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Development of Android-based Augmented Reality Learning Media on Atomic Matter

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Abstract. Material and limited chemistry learning media resulted in less than optimal student scores. Necessary to develop learning media that can support studying by utilizing technology. This study aims to determine the quality and develop android based augmented reality learning media on atomic material. The type of research used is development research with the 4-D model (define, design, develop, and disseminate, which is limited to the development stage. The product was validated by one media expert lecturer, one material expert lecturer, and three reviewers (senior high school teachers) and responded to by ten senior high school students. The instrument used was a product quality sheet with a Likert scale and a student response sheet with a Guttman scale. The product's characteristics developed in the form of an application with atomic materials, augmented reality cameras, and student quizzes. The results of the quality assessment by media experts got a percentage of 97.14%, by material experts got a percentage of 83.33%, and the reviewer got a percentage of 95.8% with a very good category. The product was responded to positively by students with a percentage of 99%. Based on these results, android-based augmented reality learning media on atomic material in senior high school can be used as an alternative learning media to increase student interest in learning chemistry.
Keywords: Development research, augmented reality, atom

Introduction

The 2013 curriculum requires teachers to carry out the learning process of building students' knowledge, skills, and attitudes (Ramadani et al., 2020). Implementation of the 2013 curriculum, some teachers still use old model devices, and the learning process in the classroom still applies to learning using the lecture method so that learning becomes passive (Kholisho & Marfuatun, 2018). for students to be active during learning, teachers are expected to use suitable examples, approaches, and methods to attract student interest and build students' abilities in each subject, especially science, namely chemistry (Ramadani et al., 2020).

Chemistry is a subject that is considered difficult for students because it has never been studied before and requires a reasonably high understanding (Rikawati & Sitinjak, 2020). Relatively new chemistry material because failing to receive chemical sains subjects in junior high school is the cause of alchemy challenging to learn. The characteristics of chemistry in junior high school are abstract materials whereas, in junior

high school, chemistry includes acids, bases, and salts; elements and ways of writing emblems; chemical formula of the compound; mixtures and some properties of solutions; chemical changes; particles of matter; and household chemicals (Manasikanal et al., 2022). In addition, concepts in chemistry that are generally abstract have the potential to cause difficulties in students and reduce student motivation to learn chemical sains. One abstract material that makes it difficult for students to learn chemistry is atomic structure substance, so the students must understand these concepts correctly and sincerely. So that students have difficulty in solving problems on the subject of atom structure, namely on concept problems, because students only memorize and need help understanding the concept correctly (Afrianis, 2022). students need help imagining atomic models based on atom inventors (Oktiarmi, 2020).

Chemistry study emphasizes direct study experiences through used process skills development and scientific behavior, which can be done with practicum, teaching aids, tutor materials, and learning media (Ruslan & Putri, 2018). Learning media can make it easier for students to understand the material and like studying (Mawarni, 2018). Therefore, it is necessary to utilize technology to develop learning media to increase student motivation in study (Mufida et al., 2022). Based on an interview with a chemistry teacher at 1 Jetis Senior High School in November 2021 stated that the limited chemical sains learning media in the form of printed books or LKS on the material makes students feel that they do not understand the atomic matter properly, so it is necessary to develop learning media that can support study, one of which is utilizing technology. Technology can be used as an exciting learning medium for students without reducing the essence of the material (Nandyansah, 2019). One example of learning media that can be concreted by utilizing technological developments in the field of Education is android-based learning media (Kuswanto & Radiansah, 2018). Augmented reality (AR) android-based technology currently being developed (Harahap et al., 2020). AR a technology that is still new and still has little use for people in Indonesia. Hence, the use of AR is one of the alternative learning media to make the learning process more fun and exciting. AR can also be used to overcome printed books, modules, or trainers that are pretty expensive and can be purchased by schools. Augmented Reality is an attempt to combine the natural and virtual worlds created through a computer to make the boundary between the two thin by utilizing 3D animation technology visualized through Augmented Reality using devices. AR is a technology that can transform two-dimensional or three-dimensional virtual objects into a natural environment and project them in real-time (Nirwanto, 2021).

