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Development of Multiple Representation-Based E-Modules Utilizing Augmented Reality in the Material of Molecular Shapes and Inter-Molecular Interactions

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ABSTRACT

The goal of this research was to create an e-module based on multiple representations in the material of molecular shapes and interactions between molecules using augmented reality technology. The method used is the Research and Development (R&D) method with the ADDIE model, which consists of 5 phases: the analysis phase, the design phase, the development phase, the implementation phase, and the evaluation phase. Data collection techniques include interviews, student questionnaires, validation sheets, and user response questionnaires. Two methods were used in small-scale trials: one-on-one testing and user response. The one-on-one test involves three students with high, medium, and low abilities. The data obtained from the interviews are in the form of supporting questions related to opinions on the use of teaching materials, followed by assessments of questionnaire sheets and validation sheets in the form of scales. The type of scale used is a Likert scale with a score of 1-4. User response assessment involved three teachers and 30 students. The results showed that the developed e-module obtained an average percentage of material experts (95.7%) and media experts (92.2%), with very valid criteria; a one-on-one test to get students' comments for e-module components that must be repaired; and user responses, (namely teachers and students), with percentages of 93.1% and 93.7%, with very good criteria.

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1. INTRODUCTION

Quality education can be realized through efforts that are able to optimally synergize all components of education so that the process of interaction between students and learning resources can run according to the learning setting (Cahyadi, 2019). Education is said to be of high quality, if it can produce graduates who are able to face the challenges of life they face (Rusmulyani, 2020). Therefore, improving the quality of education is an effort that must be pursued continuously so that expectations for quality and relevant education can be achieved. Quality education is the hope and demand of all education stakeholders (Fadhli, 2017). Quality education can be realized through quality learning. If the definition of quality education is described in a quality learning paradigm, then teachers must be able to relate teaching materials to students' lives and facilitate and guide students in learning to solve life's problems by applying what they have learned (Cahyadi, 2019).

In addition to knowing the knowledge and material to be taught, teachers must also have a set of technical skills and knowledge about how learning works. The quality of learning that has taken place so far still has many problems (Jihad, 2013). Thus, the development of learning needs to be continued. However, the form of development needs to be studied scientifically so that the development product can be a solution for solving student learning problems. Simamora & Donda (2019) indicate that most school graduates are unable to adapt to changes or developments in science and technology and are unable to develop themselves according to the needs of society. Thus, the findings indicate that the learning activities carried out in schools are still unable to touch or develop the abilities and potential of students as a whole.

The role of educational technology is important in implementing quality learning that leads to solving student learning problems by using learning resources in the form of messages, people, materials, equipment, techniques, and settings (Mashudi, 2015). The development area includes a wide variety of technologies used in learning. However, this does not mean that it is free from theory and practice related learning and design (Ni'matullah, 2016). According to Fitriana (2021) the development of learning with information technology-based teaching materials such as video teaching materials, interactive teaching materials and e-learning makes learning more efficient and effective in delivering teaching materials. According to Nurhasnah & Sari (2020), many teaching materials are found to be more material-focused, less contextual, and monotonous, and there is no scientific knowledge in solving a problem in teaching materials. Teaching materials for students provided by schools so far are not only limited but also do not lead to scientific literacy in students.

The results of interviews with teachers show that during learning, teachers use printed teaching materials, such as textbooks, modules, LKS, and PPT teaching materials. This shows that teachers have not maximized the use of technology in chemistry learning, so they have not fulfilled the efforts to face the challenges of the industrial era 4.0 and the 21st century, as expected in the implementation of the 2013 curriculum. In addition, there are several other obstacles that teachers face during the learning process, such as limited textbooks and technical constraints on electronic media, which are limited to teaching materials that cannot explain chemical material in 3 levels of chemical representation, so that students' scientific literacy is classified as low because they find it difficult to understand the concepts of the material being studied. In addition, on the results of the student questionnaire in the preliminary research, information was obtained that more students liked electronic-based teaching materials (51.6%).

