Characteristics and Validation of Augmented Reality-Based Learning Media on Hydrocarbon Material for Vocational High School

Vita Fitria Ningrum*, Woro Sumarni, Edy Cahyono

Postgraduate Science Education, Semarang State University, Indonesia
*Corresponding Author: vita.alfian@students.unnes.ac.id

Abstract. The development progress of technology digital very necessary era of learning time is. One of the technologies that can help improve the understanding of the participants of learners is augmented reality. This research is intended for designing and developing media learning-based augmented reality in the material hydrocarbon and validity for determining the feasibility of the media is. The research is a kind of research development using Design Research and Development (R&D). The product validity testing phase was carried out by two material experts and three media experts. In addition, it was done testing the response of the participant students. Mechanical analysis of the data using instrument questionnaire as well as technical analysis of statistical descriptive. The results of the research of this are: 1) the results of the development of media learning-based augmented reality in the material hydrocarbon the form of an application android which consists of five menu main that is KD and indicators, material, AR camera, practice questions, and the identity of the researcher, as well as seven cards molecule from the molecular structure of chemical compounds; 2) the results of the validity assessment by material experts with an average score of 85% in the "very valid" category, and the validity assessment by media experts with an average score of 94 % in the "very valid" category; 3) the results of testing the feasibility of using small- scale media with an average score of 81,9% with the "very feasible" category used as learning media.

Key words: augmented reality; application android; media learning; hydrocarbons; molecule card.

How to Cite: Ningrum, V.F., Sumarni, W., Cahyono, E. (2021). Characteristics and Validation of Augmented Reality-Based Learning Media on Hydrocarbon Material for Vocational High School. *ISET: International Conference on Science, Education and Technology*, *7*(1), 632-639.

INTRODUCTION

Advances in science and technology can influence the mindset of educators in facilitating the learning needs of their students, one of which is the use of learning media (Ekayani, 2017). With the existence of interesting learning media such as impressions or displays produced from learning media, students will easily remember and absorb the learning material presented by the educator. Technology integrated into learning is one of the strategies for achieving learning objectives because technology is no longer considered something new, especially in the current era of online learning. The learning system in the current millennial era requires educators to develop various creative and innovative learning media, especially by utilizing ICT.

Information and Communication Technology (ICT) the field of education includes not only various online platforms currently available, but also many offline ones such as games, virtual reality (VR), augmented reality (AR), gamification, mobile learning (m-learning), and learning analytics (Nistrina, 2021). Digital technology-based learning media have been widely developed, for example, the use of social networks such as Edmodo, classroom, google form, WhatsApp, and other digital platform applications that can support two-way learning communication (Abd. Syakur et al., 2020; Helsa & Kenedi, 2019). Augmented reality-based virtual media in applications, books, modules, and e-books have also begun to be widely used in learning the sciences, which have been proven to create interactive learning (Kaur et al., 2020; Martín-Gutiérrez et al., 2017; Setyawan et al., 2019).

Augmented Reality is defined as a technology that can combine two or three-dimensional virtual objects into a real environment or the real world with a virtual world as if there is no boundary between the two which then raises or projects it in real-time (Arifitama, 2015; Setyawan et al., 2019; Susanto & Basuki, 2016). According to Aliyu et al. (2020), AR is a computer-based technology where digital information, content, and graphics are combined with education 4.0 as a reflection of industry 4.0. Then, these virtual objects are projected in real-time directly through media in the form of markers or markers directed at the camera. Using this technology, students can

see a real visualization of hydrocarbon compounds applied to Android mobile devices. This technology can serve as a pathway to realize education and industry 4.0. by integrating augmented Reality in chemistry teaching, which is expected to improve 21st-century critical thinking skills, problem-solving, creativity, and collaboration (Aliyu & Talib, 2020).

Augmented Reality media has great potential in improving the quality of learning, especially in understanding abstract material concepts in science that are difficult to see in real (Bursali & Yilmaz, 2019). Augmented reality (AR) technology can visualize images in three dimensions (Ramadani et al., 2020) so that its use can maximize students' understanding of abstract chemistry concepts. AR media is also able to increase students' interest in learning and facilitate understanding of the material (Susanto & Basuki, 2016). Augmented reality-based learning media has been widely used in various learning materials, especially those that utilize the Android system mobile AR facility. In the research of Umamah et al. (2020), the development of an AR-based Biotechnology material module, able to help and facilitate students in understanding the material by modifying abstract and real concepts. Baran et al. (2020) also researched that the use of AR-based media also provides an attitude of individual learning independence (Baran et al., 2020).