The use of educational media AR can directly provide learning wherever and whenever students want to carry out the learning process (Yuliono et al., 2018). Based on the results of interviews with chemistry teachers in schools, it is necessary to develop a learning media to realize abstract chemistry learning materials, especially on the atomic matter, where using AR can visualize explanations of atoms so that chemistry learning is more interactive, practical, and varied. In addition, using AR learning media can increase student interest in learning chemistry. In addition, according to Nirwanto (2021), AR in education has a positive impact, namely being attractive for multimodal learning, increasing the accessibility of educational content, increasing student control over educational content collaborative learning opportunities, motivating students to be actively involved, and turning something abstract into the concrete. There are even significant differences in learning outcomes using AR learning media that can increase student understanding (Uliontang et al., 2020). Research related to android-based AR learning media development on the atomic matter has yet to develop. Therefore, researchers focus on developing android-based AR learning media on atom matter to

know the characteristics of learning media, the quality of learning media, and student responses to android-based AR learning media on atomic matter in high school. This learning media can be an alternative learning medium for atom matter and increase students' interest in learning chemistry (Arum, 2022). This study aims to determine the characteristics and quality of android-based AR learning media on atomic material based on assessments from material experts, media specialist and teachers, and to determine student responses to the product.

Methods

This research uses a development model, name research and development (R&D). This development research method aims to produce a product and test students' responses to the product developed (Rahmawati, 2022). The procedure used is the 4-D development model, according to Thiagarajan (1974) the 4-D model is divide into 4 stages, namely define, design, development, and disseminate (Azmi, 2022). This research is limited to the development stage. The products developed in this study are augmented reality android applications and marker cards on the atomic matter. The procedure in this study can be seen in Figure 1. Products were review by peer reviewers, namely three chemistry education students of UIN Sunan Kalijaga Yogyakarta to provide suggestions, validated by one material expert and one media expert, and assessed for quality by three reviewers, namely one chemistry teacher in each school (MBS Pleret Yogyakarta, MA Muhammadiyah 1 Yogyakarta, and SMA Negeri 1 Jetis Bantul), and respond by five students of class X MIPA SMA Negeri 1 Jetis and five students of class X MIPA MBS Pleret Yogyakarta.

The data collection techniques used are indirect communication using 5-scale product quality assessment questionnaire sheet instruments for material experts, media experts, and teachers and Guttman scale questionnaires for student responses. The grid of augmented reality media quality assessment instruments can be seen in Table 1.

Table 1. Augmented reality media quality assessment grid

Aspects	Number of indicators	Material Expert	Media Expert	Teacher
Presentation of the material	3	√		√
Material	5	√		√
Language	2	√	√	√
Uselfulness	2	√		√
Visual communication	2		√	
Software engineering	3		√	√

