Development of The Interactive Learning Media Based on Augmented Reality 3D on The Petroleum Concept

Sultan Fakhrur Rassyi [a], Supriadi [b], Yayuk Andayani [c], Aliefman Hakim [d], Burhanuddin [e], Saprizal Hadisaputra [f,*]

[a, b, c, d, e, f] *Chemistry Education Divison, Faculty of Teacher Training and Education, University of Mataram. Jalan Majapahit no 62 Mataram 83125, Indonesia*

**Corresponding author: rizal@unram.ac.id*

Received: May 02, 2022; Accepted: March 18, 2023; Published: April 15, 2023

ABSTRACT: Chemistry is studied by students at the high school level. However, due to the abstract concept of chemistry, chemistry becomes difficult for some students to learn. One problem with studying chemistry is the petroleum material in online and offline learning systems. This study aimed to determine the feasibility and practicality of interactive learning media based on the 3D augmented reality of petroleum topics. This study aims to describe the making of applications with augmented reality technology as a medium for learning chemistry. The research type was development research that adopted a 4D model (define, design, develop, disseminate) but was limited to the development stage. The population in this study was 192 students of public high school SMAN 7 Mataram, Indonesia. This study's sampling was carried out using a random sampling technique measured through an expert validation sheet with three assessment aspects assessed by three validators. The practicality level of the media was measured through a practicality questionnaire filled out by 22 students in eleventh-grade students at SMAN 7 Mataram. The results showed that the validator assessed media feasibility was 90.16%, which indicated that the media developed was very feasible. Meanwhile, the media practicality test results revealed that students responded positively to all media components with a practicality percentage of 94.39%. In conclusion, the media developed is feasible and practical to use.

Keywords: augmented reality 3D, learning media, petroleum

INTRODUCTION

The COVID-19 pandemic is among outbreaks that have spread to various countries, including Indonesia, which had its first COVID-19 case in early March in Jakarta. The number of people infected with COVID-19 in Indonesia increases by the day. According to the most recent data, as of March 1, 2022, there were 5.59 million positive cases, 4.8 million recovered, and 148 thousand persons confirmed dead. The COVID-19 pandemic has had a significant impact, mainly because all components of society have been forced to self-isolate at home, with all activity in various domains unable to operate as usual. Education is one of the areas affected by this pandemic [1]. In addition, learning with the selection of learning media appropriate to class conditions and the environment can support learning activities but is not used interactively. Hence, students get bored easily when learning is direct or engaging.

Due to the COVID-19 pandemic, distance learning is currently used to maximize learning. Every teacher, employee, and lecturer conducts lectures and learning from home using digital documents, video conferencing, and other internet resources. The Ministry of Education, Culture, Research, and Technology has advised learning activities to be carried out using facilities from a variety of digital educational platforms, including Zenius, Sekolahmu, Microsoft Office 365, Google G Suites for Education, Ruang Guru Online School, Quipper School, and Learning House [2]. According to the observations, the online teaching and learning process only provides a solution for some parties, as some students complain about problems and more complex obstacles due to the transition in the learning system from face-to-face to online, particularly in chemistry lessons.

Chemistry is an experimental discipline that cannot be learned solely through reading, writing or listening. Learning chemistry entails mastering knowledge in the form of facts, concepts, and principles and challenging students' mindsets to think critically about problems and events that occur in everyday life [3]. One of the materials in chemistry subjects is petroleum.

Petroleum material is memorized content, discusses a lot of material, and is explained in books in the form of paragraphs. This petroleum material learning technique frequently employs lecture and memorization methods. It is challenging for students to remember and does not create a pleasant impression, especially throughout the teaching and learning process [4]. Moreover, there is a lot of studying petroleum material related to the experimentation of compounds contained in various kinds of products from petroleum, so a 3D concept is needed in learning so that you can see the structure of petroleum content. The material is interesting to read if the appearance is engaging, distinctive, and good and if it can be related to the real world. Thus, studying petroleum material entails understanding petroleum separation procedures, which have several steps and require an interactive media ideal for online learning [5].