One of the chemicals that requires visualization of the shape/structure of the molecule is hydrocarbons. The material for hydrocarbon compounds contains material about compounds consisting of carbon (C) and hydrogen (H) atoms that have interrelated carbon chains between C and H. In this material, students not only have to know the peculiarities of the C atom, the classification of hydrocarbon compounds, the nomenclature of hydrocarbon compounds, they also have to understand the position of the C atom in the carbon chain, which cannot be done just by memorizing but requires visualization through the use of innovative and interactive learning media. Ramadani et al., 2020)

The results of observations of learning needs at SMK Gondang Pekalongan indicate that most students had difficulty understanding hydrocarbon compounds' chemical structure because educators only used two-dimensional media, such as images displayed through power points or textbooks. The students find it difficult to get a picture of how the three-dimensional structure of the hydrocarbon compound is as students find it difficult to visualize the molecular shape of the compound. Several attempts have been made by schools/teachers to visualize the 3-dimensional shape of molecules, including using molymod from plasticine/rubber or balloons but have not been effective.

As many as 74.2% of students have used android gadgets to help the learning process. There have been many learning media that can be operated through Android, one of which is augmented reality. This media can be used online or offline. In Althea's research (2016), alkanol compound AR android media have been developed (Althea et al., 2016), so that it is necessary to develop AR for several other hydrocarbon compounds in learning. Based on the background presented, the researchers are interested in developing augmented reality-based learning media on hydrocarbon materials. In order for the developed media to be suitable for use in hydrocarbon learning, validation is needed. This study aimed to test the feasibility of AR media through validation and response questionnaires and to describe the characteristics of the AR media developed.

METHOD

This study uses a Research and Development (R&D) design with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The analysis stage is by analyzing the problems and needs of making AR-based learning media. The design stage is done by designing the shape of the molecular card to the application applied to android. The application model design is created and developed at the development stage according to the AR media validation criteria. The implementation stage was carried out by testing the learning media in class X SMK Gondang, which was then continued by the evaluation stage, namely a summative test in questionnaire response from teachers and students.

Sample and Data Collection

In this research trial, the samples used in this research trial were students of class XI TKJ at SMK Gondang, with data collection techniques as listed in table 1.

Table 1. Data and Data Sources

Num	Data	Data Type	Data Sources
1	Characteristic of media	Development analysis	Study of literature and AR programmer
2			
3	Media validity Matter validity	Quantitative Quantitative	Media expert Material expert
4	Response Questionnaires	Qualitative and Quantitative	Teacher and students

Analyzing of Data

The data obtained at each step of the study were then analyzed both descriptively and quantitatively. At the stage of developing AR-based learning media, a descriptive analysis was carried out to determine the characteristics of the media produced. Validation data was carried out by quantitative analysis using Table 2.

Table 2. Scala Linkert Criteria

Score	Value	Criteria	Description
4	85 < value < 100	Very valid	Can be used without revision
3	70 < value < 85	Valid	Usable with minor revisions
2	55 < value < 70	quite valid	Can be used with multiple revisions
1	40 < value < 55	Not valid	Can't be used yet

To test the validity of the media created, it is calculated using the equation formula:

$$P_{(s)} = \frac{S}{N} X\ 100\%$$

Information:
$P_{(s)}$: Percentage of sub variables
S : Total score obtained
N : Total maximum score

RESULTS AND DISCUSSION

Characteristics of Augmented Reality-Based Learning Media on Hydrocarbon Material

Based on the results of the research which includes the steps of analysis, design, and development, the learning media is obtained in the form of an android application with 7 molecular cards integrated with the AR camera in the application. The scene in the application consists of:

1. Initial Scene

The initial scene was the initial view when the hydrocarbon augmented reality application is run. This scene will bring up the main menu scene.

Picture 1. Initial Scene

2. Menu Scene

Scene menu is the main menu display which consists of

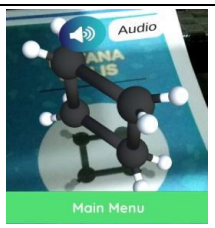
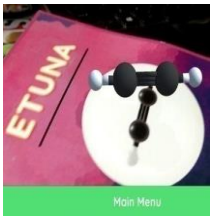
a) Media title, namely "Augmented Reality-Based Learning Media Hydrocarbon Material,"
b) UNNES logo,
c) Identity button (i), which contains the identity of the researcher,
d) KD & Indicator buttons contains the competence of learning hydrocarbon material and four indicators that can be achieved using AR media,
e) Material button, which includes a summary of hydrocarbon material,
f) AR camera button, integrated marker on the molecule card that describes several chemical molecules,
g) Practice question button contains five interactive questions about hydrocarbons, and
h) The menu exit button (X).