Based on the information above, it is necessary to procure teaching materials that are tailored to the needs of students and capable of being a solution in presenting innovative teaching materials for use in the learning process so as to increase students' scientific literacy. The digital form of a module is an electronic module or e-module for short. According to Tan & Jia (2016), multimedia electronic modules (e-modules) in learning can serve as a viable solution for students. According to Aydin & Aytekin (2018) learning with e-modules allows students to learn independently; with independent learning, students' knowledge of learning is more meaningful and they can develop the knowledge they have.

In preliminary research, the results of interviews with teachers in the field of chemistry studies revealed that chemistry lessons are frequently regarded as difficult and unappealing subjects. The results of the interviews are in line with Tsui & Treagust (2013) that chemistry lessons are classified as difficult because they are closely related to abstract and complex concepts and because there are three levels of representation in chemistry, which include submicroscopic, macroscopic, and symbolic levels. The submicroscopic level is a chemical phenomenon that is not directly observable, such as electrons, molecules, and atoms. The symbolic level involves the use of symbols, formulas, and diagrams.

Abstract chemical material, namely material for class X molecular forms in the content of Molecular Forms and Inter-Molecular Interactions, is abstract content. This is based on a 3-dimensional geometric structure in which the shape of the molecule can vary because elements that have bonded (formed compounds) produce a certain molecular shape, which is represented by a certain geometric molecular shape as well. The shape of certain geometric molecules must be illustrated by students in three dimensions. The various molecular shapes will make it more difficult for some students, especially those who do not have a visual learning style. As a result, teaching material that can describe a molecule's shape in three dimensions is required. Tasker & Dalton (2006) in their research that students need media that is able to represent these three levels. The results of interviews with chemistry teachers stated that the concepts that were difficult to teach to students were the concept of molecular shape, the Valence Shell Electron Pair Repulsion Theory (VSEPR), interactions between particles, and the relationship between intermolecular interactions and the physical properties of substances. This concept is difficult because it is abstract, so it requires teaching materials that can describe it concretely. In addition, it takes a long time for students to understand these concepts. This can be seen from the low student scores on the subject of molecule shapes and interactions between molecules.

The above results are in accordance with Hurrahman (2022), where one of the biggest challenges in learning chemistry, especially in the material of molecular shapes and interactions between molecules, is the difficulty of visualizing concretely at the submicroscopic level, such as electrons, molecules, and atoms. Therefore, modeling is needed to represent the submicroscopic and symbolic levels that cannot be seen by the eye (Dwiningsih & Safitri, 2020). Based on this, earlier research suggested that alternative ways of learning about chemistry would be better if the three levels of representation, especially the submicroscopic level, could be shown in a balanced way. One of the technologies that can be added to the e-learning module is augmented reality (AR)-based technology.

According to Bistaman & Rashid (2018), augmented reality technology can support seamless interaction between real and virtual environments and allow the use of real-world interface metaphors for object manipulation. This underscores the importance of developing augmented reality-based learning media in this research. The use of augmented reality technology in learning with e-Module teaching materials can play a role in helping students visualize abstract material in 3D so that it makes it easier for them to understand the material. The augmented reality-based e-module used in this study is Assemblr Studio because it is available on the Android platform and is quite easy to use. Based on the explanation above, to foster student understanding, teachers need teaching materials in the form of multiple representation-based e-modules combined with Augmented Reality technology as a medium that can display 3D objects made from molecular-shaped material. Therefore, the main purpose of this research is to produce teaching materials that are valid and see how students and teachers respond to the use of teaching materials, so the authors want to conduct research on the "Development of Multiple Representation-Based E-Modules Utilizing Augmented Reality in the Material of Molecular Shapes and Inter-Molecular Interactions ".

2. METHODS

The method used is the Research and Development (R&D) method with the ADDIE model, which consists of 5 phases: the analysis phase, the design phase, the development phase, the implementation phase, and the evaluation phase. Data collection techniques included interviews, student questionnaires, validation sheets, and teacher and student response questionnaires. Validation was assessed by 6 experts, namely 3 material experts and 3 media experts. Two methods were used in small-scale trials: one-on-one tests and user responses. The one-on-one test involved three students with high, medium, and low abilities. User response assessment involved three teachers and 30 students. in the teacher response questionnaire technique as a tool to get teacher responses to the use of multiple representation-based e-modules with augmented reality in the chemistry learning process. The teacher's response questionnaire was adopted from Putri (2020). Teacher response questionnaires were given directly to chemistry teachers in class X in November 2022. The student response questionnaires in this study were adopted from Zulfianda's research (2016) and modified as needed. Student response questionnaires were given directly to 30 students in November 2022.

