JPPIPA 7(Special Issue) (2021)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Augmented Reality-Based Learning Media on Concept of Hydrocarbon to Improve Multi-representation Ability

Vita Fitria Ningrum[1*], Woro Sumarni[1], Edy Cahyono[1]

[1] Postgraduate of Science Education, University States of Semarang, Semarang, Indonesia.

DOI: 10.29303/jppipa.v7iSpecialIssue.1038

Article Info
Received: October 13th, 2021
Revised: December 8th, 2021
Accepted: December 13th, 2021

Abstract: This study aims to design and develop learning media based on augmented reality on hydrocarbon material and its validity to determine the media's feasibility and increase students' multi-representation ability. This research is a type of development research using Design Research and Development (R&D). The product validity test phase was carried out by two material experts and three media experts. In addition, testing was carried out on the responses of the participating students. The implementation stage of learning was carried out by class X TKJ 2 SMK Gondang Pekalongan with a total of 32 students. The data analysis technique used a questionnaire instrument and the technical descriptive statistical analysis. The results of this study are: (1) the development of augmented reality-based learning media on hydrocarbon material in the form of an android application consisting of five main menus, namely basic competencies and indicators, materials, AR camera, practice questions, and the identity of the researcher, as well as seven molecular cards of the structure chemical compound molecules; (2) 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 feasibility test results for using media in the implementation of learning obtained an average student response score of 78%, with the "feasible" category used as learning media. The increase in multi-representation abilities is shown by increasing student learning outcomes using multi-representation questions, including macroscopic, submicroscopic, and symbolic levels. The macroscopic level increased by 27.50%, the submicroscopic increased by 36.70%, and the symbolic level increased by 33.30%. The results of this study indicate that augmented reality-based learning media on hydrocarbons is very suitable for use in chemistry learning and has been proven to increase students' multi-representation abilities.

Keywords: Augmented reality; Learning media; Molecule card; Hydrocarbons; Multirepresentation

Citation: Ningrum, V. F., Sumarni, W., & Cahyono, E. (2021). Development of Augmented Reality-Based Learning Media on Concept of Hydrocarbon to Improve Multi-representation Ability. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 256–365. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1038

Introduction

In the era of digital learning, it is important to equip students with various digital literacy that can support learning success. Appropriate learning media can stimulate various representations of students about the subject matter they understand, especially in learning chemistry. Students need to be equipped with multi-representation abilities, so they are expected to solve a problem in various forms of representation. (Ekayani, 2017; Siswanto, 2020). Currently, many schools are still implementing conventional learning, both in terms of the learning system, the use of media, and the delivery of information to students. Understanding the concept of material in students is related to how the information can be received so that the learning objectives can be achieved. The effectiveness of a learning and learning process is

*Email: vita.alfian@students.unnes.ac.id

determined by the interaction between students and educators, lesson materials, delivery methods, learning strategies, media, and learning resources (Pane & Dasopang, 2017).

Chemistry is one of the lessons given at the Vocational High School level. Chemistry studies matter, its properties, structure, changes or reactions, and the energy is accompanying these changes. Chemistry also studies understanding the properties and interactions of individual atoms to apply that knowledge at a macroscopic level (Rajmah, et al., 2017). Chemistry must also be studied in a certain order because chemical substances are related to one another. In addition, chemistry questions consisting of numbers are an important part of studying chemistry. However, participants must also learn descriptions such as facts, rules, terminology, etc. These characteristics cause chemistry subject matter to contain many concepts that are quite difficult for students to understand (Desyana, et al., 2014).

Based on a survey questionnaire, out of 210 students in SMK, only 41.4% like to study chemistry, and as many as 50.5% do not have LCD facilities in schools that can support chemistry learning. They think that chemistry studies study abstract material that is difficult to understand and uninteresting. Characteristics of chemical materials include abstract concepts, mathematical calculations, graphs and involve daily life applications that require multi-representation abilities for problem-solving (Larasati, et al., 2019; Musya'idah, et al., 2016). Reinforced by the research (Desyana, et al., 2014), chemistry learning theories and findings of chemical science can be reflected by macroscopic, submicroscopic, and symbolic representations or referred to as multi-representation abilities. This reflection aims to facilitate the explanation of these abstract chemical concepts. Students also need Multi-representation abilities to be able to solve problems with various representations.