Because petroleum involves abstract and sophisticated concepts, it must also be conveyed through three levels of representation. 3D teaching aids are required to help students understand these abstract and challenging concepts. Students must understand three levels of representation to learn the notion of chemistry [6]. According to Johnstone, there are three levels of chemical representation: macroscopic, submicroscopic, and symbolic. Observation of a 3D phenomenon with different features, such as shape, fragrance, and color, is used to create macroscopic representations. Submicroscopic representations of phenomena at the particle level are used to understand them. Symbolic representation is obtained through symbols at the particulate level [7]. Explaining the three levels of representation requires new technology.

The advancement of science and technology provides new impetus to initiatives to revitalize the use of technological outcomes in the learning process. Students use their Android devices more frequently than they read books of information, which are valuable for providing insight into the teaching and learning process at school and outside of school. Furthermore, its evolution has an impact on the growth of media. Learning media that is more concise and engaging while not sacrificing the essence of the material is needed. One is the relatively new learning media development, especially instructional media based on 3D augmented reality [8].

The development of Augmented Reality technology is still in its early stages, and people have yet to use it in their daily lives widely. The most obvious example of the use of Augmented Reality technology in society is the game Pokemon Go 2016 on mobile phones, which experienced a surge in the number of enthusiasts a few years ago. There are several aspects of why Augmented Reality has yet to be utilized optimally in people's lives in Indonesia—starting from the price of equipment which can be quite high so that people are reluctant to use it. It can also be caused because this technology is still relatively new, so there are still people who do not know about the existence of this technology. In addition, devices such as mobile phones still need to support Augmented Reality technology can be why this technology has yet to be fully utilized. Augmented reality can take a big place and role in the new normal era, where work and study are done from home (work from home). This technology enables remote work collaboration as it is currently being developed, which is more commonly referred to as The Need for Collaborative AR. Many applications, such as Mix Assistance or AR/VR Remote Assistance, use AR for collaboration. Augmented reality 3D is a revolutionary three-dimensional technology that integrates virtual things (3D) into the actual environment. In this case, students initially study by looking at photos (2D), but after using 3D augmented reality, they see the material as real and occurring in front of them. Augmented reality (AR) is a technology that integrates three-dimensional (3D) virtual things into the real three-dimensional world and displays them in real-time [9]. The 3D augmented reality technology, which combines a virtual and actual world, is projected to give a more efficient and effective teaching and learning process and provide pupils with a clear visualization [10]. However, for this technical potential to effectively be used to promote educational performance, it must be carefully monitored. During the COVID-19 epidemic, the researcher took the initiative to create interactive learning media based on 3D augmented reality on class XI petroleum materials.

METHOD

This research is a research development or Research and Development (R&D) used to find results in a particular product and test its effectiveness [11]. This R&D research uses a 4-D model (define, design, develop, and disseminate). The development stage used in this study is the Initial analysis of learning activities, task analysis, concept analysis, and formulation of learning objectives. The second stage is The design and preparation of learning devices, including the Application Model, Learning Media. Research instrument. Finally, validation by experts, product revision, and practicality tests.

The research was conducted at SMAN 7 Mataram in March 2022. The population used was class XI natural science at SMAN 7 Mataram, which consisted of 192 students. The sampling technique used was random sampling. Thus, the number of samples required from the calculation results is 22

students. The research instruments used in this media development research were media validation sheets and media practicality sheets. The media validation sheet is used to obtain data related to the assessment of augmented reality-based learning media from expert validators. In contrast, the media practicality sheet is intended to determine student responses to augmented reality-based learning media. The validation and practicality sheets of the media are used to improve the learning media that researchers have developed.

The data were obtained from the validation sheet of the 3D augmented reality-based learning media instrument that has been validated and the practicality of the media aimed at students and for data collection from a limited trial of 3D augmented reality-based learning media. The research data were analyzed using descriptive statistical data analysis. According to Sugiyono [12], descriptive statistics are the presentation of data through tables, graphs, pie charts, pictograms, decile calculations, percentiles, calculation of data distribution through the analysis of the average and standard deviation, the calculation of the percentage of research data can be analyzed as follows:

Expert Validation Data Analysis

The expert validation data for each media were analyzed and considered based on the validators' input, suggestions, and comments. The analysis results are presented to improve the learning media that have been developed (Table 1). The data analysis technique used to obtain data analysis of the validity of learning media based on 3D augmented reality can be determined from the equation expressed [13] as follows:

$$V - ah = \frac{TSe}{TSh}\ x\ 100\%$$

where: $V - ah$ = Expert validation; TSe = Total Score achieved; TSh = Total score expected