Picture 2. Main Menu Scene

3. Marker Scene

The image of the molecule on the molecule card consists of 6 chemical compounds and 1 cover card. The following is a scene marker that is displayed on an augmented reality-based learning media application that uses a molecular card.

Table 3. Molekule Card Scene Marker at Application

Card Num	Molecule Name	Molecule Card	Scene Marker
1	Cover card		-
2	Methane		
Card Num	Molecule Name	Molecule Card	Scene Marker
3	Carbon chain		
4	2-Metil Butane		
5	Butana Siklis		
6	2-Buthene		
7	Etune		

Augmented reality-based learning media on hydrocarbon material has been successfully developed on Android 5.0 lollipop for at least 1 GB of RAM. This media has several characteristics that can help students in studying hydrocarbon material. The characteristics of this AR-based learning media include:

a) The application can be installed and operated easily on android 5.0 lollipop with at least 1 GB RAM, so for android specifications below 5.0, lollipop installation cannot be done.
b) The application has several scenes with features rotate and audio on the AR camera to help students understand the material displayed through the molecular card on the AR camera.
c) The exercises displayed are interactive to immediately find out the correct answers to the questions.
d) Molecular cards are practical, with attractive colors, and easy to carry anywhere so that students can use them in every opportunity to study hydrocarbon molecules.

Augmented Reality (AR) Based Learning Media Validation

The validation of augmented reality-based learning media includes material validation and media validation. Material validation was carried out by two validators of chemistry experts and three validators of learning media experts. The results of material validation are shown in table 4.

Table 4. Material Expert Validation Results

Num	Evaluation	Validation Result Score	Criteria
1	Validator 1	73.33	Very valid
2	Validator 2	96.67	Very valid
	Average	85	Very valid

Material validation includes three aspects, namely 11 indicators with 15 statements. In the aspect of material components, there are six statements with the average score percentage between validator I and validator II is 87.5% with very valid criteria. In the material presented, seven indicators obtain an average score percentage of 80.4%, very valid criteria. While in the aspect of the benefit component with two indicators, the average percentage score is 94%, the criteria are very valid. Two material expert validators carried out material validation based on these three aspects with an average score of 85%. This figure shows that the material in AR-based learning media has very valid criteria.

Table 5. Analysis of Material Validation Results in Each Aspect

Aspect	Validator I	Validator II	Max. Score
Material components	19	23	24
Material presentation	18	27	28
Benefit components	7	8	8
Total score	44	58	60
Percent	73.33	96.67	100%
Score average	51 (85%) very valid criteria		

The validity of AR-based learning media on hydrocarbon material uses a media assessment instrument. The instrument used is a media validation sheet based on a media assessment reference (Novitasari, 2020) adapted to AR media. Media validation was carried out by three media expert validators consisting of lecturers, IT teachers, and practitioners. This validation includes three aspects, namely, media design aspects include: media suitability, display design, text, image quality, and navigation buttons; software aspects include: compatibility, usability, reusability, and maintainability; and benefits aspects. Obtained a validation score of 94 with very valid criteria. The validation results can be seen in Table 7 as follows:

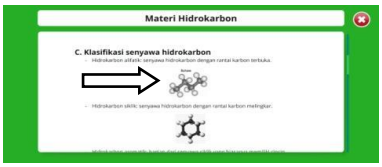
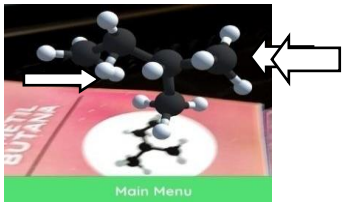
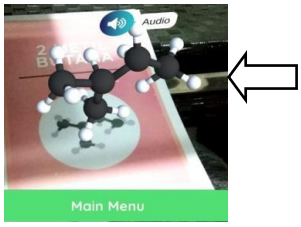
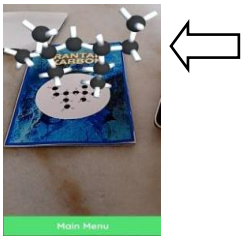
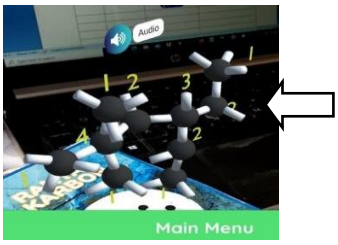
Table 6. Learning Media Expert Validation Results