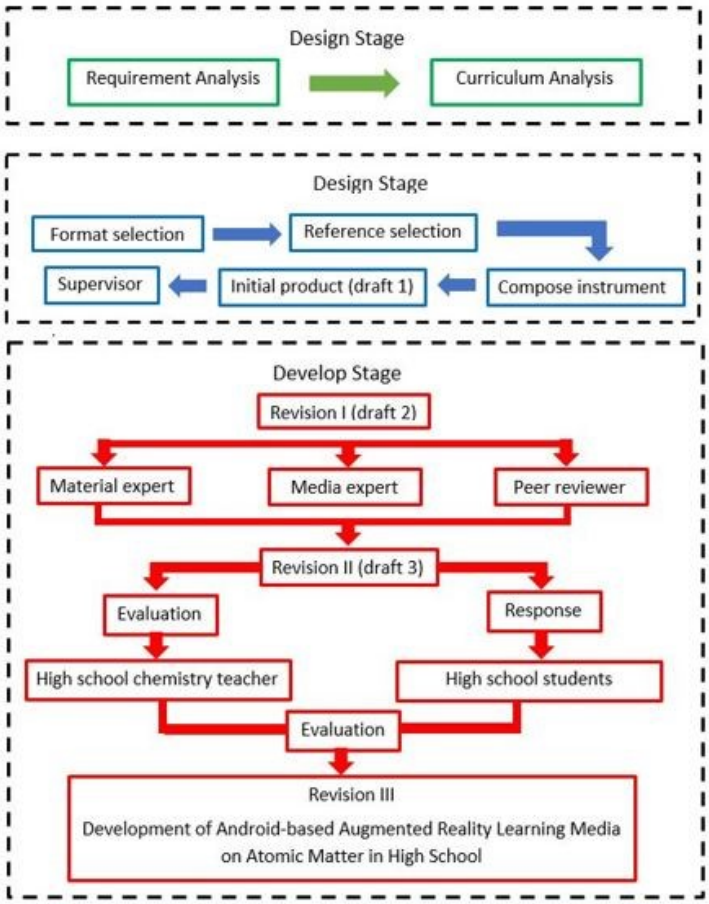

Figure 1. Research procedure for learning media development

Data in the form of input from material, media experts, peer reviewers, and teachers are analyzed descriptively to revise the product. Data analysis of product quality assessment results from material, media experts, and teachers was carried out to obtain numerical scores with scores in the form of letters (qualitative) converted into scores (quantitative) with provisions based on scales (Azmi, 2022) in Table 2. Then the average of all aspects and each aspect of the assessment is calculated using formula (1). Furthermore, the scores obtained are converted into qualitative data based on the ideal assessment criteria in Table 3. Next, the percentage of product ideality is calculated as a whole and each aspect using formula (2).

$$\bar{x} = \frac{\sum x}{n} \qquad (1)$$

with

$\bar{x}$ = Average of score
$\sum x$ = The total score of each rater
n = Number of appraisers

Table 2. Convert qualitative data into quantitative data

Category	Score
Very good	5
Good	4
Enough	3
Less	2
Very lacking	1

(source: Rohmah, 2020).

Table 3. Ideal assessment criteria

Scor range	Category
$\bar{x}$ > (Mi + 1,8 Sbi)	Very good
(Mi + 0,6 Sbi) < $\bar{x}$ ≤ (Mi + 1,8 Sbi)	Good
(Mi – 0,6 Sbi) < $\bar{x}$ ≤ (Mi + 0,6 Sbi)	Enough
(Mi – 1,8 Sbi) < $\bar{x}$ ≤ (Mi – 0,6 Sbi)	Less
x ≤ (Mi – 1,8 Sbi)	Very lacking

(source: Rohmah, 2020).

Analysis of learner response data from qualitative data is converted into quantitative data based on the Guttman scale. The average value for the entire aspect is calculated using formula (1). Then calculated the percentage of overall product ideality and each aspect formulated by the research result score divided by the maximum idea score multiplied by 100%. The Guttman scale is used for data analysis techniques for student response results to obtain quantitative data (scores) which were originally qualitative (Rahmawati, 2022), the score on the Guttman scale will be 1 if the answer is "Yes" and 0 if the answer is "No".

Result dan Discussion

Android-based AR learning media on atomic matter developed in this study is a type of R & D using a 4-D model. The 4-D stage consists of four stages, namely define, design, develop, and disseminate. This research is only limited to the development stage. The description of the study is as follows.

Define

The define stage is carried out with initial analysis, needs, and curriculum. Literature studies from various sources such as journals regarding product needs must be developed and observations of students about the learning media used are things done for initial analysis. The initial analysis stage is carried out to determine the needs and problems experienced and faced by students in chemistry learning. The initial analysis was carried out by studying literature from various sources such as journals regarding the need for products to be used as learning media and supplies of learning media used in the classroom. In addition, observations were also made to students regarding the use of learning media in class.

The results of the initial analysis are then deepened again by knowing the learning process in a class by analyzing needs. Then interviews were conducted with chemistry teachers at SMA Negeri 1 Jetis and MAN 2 Kulonprogo to find out the needs, problems, and obstacles during learning as a needs analysis. The interview results stated that educators still use conventional learning media such as books and student worksheet so students feel bored with the media used. This resulted in students' interest in learning chemistry.

It is necessary to develop learning media innovations that utilize technology such as AR so that students do not feel bored when learning atomic matter chemistry. In addition, learning media has advanced and developed along with the birth of the communication revolution which is used for learning purposes other than pre-existing media such as teachers, textbooks, and whiteboards (Yaumi, 2018). The use of interesting learning media can also increase the imagination of students in learning. Furthermore, curriculum analysis is carried out by analyzing Core competencies and basic competencies (KD) in the 2013 curriculum for the 2021/2022 academic year. The curriculum analysis aims to establish competencies to be developed on android-based augmented reality on the atomic matter. The result of the curriculum analysis is the KD are selected to be the target of development.