One of the chemical materials for class X SMK that is quite important to learn is hydrocarbons. Hydrocarbons study the compounds between hydrogen and carbon elements, which can form alkanes, alkenes, and alkynes. The introduction of hydrocarbon compound molecules in the form of three-dimensional or augmented reality models has been proven to increase students' interest in learning (Buchori & Rahmawati, 2018). A good understanding of molecular structure will help students learn the next material related to hydrocarbon compounds, for example, petroleum and polymer chemistry.

The use of technology-based learning media is growing rapidly because technology is considered appropriate in establishing two-way communication between teachers and students, especially in the era of online learning during the Covid-19 pandemic. One of the learning media that is growing rapidly is augmented reality (AR). AR media in android applications, e-books, modules, student worksheets, and AR-based learning books have been widely developed and used in the education (Larasati, et al., 2019). AR media also provides meaningful learning for students in various lessons that require a deeper level of understanding of three-dimensional objects such as the digestive system in biology learning, molecular bonds in chemistry learning, as well as learning in virtual laboratories both physics and chemistry (Adami & Budihartanti, 2016; Arslan, et al., 2020; Setiahadi, et al., 2017; Supriono & Rozi, 2018; Thees, et al., 2020).

Augmented Reality is defined as a technology that can combine two or three-dimensional virtual objects into a natural 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 an accurate visualization of chemistry learning 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).

The Multi-representation ability of students is needed in problem-solving, especially problem-solving in chemistry learning. Multi-representation is considered the key to successfully understanding a particular discipline. There are two motivations to consider in terms of multi-representation-based learning; (1) how students use multi-representation to solve problems, and (2) what are the best techniques to help students understand problem solving using multi-representation (Huda, et al., 2016). This research was reaffirming to improve students' multi-representation abilities, especially in learning chemistry related to hydrocarbon materials using augmented reality.

In the research of Widianingtyas, et al. (2015), the multi-representation approach provides five benefits, namely 1) Accommodating different intelligence abilities; 2) Visualization for the brain; 3) Help construct other forms of representation; 4) Multiple representations are useful for qualitative reasoning, and 5) Abstract mathematical representation is used for quantitative reasoning. Various learning systems

applied in schools, both processes, strategies, teaching materials, and learning media, can affect students' multi-representation abilities (Puspaningrum, et al., 2015; Tima & Sutrisno, 2020).

Based on the initial study and the description above, improving students' multi-representation abilities related to chemistry is important, namely hydrocarbons, using augmented reality-based media. This learning media is made using a molecular shape card integrated with the android application on the student's gadget.

Method

This study used the development method to develop learning media for three-dimensional molecular models of Android-based augmented reality applications on hydrocarbon materials. This study uses a Research and Development (R&D) design with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The ADDIE model is used to describe a systematic approach to the development of learning media.

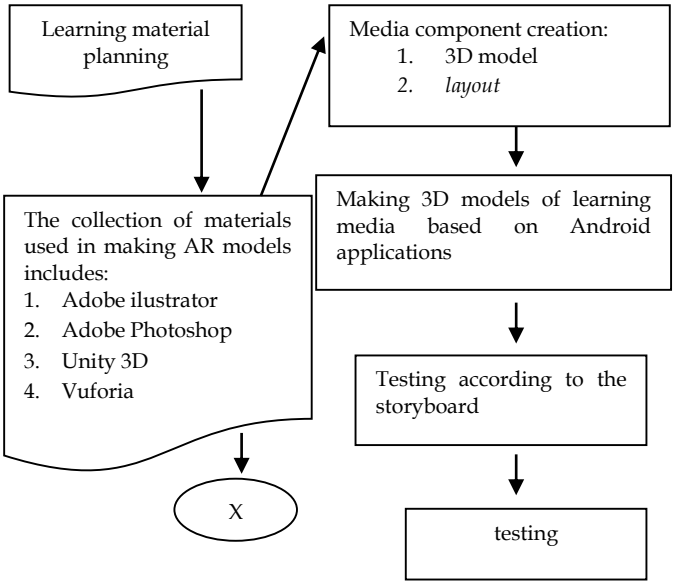

Figure 1. AR-Based Media Development Design (Rani R, 2018)

In the analysis stage, a preliminary study and literature study were conducted. Preliminary studies are used to obtain initial information about the characteristics of students and school needs regarding learning media, especially chemistry. Preliminary studies in teacher interview data, student questionnaires, and PTS value data in semester 2. The design stage is to design the required molecular card design and the android application made. The process of making AR-based learning media entered the development stage, which then the results were validated by media and material experts.