No	Evaluation	Validation Result Score	Criteria
1	Validator 1	88	Very valid
2	Validator 2	98	Very valid
3	Validator 3	97	Very valid
	Average	94	Very valid

According to media expert one, the results of the validation are adding sound or music effects to the application to make the media more optimal for use by students and more exciting and only include indicators that can be achieved using AR media. According to media expert 2, it is necessary to add AR molecular markers to use AR in learning is more dominant. While the validation results, according to media experts 3,

are questions on the application, and the answer choices are made more interactive, as well as the addition of color to molecules in the material scene. Design changes according to the validator's suggestions are presented in table 8 as follows:

Table 7. AR-Based Learning Media Design Changes

Num	Validator Suggestion	Initial Design	Revision Desain
1	Adding color to molecules in the material scene		
2	Questions in the application are made interactive		
3	The application only lists the indicators to be achieved using AR		
4	Added audio features		
5	Numbering on the carbon chain		

Augmented Reality-Based Learning Media Feasibility Test Questionnaire

The questionnaire for the feasibility test of augmented reality-based learning media was conducted on teachers and students. This feasibility test was conducted on a small scale with 16 students and one chemistry teacher. The results of the teacher's response questionnaire are shown in table 6.

Table 8. Results of the Chemistry Teacher's Questionnaire on AR. Media

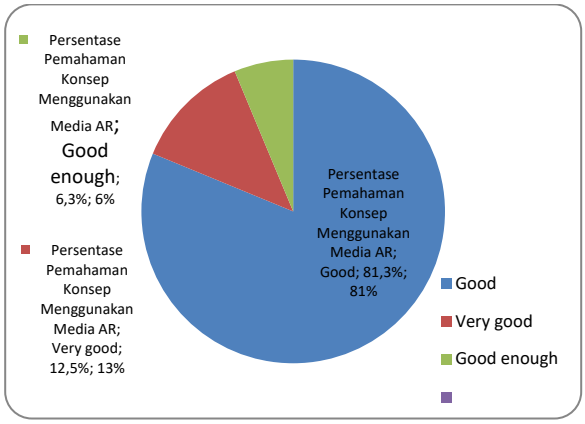
Num	Aspect	Score	Max core	Persentase(%)	Criteria
1	Material components	20	20	100	Very good
2	Media components	29	32	91	Very good
3	Effectiveness component	27	28	97	Very good

Based on the results of the teacher's response questionnaire above, the percentage score of each aspect with excellent criteria was obtained. Augmented reality-based learning media on hydrocarbon material had excellent material, media, and effectiveness components.

Table 9. Results of Analysis of Student Responses to AR-Based Learning Media

Num	Statement	Ideal Score	Total Score	Percentage	Criteria
1	AR-based learning materials and media are by learning objectives.	64	56	87.5	Very good
2	AR-based learning media is enjoyable to use in learning and easy to understand its use.	64	55	85.9	Very good
3	Learning is more fun.	64	56	87.5	Very good
4	Learning spurred me to be more active in activities.	64	55	85.9	Very good
5	Learning helps me find chemical concepts that match my understanding.	64	47	73.4	Good
6	Learning makes me more active in asking and answering questions from the teacher in class.	64	49	76.6	Good
7	Learning makes me more active to express opinions.	64	49	76.6	Good
8	Learning makes me more responsible in doing assignments.	64	51	79.7	Good
9	Learning greatly increases my knowledge in the field of digital literacy/the latest technology.	64	54	84.4	Very good
10	3D depiction of molecules makes me understand the material more contextually	64	52	81.3	Very good

Interpretation of the results of the analysis of student responses obtained an average score presentation of 81.9 with excellent criteria. The following shows the data analysis diagram in statement no 5, namely, learning using AR media can help students get the concept of hydrocarbon chemistry by their understanding.



Picture 3. Graphics of Concept Understanding Using AR Media

A total of 13 students stated that their understanding of the concept of material using AR media was in a good category, meaning that it could be understood thoroughly according to the indicators to be achieved. 2 students stated that they were outstanding in understanding the concept, meaning that they could fully understand the hydrocarbon material contained in AR media. In contrast, the rest stated that they had a pretty good understanding of the concept.