TABLE 1. Media Eligibility Criteria

Score (%)	Criteria
86.00-100.00	Very valid
71.00-85.00	Valid
56.00-70.00	Quite valid
41.00-55.00	A little valid
25.00-40.00	Invalid

Media Practical Analysis

Product evaluation was carried out with an analysis phase that aimed to understand the level of practicality of product development or learning media. A product is declared practical if it can apply learning media easily. Practicality can be measured using a Likert scale modified by Riduwan [14] with alternative answers 1 = very impractical, 2 = impractical, 3 = quite practical, 4 = practical, and 5 = very practical. The formula can calculate the practicality of questionnaire analysis:

$$p = \frac{f}{N}\ x\ 100\%$$

where: p = Final value; f = Score obtained; N = Maximum score

After the practicality value is obtained, the next step is to group it according to the practicality category in Table 2.

TABLE 2. Practicality Category

No.	Score	Category
1	80% <x≤100%	Very practical
2	60% < x≤ 80%	Practical
3	40%< x≤ 60%	Quite Practical
4	20% < x≤ 40%	A little practical
5	0% < x≤ 20%	Not practical

RESULT AND DISCUSSION

Result of Quantitative Analysis

A. Defining Stage

This initial analysis revealed that currently, there are no interactive learning media used to carry out chemistry learning which aims to increase the understanding of students of SMAN 7 Mataram on

petroleum materials, especially in the digital era. The researchers will develop learning media based on 3D augmented reality on petroleum material based on the analysis results.

This problem analysis resulted in selecting learning material to be used in the developed media. Based on an examination of the chemistry syllabus, the basic competencies used as learning materials and the indicated indications of competency achievement.

This concept analysis produces material presented in 3D augmented reality learning media, namely material that focuses on three levels of chemical representation of petroleum material: macroscopic, submicroscopic, and symbolic. Concept analysis has a theory where a literature review of books or other relevant sources is carried out to contain adequate theoretical material that can support students' understanding of the 3-dimensional application concept of each compound. In this case, innovations in learning media are also carried out to improve students' understanding of learning through the three levels of chemical representation.

The formulation of learning objectives is based on the results of the initial analysis of tasks and concepts. The formulation of the objectives resulted in the need for research on developing interactive teaching media based on 3D augmented reality on petroleum materials. It is known that learning activities at SMAN 7 Mataram generally only use lecture and discussion learning methods, with learning tools in the form of blackboards and printed books, causing students to get bored with learning. In the current pandemic conditions, it is impossible to only carry out learning by applying discussion and lecture methods with less interactive media. For this reason, innovation in learning activities is needed. From the formulation of this learning objective, the researcher will develop interactive teaching media based on 3D augmented reality of petroleum material to increase students' learning motivation in class XI Natural Science at SMAN 7 Mataram.

B. Designing Stage

The Crude Oil AR3D 1 application is the term given to the resulting learning material. This learning medium includes an initial display, developer information, application instructions, and a menu display. Several submenus on petroleum materials are presented in the menu display, including the definition of petroleum, the method of formation and processing of petroleum uses and compounds of petroleum components, and petroleum fractions [15]. Furthermore, this learning media is backed up by a module that includes markers as molecular detectors on Crude Oil media. The image in the module is of a petroleum substance, and the institutional sign is on the top left of the module's cover.

The learning media content component is carried out for independent learning, in which students can theoretically master the material through three levels of chemical representation. The suitability of the material with learning objectives and main competencies, the completeness of petroleum material in the learning media, the material presented in the media, and authentic learning, which includes accuracy. Facts with concepts or theories about petroleum, color presentation, graphic sizes, animations on 3D images, and explanations and back sound in petroleum learning media. Learning media development has been adjusted to the indicators that will be realized. This media content also stimulates students' curiosity when studying petroleum material in the media. Figures 1 and 2 show visualization of the results of developing 3D augmented reality-based teaching media on petroleum materials.