The research instruments used were media expert validation sheets, material expert validation sheets, multi-representation-based pretest-posttest test questions, and teacher and student response questionnaires. Implementation of AR-based learning media applied to class X TKJ 2 SMK Gondang, with a total of 32 students. The AR media produced were then evaluated using pretest-posttest questions and teacher and student response questionnaires.

Result and Discussion

Development of Augmented Reality-Based Learning Media on Hydrocarbon Material

Augmented reality-based learning media development is expected to produce excellent and practical chemistry learning media in the learning process. The development stage starts from the analysis stage by conducting observations and interviews as analysis needed in research. The results of observations and interviews In doing so, the researcher analyzes conceptually based on his curiosity about science, technology and applies procedural knowledge in a specific field of study according to his talents and interests to solve problems with essential competencies in analyzing the structure and properties of hydrocarbon compounds based on the specificity of the carbon atom and its classification.

Analysis of the learning needs of students, it was found that the students of class X TKJ SMK Gondang Pekalongan generally showed disinterest in learning chemistry. Another problem obtained is the learning outcomes of participants students in chemistry lessons are still low, and the use of gadgets by students who are less effective during the learning process. So that with the development of augmented reality-based learning media can improve learning outcomes and understanding of students' concepts. Learning analysis is adjusted to the fundamental competencies listed in the 2013 curriculum that applies at SMK Gondang Pekalongan regarding Chemistry subjects, the subject matter of hydrocarbon compounds. Concept analysis, identify subject matter by arranging sub-materials of hydrocarbon compounds. Next, formulate learning objectives according to the needs and curriculum currently applied.

In the design phase, the researcher first designed the AR media to be made, which consisted of a physical form in the form of a molecular card. After that, then design a three-dimensional visualization application based on augmented reality consisting of design application, application button design, image markers,

and three-dimensional images. After design at the design stage is complete, then the media is made according to the procedure specified in the design. In the design of making molecular card media and printing, it is done by the researcher himself, while in making the application, the researcher is assisted by the programmer.

The development stage is carried out to determine the validity of AR media; this stage is carried out by conducting an assessment of learning media based on augmented reality hydrocarbon material. Five experts assessed that three media experts from the UNNES Chemistry Department Lecturer, certified SMK IT teachers, and AR learning media practitioners, as well as two material experts from Lecturers Department of Chemistry, FMIPA UNNES, and certified SMK chemistry teachers. Validators provide assessments and suggestions for improvement. AR-based learning media that have been declared valid/feasible to use are implemented, in-class students. XI TKJ SMK Gondang Pekalongan for a limited trial. This trial aims to determine the initial response and effectiveness of the media that has been developed.

The number of subjects for this trial was 16 students. The results obtained at this stage are that students feel happy learning because it makes it easier to find their concepts and theories. Moreover, they can see the two-dimensional image on the molecular card into three dimensions using the application. They do not have to imagine the available images but see the molecules that exist.

The following procedure carried out after the limited trial stage is a large-scale trial. This trial aims to determine the effectiveness of the AR media developed by looking at the increase in its multi-representation capabilities. The number of research subjects is 32 participants, class X TKJ SMK Gondang Pekalongan. At this stage, students seem very interested in learning chemistry during learning. This can be seen from the responses of students obtained when learning to use. They have augmented reality-based chemistry learning media.

Implementation of AR media on classroom learning is carried out for see the effectiveness of the media so that expected to be used for improve student learning outcomes Class X is mainly on the material of hydrocarbon compounds. So that students can improve their learning outcomes with an indication of an increase in multi-representation abilities. Therefore, researchers measure the results learn by collecting and recapitulating posttest scores on multi-representational questions after using AR media. An analysis was also carried out to improve multi-representation abilities covering macroscopic, submicroscopic, and symbolic aspects.

Development research results use augmented reality accordingly with research conducted by Reski Ramadani, (2019) explains that through augmented reality, teachers can create learning media that are fun, interactive, and easy to use. Augmented reality can also replace learning media that is not yet in school in virtual form or virtual. Students can see and use media in virtual form.

Characteristics of AR Media Development Results (Products).

a. The Validity of AR-Based Learning Media on Hydrocarbon Material

Before field testing and being used in learning, the developed product was validated by a material expert. Validation by material experts aims to obtain information, criticism, and suggestions so that the media developed by researchers becomes a quality product. Aspects of material assessment include material components, material presentation components, and benefits components. The results of data analysis obtained from material validation are shown in Table 1.