Design

The design stage is carried out by selecting media and formats, references, preparing instruments, and the initial design of the product to be made. Based on the initial analysis, needs analysis, and curriculum analysis the media developed is an android-based AR. The selection of learning media formats is adjusted to the chemistry and characteristics of students obtained from observations and interviews. The material in this learning media is atomic. The selection of formats developed includes learning objectives, materials, AR cameras, instructions, and quizzes.

The medium to be created in AR is an atomic matter which includes: the development of atomic models, atomic structure, and atomic number and mass number. The development material of the atomic model is equipped with AR3D modeling of the atom so that the atomic model can be visualized. Reference material to be used is obtained from college chemistry books, high school chemistry textbooks and LKS, research journals, and youtube. After all the material is collected, the learning media is made by unity, vuforia SDK, blender, and corel draw. The selection of 3D Blender is reviewed from the aspects of modeling and animation (Mongilala et al., 2019). While the Vuforia SDK is used to analyze images by detecting markers so the information is generated in the form of 3D objects created (Firdanu et al., 2020).

Instrument making is done by studying literature on the criteria of android-based AR as a good learning medium and adopting several instruments that have been made before then instruments that have been compiled in validation by instrument experts. The material that has been prepared, the design of the application design, and the functionality of the application are used as considerations for making instruments. Instrument-making is done by looking at aspects and indicators regarding the product to be developed.

The initial design stage (draft I) was made by designing media content and preparing android-based AR applications. Microsoft word is a reliable word processing

program and is most widely used by computer users, so the design of media content uses word office applications (Septian, 2019). In materials designed to be arranged into developed media, it is not 100% KD of atomic matter. This is because if all material according to KD is arranged into development media, it will affect the size of the application which becomes large, so it takes up a lot of storage memory in the user's android. Furthermore, the preparation of android-based augmented reality by 1) designing a design, using corel draw where the advantage of this vector is that the image will have a relatively small file capacity (Afriansyah, 2018), then choosing background colors and icons, 2) making 3D modeling of atomic shapes using the blender application which is a series of free and open source 3D creations, which supports the overall 3D concept, namely modeling, rigging, animation, simulation, rendering, compositing, and motion tracking, even video editing and game making (Mongilala et al., 2019). The 3D shapes made are ten objects including the Dalton atomic model, Thomson atomic model, two Rutherford atomic models, two Bohr atomic models, quantum mechanical atomic models, cathode ray firing experiments, and alpha ray shooting experiments, 3) creation of a license in the Vuforia SDK, the finished barcode is then licensed to the Vuforia SDK to find out the level of sensitivity if the barcode is scanned by the application. Vuforia uses consistent sources of computer vision that focus on image recognition, but it has many features and capabilities that can help developers to realize their thoughts without technical boundaries. Vuforia supports developers to create applications that can be used on almost all types of smartphones and tablets (Mongilala et al., 2019), 4) combining assets into Unity which is used to develop multi-platform games and can also be used to create three-dimensional animations. The designs that have been made are then put into unity and then bolted programs and coding to make the application run as the developer wants. Unity is great and full of professional applications. The editor in Unity is made with a simple user interface (Mongilala et al., 2019), 5) the resulting product (draft I) is an Android-based augmented reality learning media on the atomic matter. The product developed has several components, namely the homepage, main menu in which there is a menu of hint buttons, competencies, materials, AR cameras, quizzes, developers, and exits. The homepage is the initial screen before starting the application, inside the homepage there is a start button to start the application, and when opening the application will appear music as an accompaniment when the application runs.

The characteristic of android-based augmented reality developed is the integration of atomic matter with technological aspects to visualize atomic models. So that it can be an alternative learning medium in the classroom. The use of augmented reality in chemistry learning is in line with the times by studying the atomic matter, visualizing atomic models through AR cameras, and ending with an atomic matter quiz.

