving 3 validators, the average percentage value obtained is 94% with a very valid category. Judging from the aspect of relevance with an average percentage of 92% which is categorized as very valid, Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on the reaction rate has met the indicators of the suitability of the questionnaire with the research objectives. Then viewed from the construction aspect with an average percentage of 94% which is categorized as very valid, Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on the reaction rate has met the indicators: 1) Clarity of instructions for filling out the questionnaire; 2) Clarity of statement items; 3) Statements are written briefly and concisely. Furthermore, in terms of the language aspect with an average percentage of 96% which is categorized as very valid, Augmented Reality learning media assisted by the Assemblr Edu application on the subtopic of the effect of concentration and catalyst on the reaction rate has met the indicators: 1) The use of language is following PUEBI; 2) The language used is simple and easy to understand.

D. Implementation

After going through the product development stages, then the product can be tested to measure the effectiveness of the product application in chemistry learning. The product was tested on 10 prospective chemistry teacher students. Before the product trial, students were given a pretest to measure their initial understanding. Then a product trial was carried out and after that, a posttest was held to measure how effective and influence the use of learning media was in increasing the conceptual understanding of prospective chemistry teacher students.

The results of the test scores of prospective chemistry teacher students in Table 9 before and after the use of learning media show a significant difference. Based on the general analysis, shows that there is an increase in scores after using learning media with an average pretest score of 43 in the less effective category and an average posttest score of 70 in the effective category.

Table 9. Assessment Results for Prospective Chemistry Teacher Students

No	Respondent Code	Pretest Score	Category	Posttest Score	Category
1	S1	33	Less Effective	50	Less Effective
2	S2	50	Less Effective	50	Less Effective
3	S3	17	Ineffective	67	Effective
4	S4	67	Effective	67	Effective
5	S5	83	Very Effective	83	Very Effective
6	S6	33	Less Effective	83	Very Effective
7	S7	17	Ineffective	83	Very Effective
8	S8	33	Less Effective	67	Effective
9	S9	33	Less Effective	67	Effective
10	S10	67	Effective	83	Very Effective
	Average	43	Less Effective	70	Effective

Based on the analysis of the pretest data, there are still some respondents who have a lower score with an average of 43% in the very less effective category. This could be because respondents are still not trained in developing their thinking skills and are still lacking in applying the concepts they have learned because they only memorize the concepts.

To improve understanding of the subtopic of the effect of reactant and catalyst concentrations on the reaction rate, a trial of Augmented Reality learning media assisted by Assemblr Edu was carried out. Respondents were given a barcode card and class code to access the learning media. Some respondents access the media by entering the classroom using the class code and others directly using the barcode scan feature on the Assemblr Edu application or the scan feature on the device. The trial begins with a demonstration explaining the use of learning media on the effect of reactant concentration on the reaction rate. The product describes the chemical reaction between magnesium metal and HCl solution with 3 different concentrations (0.5 M, 1 M, and 2 M). The product visualizes the increasing number of HCl molecules and products (Hydrogen gas and $MgCl_2$ solution) as the concentration increases. Then the test of the learning media on the effect of the catalyst on the reaction rate begins with a demonstration of the explanation of the use of the learning media on the effect of the catalyst on the reaction rate. Furthermore, the product describes the reaction mechanism of ethylene hydrogenation with the help of a catalyst in the form of Ni metal. The product can visualize the molecular arrangement in the ethylene hydrogenation reaction mechanism and the role of the catalyst in lowering the activation energy so that the reaction rate increases.

During the trial, several respondents had difficulty accessing the media due to an unstable internet network. However, on average, other respondents can access and use the media well. They said that the learning media was very interesting and colorful, playable, and not boring, in addition to visualizing the microscopic dimensions there was also a credible explanation and added to the understanding of the subtopic of the effect of reactant and catalyst concentrations on reaction

rates. In addition, during the trial, the respondents became interested and more active in learning the material in the learning media.

The results of the posttest data analysis showed that there was a significant increase with an average posttest score of 70% in the effective category. There was an increase in the respondent's value after studying the subtopic of the effect of reactant and catalyst concentrations on the reaction rate using Augmented Reality learning media assisted by Assemblr Edu. This media can make it easier to explain chemical material that can visualize microscopic material. In addition, the material can be presented in a visual, attractive, colorful, and can be played in a real display, so that learning will be more interesting and able to facilitate understanding of learning. However, in the results of the respondents' scores, it can be seen that some have not increased in value. This can be due to the respondent's understanding that is still lacking or even at the time of working on the questions. This is following what was stated in Nurdin [23], where respondents were not serious in working on the questions and only guessed the answers that had been provided the questions. This can be seen in items numbers 2 and 4 with the average majority of respondents answering incorrectly either on the pretest or posttest. Whereas in items numbers 2 and 4, there is an explanation in the learning media.