Table 1. 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	

Based on Table. it can be seen that the results of augmented reality-based chemistry learning media on hydrocarbon material by material experts show that for the material component, an average score of 21 is obtained, the material presentation component has an average score of 22.5, and the benefit component has an average score of 7.5. As for the overall material assessment, experts covering all components obtained an average score of 51 with 85%. So if it is categorized based on the validity category, then the average score is included in the very valid category.

In addition to material expert assessment, Suggestions and inputs are also given media development. Based on data obtained in the form of suggestions and comments from material experts that have been obtained before then, follow up in the form of revisions or improvements to the media augmented based chemistry learning the reality of hydrocarbon compound material. According to Validator I, the results of material validation, learning indicators must

emphasize students' understanding, and hydrocarbon material must be contextual. In hydrocarbon learning, researchers apply only indicators that can be achieved using AR media listed on the android application. Validator II provides suggestions that the molecular images of the material applied are more varied and colorful. This aims to make students interested in reading and understanding the material contained in AR learning media.

Media experts assess AR-based learning media on hydrocarbon materials based on three aspects of media assessment. Aspect media design that attracts students' attention, including color suitability in application layouts and molecular cards. Aspect readability and appropriate text layout in AR media applications, clarity of 3D images molecules with an attractive image design on the molecular card or application, and the appearance and layout of the buttons on the application that are easy to access. In terms of software (software), AR-based learning media has met the indicators: compatibility, usability, reusable, and maintainability.

AR learning media also fulfills the benefits aspect of media assessment; namely, it can help students understand abstract material that is generally invisible but can be seen in the form of 3D molecules. The media aspect shows the usefulness of the developed application, the quality of the design, and the ease of operation. Then the data obtained from the validation can be seen in Table 2.

Table 2. Media Expert Assessment Analysis on Every Aspect

Aspect	Indicator	Max. Score	Total Score
Media Design	Media suitability	12	11
	Design view	48	43
	Text	36	33
	Image quality	48	45
	Navigation key	48	47
Percentage		93.23% (very valid criteria)	
Software	Compability	12	12
	Usability	24	23
	Reusable	12	11
	Maintenable	12	11
Percentage		95% (very valid criteria)	
Benefits	Use of AR	12	12
	Usefulness	24	23
	AR in learning	24	23
Percentage		96.67% (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 the media assessment reference (Novitasari, 2020), adapted to AR media. The media assessment aspect consists of 3 aspects: the media design aspect, the software aspect, and the benefit aspect. The design aspect consists of 15 statements, the software aspect consists of 5 statements, and the benefit aspect includes five statements.

Based on Figure 1. it can be seen that the results of the media assessment are equipped with an augmented-based three-dimensional visualization application. The reality of hydrocarbon material by media experts shows that an average score of 93.23 is obtained for the media design aspect, the software aspect is an average score of 95, and the media benefits aspect is an average score of 96.67. So if the scores of all elements are categorized based on the validity category, then the average score is included in the very valid category

Furthermore, based on the assessment of the three media validation experts, if it is converted based on the validity criteria table, then the average score is included in the very high category. This means that the validity of AR media is included in the very high sort (very valid). In addition to the assessment, suggestions, and comments were also obtained from media experts, followed up in the form of revisions or improvements to augmented reality-based media. AR-based learning media on hydrocarbon material has been validated by three experts who are competent in learning media with a very valid score of 94. It can be seen in Table 3. as follows:

Table 3. Learning Media Expert Validation Results

Evaluation	Validation Result Score	Criteria
Validator 1	88	Very valid
Validator 2	98	Very valid
Validator 3	97	Very valid
Average	94	Very valid

According to media expert 1, the validation results are the need for additional audio and rotation features so that AR media can achieve learning indicators by increasing students' understanding. According to media experts, learning media can be improved by changing the scene of the practice questions to be more interactive by displaying the correct answers. While the validation results, according to media experts three, where it is necessary to add an AR molecular card so that learning using AR cameras becomes more dominant.