CONCLUSION

The augmented reality-based learning media developed has several characteristics, namely: 1) can be installed on android lollipop 5.0 with a minimum of 1 GB RAM, 2) has one application with several scenes including material scenes, KD scenes & indicators, practice questions scenes, and camera AR scenes. Integrated marker on the molecule card, 3) has rotated and audio features on the AR camera display, 4) has seven molecule cards with attractive and colorful 2D molecular images display.

REFERENCES

Abd. Syakur, Sugirin, & Widiarni. (2020). The Effectiveness of English Learning Media through Google Classroom in Higher Education. *Britain International of Linguistics Arts and Education (BIoLAE) Journal*, *2*(1), 475–483. https://doi.org/10.33258/biolae.v2i1.218

Aliyu, F., & Talib, C. A. (2020). Integration of augmented reality in learning chemistry: A pathway for realization of industrial revolution 4.0 goals. *Journal of Critical Reviews*, *7*(7), 854–859. https://doi.org/10.31838/jcr.07.07.155

Arifitama, B. (2015). *Panduan Mudah Membuat Augmented Reality* (Seno (ed.)). CV. Andi Offset.

Baran, B., Yecan, E., Kaptan, B., & Paşayiğit, O. (2020). Using augmented reality to teach fifth grade students about electrical circuits. *Education and Information Technologies*, *25*(2), 1371–1385. https://doi.org/10.1007/s10639-019-10001-9

Bursali, H., & Yilmaz, R. M. (2019). Effect of augmented reality applications on secondary school students' reading comprehension and learning permanency. *Computers in Human Behavior*, *95*(June 2018), 126–135. https://doi.org/10.1016/j.chb.2019.01.035

Ekayani, P. (2017). (2017). *Pentingnya Penggunaan Media*. *March*. https://www.researchgate.net/publication/315105651

Helsa, Y., & Kenedi, A. K. (2019). Edmodo-Based Blended Learning Media in Learning Mathematics. *Journal of Teaching and Learning in Elementary Education (Jtlee)*, *2*(2), 107–117. https://doi.org/10.33578/jtlee.v2i2.7416

Kaur, D. P., Mantri, A., & Horan, B. (2020). Enhancing student motivation with use of augmented reality for interactive learning in engineering education. *Procedia Computer Science*, *172*(2019), 881–885. https://doi.org/10.1016/j.procs.2020.05.127

Martín-Gutiérrez, J., Mora, C. E., Añorbe-Díaz, B., & González-Marrero, A. (2017). Virtual technologies trends in education. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(2), 469–486. https://doi.org/10.12973/eurasia.2017.00626a

Nazar, M., Oktarina, A., & Puspita, K. (2020). Pengembangan Aplikasi Pembelajaran Interaktif Berbasis Android Untuk Membantu Mahasiswa Dalam Mempelajari Materi Larutan Elektrolit Dan Nonelektrolit. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *8*(1), 39–54. https://doi.org/10.24815/jpsi.v8i1.16047

Nistrina, K. (2021). *Penerapan Augmented Reality Dalam Media*. *03*.

Novitasari, A. (2020). *Pengembangan Media Pembelajaran My Bio App Berbasis Android Terhadap Motivasi dan Hasil Belajar Siswa Materi Sistem Pencernaan Makanan di MA*. UNNES.

Ramadani, R., Ramlawati, R., & Arsyad, M. (2020). Pengembangan Modul Pembelajaran Kimia Berbasis Augmented Reality. *Chemistry Education Review (CER)*, *3*(2), 152. https://doi.org/10.26858/cer.v3i2.13766

Setyawan, B., Rufii, Nf., & Fatirul, A. N. (2019). Augmented Reality Dalam Pembelajaran Ipa Bagi Siswa Sd. *Kwangsan: Jurnal Teknologi Pendidikan*, *7*(1), 78–90. https://doi.org/10.31800/jtp.kw.v7n1.p78--90

Susanto, D., & Basuki, A. (2016). *Mobile Augmented Reality Untuk Pembelajaran IPA Kelas 7 Kurikulum 2013 Mobile Augmented Reality Untuk Pembelajaran IPA Kelas 7 Kurikulum Rapid technological developments also affects education , especially if the technology is combined with the proper ped*. *September*.