The data from the user's response and the evaluation of the validation sheet are put on a scale. The type of scale used is a Likert scale with a score of 1-4. This scale enables the validator to more easily assess the validity of the developed multiple representation-based e-Module teaching materials with Augmented Reality.

Table 1. Rating Category Based in Likert Scale

Scale	Information
4	Very good
3	Fine
2	Enough
1	Not good

(Sugiyono, 2017)

From the Likert scale rating category, the average percentage of each component will be calculated using equation (1).

$$P = \frac{\sum X}{\sum Xi} \text{ x } 100\% \quad (1)$$

Information:
P : Percentage score (rounded)
$\sum x$: Total value of respondents' answers in one item.
$\sum xi$: Sum of ideal scores in one item

The average score results from the validation questionnaire and user responses that have been obtained are then converted into qualitative data to determine the criteria for using multiple representation-based e-modules with augmented reality, which can be seen in Table 2.

Table 2. Questionnaire Criteria Interval

Percentage (%)	Criteria
81-100	Very good/ very feasible/ very valid/ does not need revision.
61-80	Good/ eligible/ valid/ no need for revision
41-60	Good Enough/ Inadequate/ Invalid/ Revision Required
21-40	Not good/insufficient/invalid/requires revision
< 20	Extremely Unfavorable/ Extremely Inappropriate/ Extremely Invalid Needs Revision

(Arikunto, 2010)

3. FINDINGS AND DISCUSSION

3.1 Analysis

The results of interviews with three chemistry teachers show that chemistry is considered a difficult subject and less interesting. This can be caused because chemistry is related to material that is abstract and complex and requires intellectual intelligence and greater effort to understand it (E. Susilaningsi, 2019). In addition, there are multiple representations that must be associated with teaching chemistry to students. According to Akram (2017), students' lack of interest in chemistry can be caused by several factors, including the methods used by the teacher in the learning process that is not in accordance with the methods students prefer. This problem is a challenge that must be faced by teachers in presenting chemistry lessons to students, so the selection of teaching materials, methods, and learning models is an important thing that must be considered.

Based on the results of the questionnaire for class X SMA IPA students, important points can be drawn from the three aspects asked of the students. The important points are that students tend to rate chemistry lessons as mediocre (55%). In addition, students prefer group learning (43.3%), and if students do not understand chemistry learning with the teaching materials used by the teacher, efforts are made to overcome it by asking friends who understand more (61.6%). For learning media, more students like electronic-based learning media (51.6%).

Curriculum analysis aims to review the curriculum used by schools so that the preparation and development of multiple representation-based e-modules is in accordance with the curriculum used. In this study, the school used the 2017 revised K–13 curriculum. In addition, based on the analysis of the material that will be included in the multiple representation-based e-module, the main material that will be provided is molecular shape material (valence electron pair repulsion theory (vsepr)), domain theory electrons, hybridization theory), and intermolecular interactions (hydrogen bonds, van der Waals forces, dipole-dipole, and London dispersion forces (instant dipole and induced dipole).

3.2 Design

At the planning stage, there are aspects of media design that will be developed. Multiple representation-based e-module designs using Augmented Reality technology as a form of solving problems found in the preliminary analysis research phase The instrument used to assess the quality of teaching materials is a questionnaire containing an assessment of teaching materials in the form of Multiple Representation-based e-Modules with the help of this Augmented Reality technology. At this point, the researcher created a product evaluation questionnaire grid. In addition to designing the contents of the multiple representation-based e-module prototypes, it was compiled by referring to competency achievement indicators and learning materials that had been described in the material analysis stage. The contents of the e-module are taken from sources, namely high school/MA chemistry books, college chemistry books, and the internet, that are relevant to the material on the shape of molecules and interactions between molecules. Multiple-representation-based e-module display design is done by preparing storyboards. The sequence of e-module display designs that have been carried out can be explained as follows:

3.2.1 E-module cover page display design

The e-module cover page is created using the Photoshop program by utilizing the polygon tool menu, clipping mask, blending, and type tools. The cover page consists of (a) the title of the e-module; (b) the name of the subject, class, and semester; (c) the logo of Tut Wuri Handayani, the University of Riau, and K-13; (d) pictures depicting e-module titles or subjects; and (e) the identity of the author.