Based on input from the validator, AR-based learning media products are obtained on valid hydrocarbon materials used in learning. AR-based learning media consists of 8 AR molecular cards and one android application. Based on the results of the validation and response to use, AR-based learning media on the material has the following characteristics: (1) Media applications on android of 35.7 MB can be run

on lollipop gadgets and above with a minimum of 1 GB of RAM; (2) This application consists of 4 main menus: basic competencies & indicators, materials, AR camera, and practice questions; (3) The application has an additional menu in the form of a developer identity button and an exit button; (34) The indicators listed in the application are learning indicators that can be achieved using AR-based learning media; (5) The hydrocarbon material in the application is presented briefly and contextually by displaying colorful 2D molecular images; (6) The practice questions in the application are made interactively to find out the correct answer directly; (7) The AR camera menu is integrated with nine molecular cards with colorful and attractive displays to provide an augmented reality-based 3D view of molecules; (8) The molecular card consists of a cover card, methane, carbon-chain, 2-methyl butane, cyclic butane, ethane, benzene, 1-propane, and 2-butene; (9) The 3D molecular display on the AR camera has features to achieve the expected competence, namely the suitable rotation feature to see molecules from various angles and audio elements to explain the molecules displayed according to the required indicators.

b. Data on Teacher and Student Responses to AR Media

Learning media that are declared valid based on validation tests carried out by material expert validators and media experts can already be used in the learning process. However, an analysis of the response to media use is carried out to produce media that meets the needs and is more perfect. This response questionnaire was filled out two times during small-scale trials, then revised and implemented large-scale learning. Students and chemistry teachers filled out response questionnaires. The teacher's response questionnaire score was 92.5 with excellent criteria, while the student response was 78 with good standards.

The questionnaire for the feasibility test of augmented reality-based learning media was conducted on teachers and students. This feasibility test was conducted with 32 students and two chemistry teachers. The results of the teacher's response questionnaire are shown in table 4 and picture 1.

Table 4. Results of the Chemistry Teacher's Questionnaire on AR. Media

Aspect	Score	Max score	Persent (%)	Criteria
Material components	20	20	100	Very good
Media components	29	32	91	Very good
Effectiveness component	27	28	97	Very good

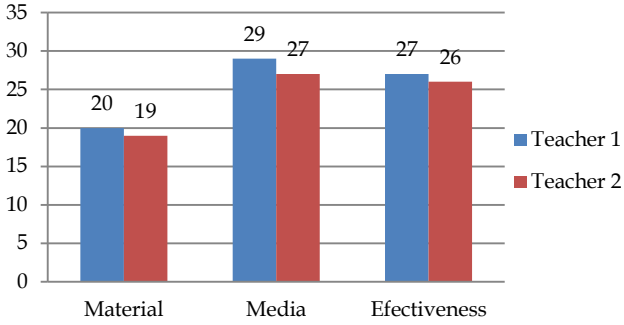

Figure 2. Graph of Teacher Response Analysis on AR Media

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. Interpretation of the results of the analysis of student responses obtained an average score presentation of 79 with good criteria.

The following shows the data analysis diagram in a statement no 5, namely, learning using AR media can help students get the concept of hydrocarbon chemistry by their understanding.

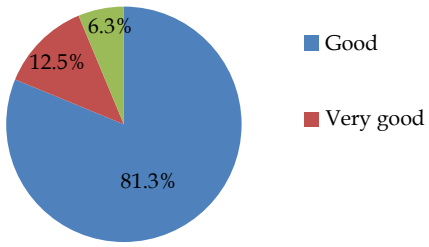

Figure 3. Graphics of Concept Understanding Using AR Media

A total of 32 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.

c. Data on the Effectiveness of Chemistry-Based Learning Media Augmented Reality Hydrocarbon Compound Material

The effectiveness of the developed media can be seen from the result data learn students. Data on student

learning outcomes were obtained using a posttest that students carried out after carrying out learning. Post-test aims to determine students' level of understanding about the material of hydrocarbon compounds after studying using AR-based learning media. Students' multi-representation abilities at the macroscopic, submicroscopic, and symbolic levels can also be analyzed based on the students' pretest and posttest results. The results of the descriptive analysis of the pretest and posttest scores are shown in Table 5.

Table 5. Descriptive Analysis Table of Pretest and Posttest Scores

Variable	Pretest Score	Posttest Score
Subject	32	32
Ideal score	100	100
KKM	75	75
Max. score	66	90
Min. score	22	70
Average	47	79
Finished	-	24
Unfinished	32	8

Based on posttest data using multi-representation-based essay questions consisting of 10 questions on hydrocarbon compounds obtained from 32 students of class X TKJ 2 SMK Gondang Pekalongan, 24 students met the minimum completeness criteria (KKM), so the percentage of completeness grade is 75%. Based on the percentage of completeness, it can be seen that the augmented-based chemistry is learning media reality of hydrocarbon compound material, practical for use in the learning process.