FIGURE 1. Main Menu Display and Petroleum

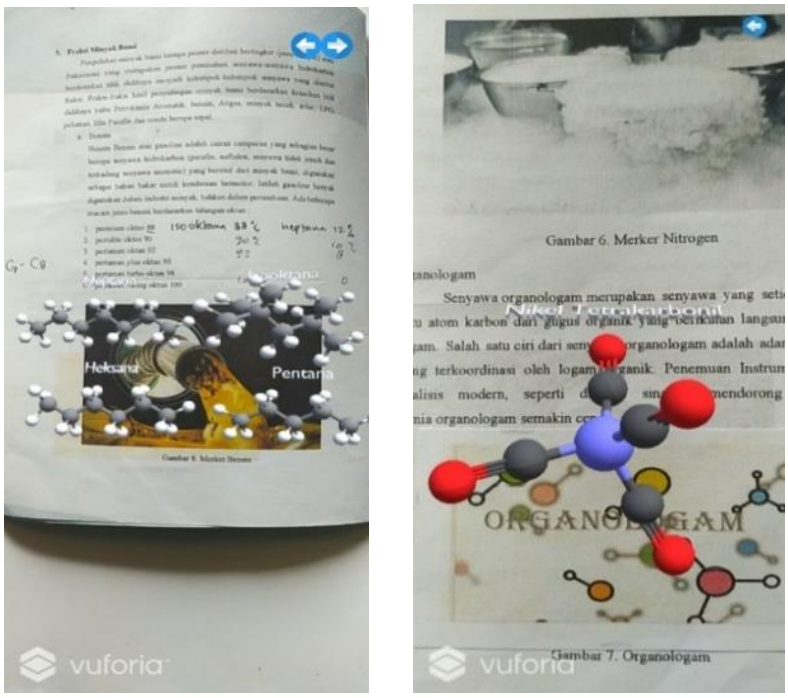

FIGURE 2. 3D Object Display of Petroleum Components and Fractions

C. Developing Stage

1. Expert Validation

This expert validation resulted in the validity of the developed learning media. Media experts reviewed and assessed the designed teaching media-based augmented reality-based 3D application. The results of the complete validation sheet are presented, and the assessment analysis results from the validator on 3D augmented reality-based interactive teaching media are presented in Table 3.

TABLE 3. Learning Media Validation Results

No.	Component	Score (%)	Criteria
1	Content Validation	93,30%	Very Valid
2	Construct Validation	92,50%	Very Valid
3	Language Validation	84,40%	Valid
	Average	90,16%	Very Valid

It is known that based on the results of the analysis of the validity of interactive learning media based on 3D augmented reality by two Chemistry education lecturers at the University of Mataram. As expert validation, the chemistry teacher in class XI at SMAN 7 Mataram, the learning media developed is categorized as very valid. It is evidenced by the value of the learning media's validity, which is 86-100%.

2. Revised

The revision results of the learning media are generally stated to have met the valid value range on the general assessment criteria. However, some suggestions from validators must be considered and acted upon. Therefore, improvements were made by spacing the image with objects with more than one molecule to make it easy for students to see as users. As a result of the researcher's modifications in line with the validator's direction, an interactive teaching media based on 3D augmented reality on petroleum material, known as the Crude Oil AR3D 2 application was obtained.

3. Revision Stage

This revision stage provides the results of chemistry learning media based on 3D augmented reality on petroleum material, the Crude Oil AR3D 2 application. 3D molecular images that have yet to be spaced between the molecules in an image object on petroleum materials make it difficult for readers or students to see them. Therefore, the first revision was to separate them according to the experts' suggestions. Molecular pictures before and after the revision are presented in Figure 3.

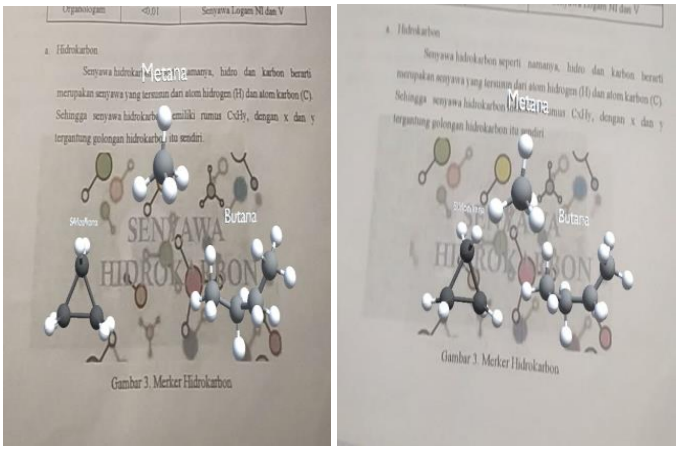

FIGURE 3. Before and After Revision

4. Practicality Test Results

Student responses to the practicality of learning media based on 3D augmented reality that has been developed were used in this study to determine the level of practicality of the media.