3.2.2 E-module content display design

Using Canva's shape menu, shape fill, text box, and background, the module's content display was made. The order of displaying the contents of the e-module consists of an introduction, core, and closing.

a) The introductory section consists of: (1) a preface; (2) a drafting team; (3) a table of contents; (4) instructions for using the e-module; (5) instructions for working on the e-module; (6) core competencies; (7) basic competence; and (8) a concept map.
b) The core part is the four learning activities in the e-module, according to the material that will be provided in the learning process. The order of display in e-modules 1–4 consists of (1) competency achievement indicators; (2) learning objectives; (3) material description; (4) summary; (5) independent assignment; (6) problem practice; and (7) feedback.
c) The closing section is a bibliography, which is a reference for the material in the e-module.

3.3 Development

The development phase involves two processes: prototyping and material validation.

3.3.1 The prototyping process

The prototyping process is the act of transforming the design in the storyboard that has been previously designed into an e-module prototype based on multiple representations on the actual display. With the assistance of Assemblr Studio, the application employs Augmented Reality technology. After collecting AR materials and designs, teaching materials are then developed with the help of Canva in such a way as to be interesting in presenting learning materials with additional assistance from 3D visualization by adding links and entering QR-code from augmented reality with the help of Assemblr Studio so that augmented reality forms can be scanned with the Assemblr application scan camera to facilitate 3D visualization of molecular shapes. This application has advantages, namely that users can insert a variety of content in the form of audio, music, flash animation, video, and hyperlinks in teaching materials. Teaching materials that have been developed in PDF form are then uploaded to the Flip Builder application. Flip builder can also be published in formats other than flash, such as html and exe, which can be accessed both locally and remotely.

3.4 Validation

The validation stage consists of material validation and media validation involving each of the six expert lecturers on e-modules based on multiple representations of material in the form of molecules and interactions between molecules.

3.4.1 Material Validation

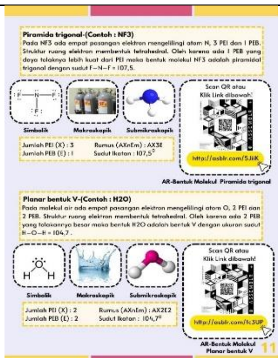
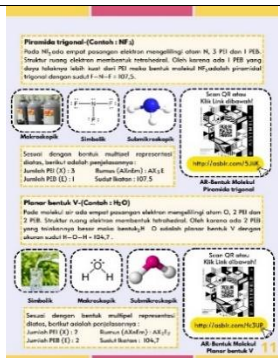
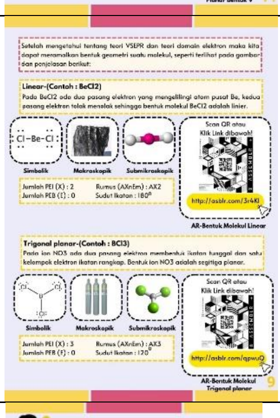
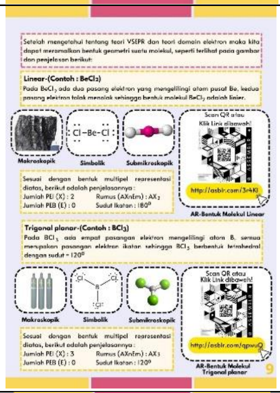
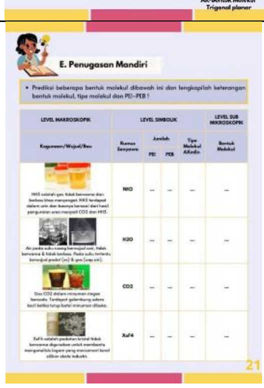
Assessment by three material validators uses a validation sheet in the form of a 1-4 Likert scale. Material expert validation assessment is based on content, pedagogic, linguistic, and graphic aspects. Three material validators have provided assessments and suggestions; improvements based on these suggestions have also been carried out and applied to e-modules based on multiple material representations of molecular shape and intermolecular interactions. The results of the average percentage of each aspect of the material validation assessment can be seen in Table 3.