The effectiveness of using AR media was also analyzed using the N-Gain Score. Based on the analysis of the pretest and posttest scores, an N-gain score of 0.58 was obtained. This score was included in the moderate/enough criteria. The AR-based learning media is quite effective in learning the chemistry of hydrocarbon materials. These results are not in line with the researchers' expectations. Several factors can cause some students to not complete their grades in studying hydrocarbon compounds, including: (1) Some students cannot install AR media due to the limited specifications of their android; (2) Limited learning conditions caused by the covid-19 pandemic; (3) Very minimal learning time in the classroom so that the use of media has not been maximized.

The increase in multi-representation ability at each level was also analyzed based on the pretest and posttest scores. The results of the analysis and comparison of pretest-posttest values can be seen in the graph in Figure 3.

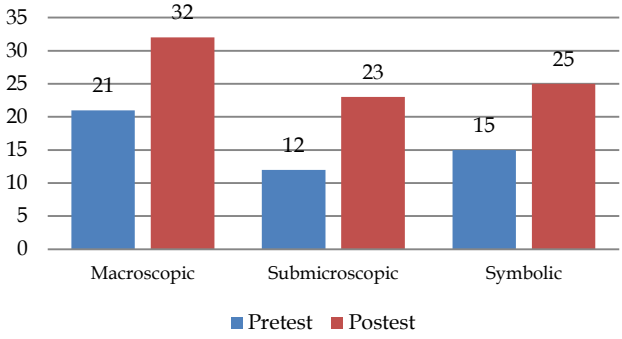

Figure 4. Pretest-Posttest Data on level representation

Students need Multi-representation abilities to be able to solve problems in all forms of presentation. Students' representation ability can be improved by implementing technology in learning media (Siregar, et al., 2019). In chemistry, students must be able to relate the three levels of representation, namely macroscopic, submicroscopic, and symbolic, to understand the overall chemical material (Desyana, et al., 2014). Macroscopic representation includes all processes observed with the five senses directly, which are experienced in everyday life. At the macroscopic level, students have no difficulty answering because they are used to observing the process of burning paper.

At the symbolic level, representation is used to describe the shape of the molecule, the symbol of the element, the shape of the compound, the structure of the chemical molecule, and so on. Based on the results of the analysis of pretest and posttest scores using multi-representation questions on hydrocarbon material, there was an increase in multi-representation abilities. At the macroscopic level, there was an increase of 27.50%; the submicroscopic rate increased by 36.70%, and the symbolic level increased by 33.30%.

The advantages and disadvantages of hydrocarbon-based AR-based learning media

Chemistry learning carried out at Gondang Vocational School is usually focused on teacher handbooks, information from the internet, and lecture or PPT material displayed by the teacher. So to provide a good understanding of the concept of chemistry is very lacking. Practical activities are also rarely carried out by teachers and students; this also causes students not to understand the material contextually. The development of augmented reality-based learning media can provide solutions in chemistry learning, especially on hydrocarbon materials.

AR media developed by researchers has differences from other developers. Several studies have developed AR modules (Agussalim, 2021; Ramadani, et al., 2020), AR books, and worksheets that are difficult to

carry everywhere, in contrast to molecular cards, which can practically be carried easily. Some AR development studies only provide the appearance of fewer molecules (Althea, et al., 2016; Supriono & Rozi, 2018), in contrast to the AR media developed by researchers. More molecules that can be displayed in 3D AR are expected to provide experience and knowledge about 3D technology that can be used in learning. An example of the shape of a molecule in a molecule card and the AR camera display is shown in Figure 5.

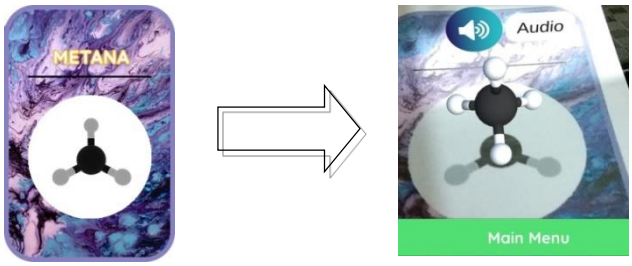

Figure 5. Methana Molecule in Molecule Card and the Shape of Camera AR in Media Application

From the results of the study, obtained several advantages of AR-based media that were developed compared to other media, including: (1) Applications on Android from AR-based learning media require about 35.7Mb of space, making it easy to install using gadgets with a minimum specification of lollipop 5 with a minimum of 1GB RAM; (2) As long as it is used in learning, this application does not experience problems such as hangs, lags, or crashes to smooth the learning process; (3) Molecular card designs and interesting applications by displaying 3D chemical molecular structures on the AR camera with rotate and audio features to make it easier for students to understand the material; (4) Development research that produces AR media can improve students' multi-representation abilities on hydrocarbon material; (5) The drawback of the developed AR media is that the application cannot be run for android specifications with RAM below 1GB, so it cannot reach all SMK Gondang students' multi-representation abilities on hydrocarbon material.