The results of the questionnaire on the responses of prospective chemistry teacher students regarding learning media *Augmented Reality* assisted by Assemblr Edu on the subtopic of the effect of reactant and catalyst concentrations on the reaction rate, the respondents received a positive response. This questionnaire contains 7 questions regarding responses to product use. The results of the questionnaire analysis of respondents' responses can be seen in Table 10.

Table 10. Results of Respondents' Response Questionnaire

No	Question	Total Score	Category	Category
1	Interesting product developed	93	Very High	Very Practical
2	The letters and numbers used in the product are clear	90	Very High	Very Practical
3	The product is easy to use in learning	80	Very High	Very Practical
4	The material in the product is clear to understand	95	Very High	Very Practical
5	Augmented Reality visualization in the product can to clarify the concepts and examples provided	93	Very High	Very Practical
6	The language in the product is PUEBI compliant	88	Very High	Very Practical
7	The language used in the product is simple and easy to understand	95	Very High	Very Practical
Average		90	Very High	Very High

From the results of the questionnaire analysis of respondents' responses to Augmented Reality learning media assisted by Assemblr Edu, an average of 90% of respondents gave a very high and very practical response to each of the indicators contained in the questionnaire. The average respondent gave a response that learning media is very interesting because it can visualize microscopic material with more color and can be played. Respondents feel that by using this learning media their interest in learning is increasing and it is easier and adds to their understanding of the subtopic of the effect of reactant and catalyst concentrations on reaction rates.

The responses given by respondents indicate that learning using Augmented Reality learning media assisted by Assemblr Edu makes users more active and can understand chemistry, especially on the subtopic of the effect of reactant and catalyst concentrations on reaction rates. This is also under the research of Sari et al. [24], which uses Augmented Reality learning media where Augmented Reality learning media can motivate learning, make users more creative, and learning becomes

more fun and meaningful. Then the visualization of images in the form of graphics and animated videos can also help students learn the working mechanism of catalysts through the formation of intermediates with a smaller activation energy value so that the reaction rate increases [25].

E. Evaluation

Based on the Augmented Reality media research assisted by Assemblr Edu that has been carried out, the learning media received a positive response from validators and respondents. This learning media is very interesting and helps increase understanding of concepts, especially in the subtopic of the effect of reactant and catalyst concentrations on reaction rates. However, Augmented Reality learning media assisted by Assemblr Edu has advantages and disadvantages. Some of these advantages include: 1) attractive media because it is visually presented with more color and can visualize submicroscopic dimensions; 2) simple and easy to use media; media can be accessed via Android, iOS, Windows, and macOS based devices; and 3) media can increase students' interest in chemistry, especially in the subtopic of the effect of reactant and catalyst concentrations on reaction rates. Increased interest in learning can be seen from the responses from respondents where the media can be played so that it motivates them to use and study the material in the media.

Augmented Reality learning media assisted by Assemblr Edu also has several limitations including: 1) the media still has limitations in features and objects in the Assemblr Edu application, thus requiring the creation of objects with the help of other supporting applications. For example, some laboratory tools such as beakers, atoms, and molecules are not yet available, so they need to be made with the help of supporting applications. In addition, when transferring 3D design data into Assemblr Studio, if the design on the supporting application has been colored, the color will not be read, so it needs to be colored by Assemblr Studio itself; 2) the media cannot be made in the form of animation due to feature limitations; 3) the quality of media visualization is highly dependent on the internet network and devices; and 4) ease of operation of the media is highly dependent on the memory on the device.

CONCLUSIONS AND SUGGESTIONS

Based on the results of research and discussion on Augmented Reality learning media assisted by Assemblr Edu on the subtopic of the effect of reactant and catalyst concentrations on the reaction rate, it can be concluded that research produces Augmented Reality learning media assisted by Assemblr Edu which is very valid, very good and very practical, and effective to apply as a medium for learning chemistry. Based on the data analysis of product validation results, the product has met the very valid criteria with an average percentage of 92% with details on aspects of product presentation and use of 92% (very valid), content aspect of 94% (very valid); the language aspect of 92% (very valid). Then the results of the product trial resulted in an average test score of 43 respondents before using the product which indicated it was less effective to 70 after using the product, indicating that the product was classified as effective. Furthermore, the results of the questionnaire analysis, obtained the average response to the product is 90% which indicates that the product is very good and classified as very practical. With the Augmented Reality learning media assisted by the Assemblr Edu application, it is hoped that educators and other researchers can use and develop Augmented Reality learning media on the topic of chemistry other.

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