Table 3 Percentage of Material Expert Validation Result

No.	Rated aspect	Percentage (%)	
		Validation I	Validation II
1	Content Eligibility	75,7	94,4
2.	Pedagogic	86,4	96,2
3.	Language Assessment	62,5	91,7
4.	graphics	80,6	94,4
Average		**78,5**	**94,7**

The material validation stage was carried out twice. In the first validation, the average percentage of the 4 aspects was 81.3%, making this a very valid category. Even though very valid results were obtained, in the first validation, suggestions were also obtained from each material validator to improve the e-module, so the researchers carried out a second revision and validation in order to obtain e-modules based on multiple material representations of molecular shape and better intermolecular interactions a second revision and validation in order to obtain e-modules based on multiple material representations of molecular shape and better intermolecular interactions. After the revision was carried out based on suggestions from the validator, in the second validation, the percentage rose to 94.7% with a very valid category.

Table 4 Results of Material Expert Validation Revision

Number	Form	Physical Results		Description
		Initial	Final	
1	Changing Images Before Validation After validation			Replacing images that are not quite right can cause misunderstandings
2	Adding Clear Commands to Sample Questions Before Validation After validation			Adjust the writing of the molecular formula
3	Adjusting Questions with IPK (Indicators of Competence Achievement) Before Validation After validation			Adjust questions based on IPK

3.5 *Media Validation*

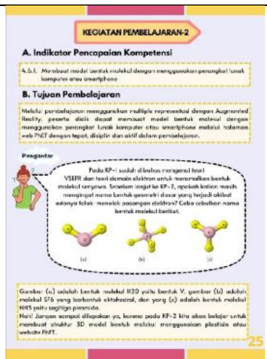
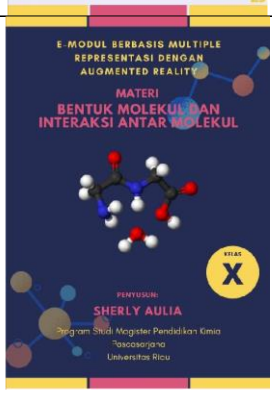
Media validation entails three validators who are media experts and lecturers. Media validation uses a validation sheet in the form of a Likert scale of 1-4. The purpose of this media validation is to assess multiple representation-based e-modules with the help of augmented reality material on the shape of molecules and interactions between molecules based on three aspects: the size of the e-module, the cover design, and the contents of the e-module. The results of the average percentage of each aspect of the media validation assessment can be seen in Table 5.

Table 5 Results of Media Expert Validation

No.	Rated aspect	Percentage (%)	
		Validation I	Validation II
1	E-module size	87,5	87,5
2.	E-module cover design	68,8	93,8
3.	E-module content design	80,3	91,7
Average		78,4	92,2

The media validation stage was carried out twice. In the first validation, the average percentage of the 3 aspects was 78.4% with a valid category. Even though valid results were obtained, in the first validation, suggestions were also obtained from each media validator for improvement of the e-module, so the researchers carried out a second revision and validation in order to obtain multiple representation-based e-modules with the help of augmented reality material on molecular shapes and interactions. better intermolecular After the revision was carried out according to the validator's suggestion, in the second validation, the percentage increased to 92.2% with a very valid category.

Table 6 Media Expert Validation Revision Results

Number	Form	Physical Results		Description
		Initial	Final	
1	Adding material to the introduction Before Validation After Validation			Adding material to the introduction
2	Adding Clear Commands to Example Questions Before Validation After Validation			Customize the writing of the molecular formula
3	Adding instructions for how to use e-modules with buttons and what those buttons do before and after validation			Added instructions for using the e-module equipped with buttons and their functions.

3.6 *Implementation*

This step is to implement learning media in the learning process at school. By conducting one-on-one trials, small-scale trials, and large-scale trials involving students, we can find out students' responses to multiple representation-based e-module materials with the help of AR material on molecular shapes and interactions between molecules.