Conclusion

Based on the results of research, data analysis, and discussion, it can be concluded that the validity of augmented reality-based learning media on hydrocarbon material is in an excellent category. Augmented reality-based learning media can improve the multi-representation ability of students with sufficient criteria. The response of teachers and students to augmented reality-based learning media is in the excellent category, so it is good for use in learning hydrocarbon chemistry.

Based on the conclusions above, there are limitations to the study, namely, some things that the teacher cannot cover using the AR-based learning media. This restriction occurred due to the Covid-19 pandemic causing several stages of research to be carried out online. So that suggestions for the development of learning media in the future can be made AR applications that can be used on all types of Android phones so that online learning can be done and developed for learning other materials.

Acknowledgments

Thank you to the Postgraduate Program at the State University of Semarang and friends from the class of 2019 majoring in science education, special thanks to my family.

References

Adami, F. Z., & Budihartanti, C. (2016). Penerapan Teknologi Augmented Reality Pada Media Pembelajaran Sistem Pencernaan Berbasis Android. *Teknik Komputer AMIK BSI*, *2*(1), 122–131. Retrieved from, http://ejournal.bsi.ac.id/ejurnal/index.php/jtk/article/viewFile/370/279 [Indonesian]

Agussalim, H. (2021). Pengembangan Modul Pembelajaran Kimia Berbentuk Komik Berbasis Augmented Reality pada Materi Pokok Ikatan Kimia. *Jurnal Pendidikan Kimia*, *4*(2), 121–132. https://doi.org/10.26858/cer.v4i2.20063 [Indonesian]

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

Althea, C., Lahallo, S., Agung, A. A. K., Wiranatha, C., & Arya, I. G. M. (2016). Media Pembelajaran Molymod Senyawa Hidrokarbon Teknologi Augmented Reality Berbasis Android. *Merpati*, *4*(2), 123–134. https://doi.org/10.24843/JIM [Indonesian]

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

Arslan, R., Kofoğlu, M., & Dargut, C. (2020). Development of Augmented Reality Application for Biology Education Reyhane. *Türk Fen Eğitimi Dergisi*, *17*(1), 167–169. https://doi.org/10.36681/tused.2020.13

Buchori, A., & Rahmawati, N. D. (2018). Pengembangan Mobile Augmented Reality Dalam Menumbuhkan Minat Belajar Siswa. *Journal of Chemical Information and Modeling*, *53*(9), 1689–

1699. [Indonesian]

Daniel, S. (2006). 3D Multi Representations of Building for Mobile Augmented Reality. *GeoEduc3D*, 1–6.

Desyana, V., Desyana, V., & Melati, H. A. (2014). Analisis Kemampuan Multipel Representasi Siswa SMP Negeri di Kota Pontianak pada Materi Klasifikasi Benda. *Jurnal Pendidikan Dan Pembelajaran*, *3*(11). Retrieved from, https://jurnal.untan.ac.id/index.php/jpdpb/article/view/7714 [Indonesian]

Ekayani, P. (2017). (2017). Pentingnya Penggunaan Media Pembelajaran Untuk Meningkatkan Prestasi Belajar Siswa. *Retrieved from,* https://www.researchgate.net/publication/315105651 [Indonesian]

Huda, C., Siswanto, J., Kurniawan, A. F., & Nuroso, H. (2016). Development of multi-representation learning tools for the course of fundamental physics. *Journal of Physics: Conference Series*, *739*(1). https://doi.org/10.1088/1742-6596/739/1/012024

Larasati, A.D.P., Ibnu, S., & Santoso, A. (2019). Model Problem Based Learning dengan Pendekatan Multi Representasi untuk Meningkatkan Kemampuan Memecahkan Masalah Siswa dengan Tingkat Self-Efficacy Berbeda. *Jurnal Pendidikan: Teori, Penelitian, Dan Pengembangan*, *4*(6), 828–834. [Indonesian]

Musya'idah, Effendy, Santoso, A. (2016). POGIL, Analogi Model FAR, KBI, dan Laju Reaksi. *Prosiding Semnas Pendidikan IPA Pascasarjana Universitas Negeri Malang*, 671–680. [Indonesian]