TABLE 4. Results of student responses to learning media

No.	Aspect	Practicality Percentage (%)
1	Ease of Use of Media	96.06%
2	Media Benefits	93.40%
3	Media Attraction	95.70%
4	Media Clarity	92.40%
	Average	94.39%

Table 4 shows the average practicality value on the assessment results of 22 respondents in the practicality test using the practicality index with four aspects of all aspects is 94.39%. This value indicates that the learning media based on 3D augmented reality developed is 80% < x ≤ 100%. In other words, learning media is very practical.

Discussion

A. The Overview of Learning Media

Based on the findings of the preliminary analysis and the end of this defining stage, an interactive learning resource, such as 3D augmented reality-based learning media, is required to be employed in learning activities. In this case, the teacher is expected to be able to build a more dynamic development of learning media in the chemical learning planning process, particularly petroleum material. The development of learning media based on 3D augmented reality makes the learning process and implementation more engaging, encouraging students to be more active and capable of displaying three levels of representation: symbolic, macroscopic, and submicroscopic. It is similar to Ramadani's research, which discovered that the initial to final analysis stage at the definition stage indicates the need for a learning resource to increase students' interest in learning and mastery of concepts, particularly during the Covid-19 pandemic [16]. Furthermore, students were found to have problems with the chemical properties of three levels of representation, namely macroscopic, submicroscopic, and symbolic. This problem develops due to the submicroscopic characteristics of petroleum products.

As a result, instructional materials that can visualize particle elements of interactive petroleum materials, such as augmented reality, are required. Augmented reality has the potential to inspire, encourage, explore, and manage students from different perspectives that have not previously been taken into consideration in the world of education [17]. Virtual objects (pictures, animations, and text) are introduced into augmented reality as if the content being studied were in a real setting [18].

The design in the preparation of this learning media produces a media and module with predetermined indicators and is displayed attractively in the media added with a marker. A marker is a real environment in the form of real objects that can create virtual reality. This marker is useful for augmented reality places [19]. The markers in this media are made in the form of modules to motivate students in the learning process. Moreover, this media is equipped with sound, explanations, and 3D

molecular shapes for each compound in petroleum through an Android smartphone without using props such as Molymod Molecular.

B. Advantages and Disadvantages of Media

Apart from the benefits of the produced learning media, the drawbacks are undeniable. The research goal is to make learning media more practical and realistic for students to utilize in teaching and learning activities. The development of learning media must have advantages where the characteristics of the media with a three-dimensional concept using Android can provide facilities for students to carry out independent study. Because learning is carried out through 3D augmented reality-based learning media, understanding the concept of petroleum material will increase in line with the rising interest in learning. Learning media based on 3D augmented reality has molecular shapes assisted by markers in the form of modules and sounds from Android. It makes this media more interactive and easy to operate by students with a simple 3D object modeling display because it displays several objects focusing on components and oil fractions. This learning media also displays three levels of chemical representation: macroscopic, submicroscopic, and symbolic levels, which can assist students in observing petroleum through a phenomenon that is implemented using 3D objects in 3D augmented reality-based interactive learning media. According to Ilmawan, teachers can directly design learning media that are more interactive, easy to use, and fun through augmented reality. Augmented reality can also be used as a substitute for learning models that have never been done in schools in the virtual or virtual form [20]. Students can still see and use the module as the original model but in a virtual form. Through this breakthrough, the many variations of existing learning media can be used to support school teaching and learning activities. As stated by the chemistry teacher of class XI Natural Science at SMAN 7 Mataram, learning material based on 3D augmented reality is appropriate for students' cognitive development. This media facilitates student comprehension of the topic, introduces students to the application of chemistry in everyday life, gives a molecular picture of each chemical without props, and is very interactive to be used as a learning medium. The teacher also advises that other interactive learning media with more materials in chemistry learning be developed in the future because of their very useful role in explaining concepts in learning materials in real-time [21].