3.6.1 Test each one one by one

A one-to-one test of multiple representation-based e-modules with the help of AR material on molecular shapes and intermolecular interactions involved 3 students of class XI at SMAN 14 Pekanbaru who had studied material on molecular shapes and intermolecular interactions in class X. All three were students who have different levels of academic ability, namely high, medium, and low. During the one-on-one test, students are given an e-module link based on multiple representations of material in the form of molecules and interactions between molecules that have been made with Augmented Reality technology. Furthermore, researchers will guide students in using the e-module directly. Students take part in learning activities and work on the questions contained in the e-module. Then the students were interviewed to obtain their comments and suggestions for the e-module. The comments and suggestions given by students can be seen in Table 7.

Table 7 Student Comments and Suggestions on the One-on-One Test

Student Code	Comments and Suggestions
ZHI	Comment: 1. The e-module used is very interesting, and the color combination is just right, so it keeps me from getting bored quickly while studying. 2. The writing is easy to read and clear. 3. The AR display is interesting.
	Suggestion: Picture quality was clarified.
SA	Comment: 1. The provided e-module is interesting and unique, and it can serve as adequate teaching material for online learning. 2. There is an interesting AR that can describe the shape of the molecule in 3D. 3. Apart from scanning, it can also be linked, which really helps with camera limitations in scanning.
	Suggestion: There are some typos that need to be fixed.
PR	Comment: The e-module provided has a good appearance and is easier to use because it is in the form of a flip builder that can be swiped left and right, not the usual website, which has to be scrolled down.
	Suggestion: There are some typo words that need to be fixed.
Conclusion	Comment: The E-Module is equipped with an interesting and easy-to-use Augmented reality. Suggestion: Improve image quality and fix typo words.

Based on the one-to-one test, it was found that students gave positive comments about the e-module provided. They argue that e-modules based on multiple representations of material in the form of molecules and interactions between molecules developed using Augmented Reality technology can make students more interested, increase their interest in learning, and not get bored easily following learning. This is because the e-module has an attractive appearance, is unique, and is easy to use. The same thing was conveyed by Adawiyah & Hadisaputra (2020) interesting teaching materials can make students more interested and motivated to participate in learning.

In addition, Augmented Reality technology allows the use of various multimedia in e-modules, which are not only in the form of text and images but also 3D simulations that can stimulate students' understanding of abstract concepts such as molecular shapes and interactions between molecules. According to Depdiknas (2008), abstract material concepts can be described in concrete terms using electronically integrated teaching materials. Presentation with the help of Flipbuilder, which is used to create e-modules, produces teaching materials that are operated back and forth like books, making it easier to use compared to other electronic teaching materials such as websites that must be scrolled up or down. In addition, there are navigation buttons that make it easier for users to find or go to the desired page in a relatively short time (Seruni, 2019).

3.6.2 Small-scale trials

At this stage, the researcher acts as an observer and does not interact with users. Responses to the small group trial were obtained from three chemistry teachers and 30 students by providing a small trial response questionnaire. Small-scale trial response data collection was carried out at SMAN 14 Pekanbaru, SMAN 4 Pekanbaru, and SMAN 1 Pekanbaru.

a) Teacher response questionnaire data

User responses with chemistry teacher response questionnaire data at 3 schools, namely SMAN 14 Pekanbaru, SMAN 4 Pekanbaru, and SMAN 1 Pekanbaru User responses involving the teacher's assessment are carried out by first providing e-modules based on multiple representations with the help of AR material on molecular shapes and intermolecular interactions, then giving the teacher time to look at the e-module carefully before giving an assessment using a response questionnaire. The results of the teacher's response questionnaire are presented in Table 8.