Novitasari, A. (2020). Pengembangan Media Pembelajaran My Bio App Berbasis Android Terhadap Motivasi dan Hasil Belajar Siswa Materi Sistem Pencernaan Makanan di MA. *Masters thesis*, Universitas Negeri Semarang. [Indonesian]

Pane, A., & Darwis Dasopang, M. (2017). Belajar Dan Pembelajaran. *FITRAH:Jurnal Kajian Ilmu-Ilmu Keislaman*, *3*(2), 333. https://doi.org/10.24952/fitrah.v3i2.945 [Indonesian]

Pendidikan, J., Indonesia, S., Safri, M., Sari, S. A., Studi, P., & Kimia, P. (2017). Pengembangan Media Belajar Pop-Up Book Pada Materi Minyak Bumi. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *5*(1), 107–113. Retrieved from, http://jurnal.unsyiah.ac.id/JPSI/article/view/8431 [Indonesian]

Puspaningrum, A., Mahardika, I., & Supriadi, B. (2015). Peningkatkan Kemampuan Multirepresentasi Ipa (Fisika) Dengan Model Quantum Learning Disertai Metode Eksperimen Pada Siswa Kelas Viii-a Smp Negeri 7 Jember. *Jurnal Pembelajaran Fisika Universitas Jember*, *3*(4), 342-348. [Indonesian]

Rajmah, M. A.-G., Andrian, M., & Sanjaya, M. B. (2017). Aplikasi Alchemist Menggunakan Augmented Reality Berbasis Android Untuk Pembelajaran Kimia Sma. *E-Proceeding of Applied Science*, *3*(3), 1448–1460. [Indonesian]

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 [Indonesian]

Rani R.R., Wibawa, S.C. (2018). Pengembangan Media Pembelajaran Aplikasi Pengambilan Sudut Gambar Menggunakan Metode Markerless Augmented Reality Berbasis android. *It-Edu*, *3*(01). 1-8. Retrieved from, https://ejournal.unesa.ac.id/index.php/it-edu/article/view/22914 [Indonesian]

Setiahadi, H., Setyati, E., & Irawati Setiawan, E. (2019). Pembelajaran Ikatan Molekul Dalam Pelajaran Kimia Menggunakan Augmented Reality. *JICTE (Journal of Information and Computer Technology Education)*, *1*(2), 80-86. doi:http://doi.org/10.21070/jicte.v1i2.2086 [Indonesian]

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 [Indonesian]

Siregar, L., Sari, N.F., Harahap, R.D., & Chastanti, I. (2019). Hubungan Kecerdasan Emosional Terhadap Hasil Belajar Siswa Pada Materi Pencemaran Lingkungan, *Jurnal Pelita Pendidikan. 7*(2), 080–086. https://doi.org/10.24114/jpp.v7i2.13360 [Indonesian]

Siswanto, J. (2020). Makalah Utama ISSN : 2527-6670 Mempersiapkan Society 5.0 melalui Pembelajaran Fisika. *Prosiding Seminar Nasional Pendidikan Fisika V*, 1–6. [Indonesian]

Supriono, N., & Rozi, F. (2018). Pengembangan Media Pembelajaran Bentuk Molekul Kimia Menggunakan Augmented Reality Berbasis Android. *JIPI (Jurnal Ilmiah Penelitian Dan Pembelajaran Informatika)*, *3*(1), 53–61. https://doi.org/10.29100/jipi.v3i1.652 [Indonesian]

Susanto, D., & Basuki, A. (2016). Mobile Augmented Reality Untuk Pembelajaran IPA Kelas 7 Kurikulum 2013 Mobile Augmented Reality Untuk Pembelajaran IPA Kelas 7 Kurikulum.

Sentia 2016. Retrieved from, http://sentia.polinema.ac.id/index.php/SENTIA2016/article/view/17 [Indonesian]

Thees, M., Kapp, S., Strzys, M. P., Beil, F., Lukowicz, P., & Kuhn, J. (2020). Effects of augmented reality on learning and cognitive load in university physics laboratory courses. *Computers in Human Behavior*, *108*, 106316. https://doi.org/10.1016/j.chb.2020.106316

Tima, M. T., & Sutrisno, H. (2020). Peningkatan Efikasi Diri Siswa Pada Materi Kesetimbangan Kimia Setelah Dibelajarkan Dengan Problem Solving Berbasis Multiple Representasi. *Jurnal Pendidikan Kimia Indonesia*, *4*(2), 70–77. [Indonesian]