The developing process of learning media is also inseparable from shortcomings. This researcher developed several shortcomings in the learning media, especially in using 3D augmented reality-based learning media in learning activities. In the implementation of the learning process, it is known that students are not interested in knowing the processes and components of petroleum and its molecules, so they cannot know in more detail what is in petroleum. This issue emerges due to the increased usage of new learning media, which requires students to be more guided. Students are expected to know the process of using and be able to apply learning independently by using various media if these efforts are made regularly. During the research, it was also discovered that Android users could only use this learning media. Therefore some students were unable to install the media. Thus, this media must be created using two different application development processes: iOS and Android. Students' low activity at the beginning of learning also arises during this study because they are more accustomed to adopting one-way learning, particularly through teacher explanations. To overcome these hurdles, teachers must link chemistry study more with learning materials relevant to everyday life to motivate students more effectively in the learning process.

CONCLUSION

Interactive learning media based on augmented reality on petroleum material that has been developed can be used in the learning process because the feasibility level is included in the very valid category, with an average value of the validity of the overall evaluation aspect of 90.16%. Meanwhile, this media's practicability level is reasonably practical, with average practicality (percentage) of 94.39%.

ACKNOWLEDGMENT

The financial support from the University of Mataram PNBP Research Grant in 2023 is highly appreciated.

REFERENCES

1. M. Adnan, J. Pedagog. Socio. Psychol, 1, 2, 45–51 (2020)
2. S. S. MD, J. Med. Sci. Clin. Res, 08, 11 (2020)
3. Y. Yusrizal, C.Z. Harun, H. Husen and M. Iqbal. Int. J. Instr. 11, 1, 33–46. (2018).
4. M. Makhrus, J. Rokhmat, K. Kosim and A. Harjono. J. Pijar Mipa, 17, 3, 420–423 (2022).

5. S. Supriadi, W. Wildan, A. Hakim, L.R.T. Savalas and M. Haris. J. Pijar Mipa, 16, 3, 282–287 (2021).
6. S. Supriadi, S. Ibnu and Y. Yahmin. J. Pijar Mipa, 13, 1, 1–5 (2018).
7. S. Su, R. Wang, R. Zhou, Z. Chen and F. Zhou. J. Ortho. Surgery. Res, 18 1 (2023).
8. J. Kalemkuş and F. Kalemkuş. Interact. Learn. Environ, 1–18 (2022).
9. T. Zuo, M.V. Birk, E.D. van der Spek and J. Hu. Entertain. Comput. 46,100563 (2023).
10. L. Cohen, L. Manion and K. Morrison. Research Methods in Education. (2000).
11. R.B. Johnson and L.B. Christensen. Educational Research Methods. (2014).
12. R. Dalimunte and R. Rohani. Jurnal Penelitian Pendidikan IPA, 8, 5, 2159–2167 (2022).
13. I. Hasan. Dinamika Pendidikan, 12, 2, 136–147 (2018).
14. Z. Munawarah, B. Burhanuddin, B.F.D. Sofia and A. Hakim. JIPP, 6, 4, 768–775 (2022).
15. R. Ramadani, R. Ramlawati and M. Arsyad. Chem. Edu. Rev, 3, 2,152 (2020).
16. K. Lee. TechTrends, 56, 2, 13–21 (2012).
17. P. Soltani and A.H.P. Morice. Comput. Edu.,155,103923 (2020).
18. A. Fombona-Pascual, J. Fombona and R. Vicente. J. Chemi. Inform. Mod, 62, 8,1863–1872 (2022).
19. D.Y.S. Low, P.E. Poh and S.Y. Tang. Edu. Chem. Eng, 39, 31–43 (2022).
20. Y. Cheng, M.-H. Lee, C.-S. Yang and P.-Y. Wu. Interact. Technol. Smart Educ. (2022).
21. E. Campos-Pajuelo, L. Vargas-Hernandez, F. Sierra-Liñan, J. Zapata-Paulini and M. Cabanillas-Carbonell. Adv. Mob. Learn. Edu. Res, 2, 2, 493–501 (2022).