Table 8 Teacher Response Questionnaire Data

Respondent	Percentage (%)	Criteria
Teacher 1	93,1	Very good
Teacher 2	91,7	Very good
Teacher 3	94,4	Very good
Average	93,1	Very good

With a 93.1% achievement rate, the teacher's response to the e-module based on multiple representations of molecular shapes and interactions between molecules is considered to be very good. Table 5 shows that the e-module based on multiple representations with the help of AR is thought to be very easy to use and that the way information and learning activities are presented is organized and in line with the indicators and learning goals. Teachers also give their full support to the creation of this e-module because they see it as an alternative way to teach that can get students' attention.

b) Student response questionnaire data

The stages of obtaining user responses from the results of student response questionnaires involved 30 students in class XI IPA from three different schools, namely SMAN 14 Pekanbaru, SMAN 4 Pekanbaru, and SMAN 1 Pekanbaru. Response questionnaire data collection involving students was carried out by giving e-modules to students, who were then given time to assess the e-module using a response questionnaire. The results of the student response questionnaire can be seen in Table 9.

Table 9 Student Response Questionnaire Data

School	Percentage (%)	Criteria
SMAN 14 Pekanbaru	92,1	Very good
SMAN 4 Pekanbaru	93,9	Very good
SMAN 1 Pekanbaru	95,0	Very good
Average	93,7	Very good

Based on Table 9, it can be seen that the results of distributing questionnaires to get student responses in 3 schools obtained an average of 93.7%. This means that e-modules based on multiple representations of material in molecular form and intermolecular interactions that have been developed with Augmented Reality technology get a very good response from students. This shows that the e-module that has been developed is able to grab the attention of students because it is considered to have an attractive appearance, makes them more enthusiastic and motivated in learning, presents material with multimedia so that it is easy to understand, and has learning activities that increase student activityvery good response from students. This shows that the e-module that has been developed is able to grab the attention of students because it is considered to have an attractive appearance, makes them more enthusiastic and motivated in learning, presents material with multimedia so that it is easy to understand, and has learning activities that increase student activity. Based on the results of small-scale tests, it can be concluded that e-modules based on multiple representations with the help of AR material on molecular shapes and intermolecular interactions have received very good responses from teachers and students as users. After going through the validation and small-scale testing stages, revisions are carried out so that the final product of the e-module is produced.

3.7 *Evaluation*

The evaluation phase of this study can be carried out at each ADDIE stage. The evaluation aims to analyze the data obtained from the research results, namely: (1) analysis in the form of the initial analysis, student analysis, curriculum analysis, and material analysis; (2) compilation of instruments for assessing the quality of teaching materials, product design (storyboards), preparation of materials, and collection of tools and materials; (3) development in the form of material and media expert validation; and (4) implementation in the form of one-on-one tests, limited trials, and field trials. The final results of the evaluation stage show that the product developed in the form of an e-module is very valid, gets a good response from teachers and students, and can increase scientific literacy.

This research is also not free from several obstacles in the field, especially for e-modules that use AR. The obstacle faced during the learning process is the connectivity network of students' cell phones because the teaching materials used are e-modules with augmented reality. Students continue to struggle with the problems presented, and they are unsure of what steps to take next. According to the results of interviews with several students, they felt that the use of e-module teaching materials was already interesting, but very often students experienced technical problems in the QR Code AR scanning process, which hindered the learning process so that it had an impact on students' interest in continuing to use teaching materials. This can be overcome by directing students in the use of other visual forms from the submicroscopic by way of 3D shape links, which is useful in overcoming the obstacles of augmented reality through scanning a QR code.

4. CONCLUSION

Based on the research that has been done, the conclusion that can be drawn is that e-modules based on multiple representations with the help of augmented reality technology to increase students' scientific literacy in the material of molecular shapes and intermolecular interactions are stated to be very valid based on material validation in the aspects of content feasibility, pedagogics, language, and graphics and declared very valid based on media validation in terms of size, cover design, and e-module content design. E-modules based on multiple representations with the help of augmented reality technology to increase students' scientific literacy in the material of molecular shapes and intermolecular interactions obtain very good responses from users, namely teachers and students. Researchers can make suggestions to educators and future researchers, such as suggesting that educators use e-modules based on multiple representations with the help of this augmented reality technology in the learning process. This research is only focused on developing e-modules as an effort to increase students' scientific literacy. The researcher suggests to future researchers that if they are interested in research and development (R&D) method development, they can refer to the ADDIE development model. In addition, other researchers can also use augmented reality applications to develop electronic-based teaching materials for other chemical materials.

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