Develop

After the product (draft I) is revised based on advice and input from experts, a revised product (II) is produced. Furthermore, draft II was corrected by three peer reviewers and validated by one lecturer, material expert, and media expert. Suggestions and input from material experts, media experts, and peer reviewers are used for revision II materials and refining the product. Furthermore, the revision II product (draft III) was assessed by three reviewers (high school / MA chemistry teachers) and responded to by ten high school students from grade XI MIPA to obtain data and input for revision III

material as the final product. The final media product developed is an android-based augmented reality application on atomic matter equipped with marker cards, applications, and marker cards can be downloaded at https://drive.google.com/drive/folders/1QrYH_SEwj0CWmaMz0e_MUPuUP7uB_TV5 addresses via android devices. As for using the application, it does not require an internet network so it can be used anytime and anywhere. The final product specifications include 1) Homepage (Figure 2); 2) Main menu (Figure 3); 3) Instructions (Figure 4); 4) Competence (Figure 5), 5) Material (Figure 6); 6) AR camera (Figure 7); 7) Quiz (Figure 8); 8) Developer (Figure 9); 9) Exit button and AR card (Figure 10).

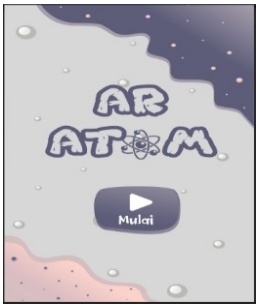

Figure 2. Homepage

Figure 3. Main menu

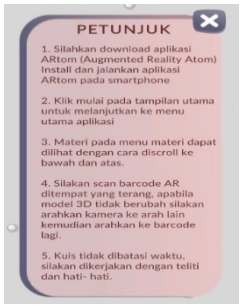

Figure 4. Instructions

Figure 5. Competence

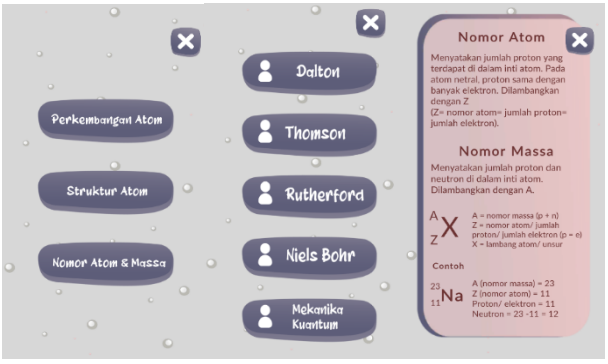

Figure 6. Material

Figure 7. AR camera

Figure 8. Quiz

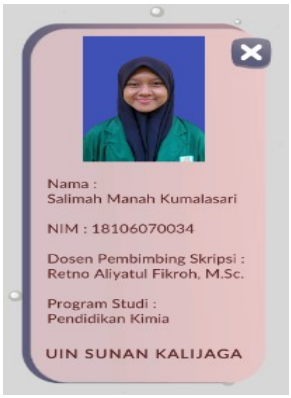

Figure 9. Developer

Figure 10. AR card

Product Assessment Result

The results of validation by material experts as a whole received a score of 50 with an ideal percentage of 83.33% and were included in the good category. Furthermore, the results of validation by media experts as a whole received a score of 34 with an ideal percentage of 97.14% and were included in the very good category. The assessment results of three reviewers (high school chemistry teachers) overall received an average score of 67.3 with an ideal percentage of 95.8% and included in the very good category. The response results of ten students as a whole received an average score of 99 with a percentage of the ideality of 99%. Data on the results of validation, assessment, and student responses can be seen in Table 5.

Based on the results of the research data the products developed are very good. The learning media developed can increase student interest in learning where the application can be used as an alternative to independent learning, add references to learning resources, and foster enthusiasm for learning. The use of interesting learning media can generate new desires and interests for students, In addition, the creativity of ideas is very good by providing an attractive, original look, and following the needs of the times. An attractive media display will make it easier for students to understand the material so that students do not feel bored learning (Wibowo & Koeswanti, 2021).

Table 5. Data from the validation of material experts, media experts, reveiwer assessment, and student responses

Response	Assessment aspect	Σ Indicator	Σ Score	Total	Ideality	Category
Material expert	Presentation of material	3	14	50	83.33%	Good
	Material	5	20			
	Language	2	8			
	Uselfulness	2	8			
Media expert	Language	2	10	34	97,14%	Very good
	Visual communication	2	10			
	Software engineering	3	14			
Reviewer (Chemistry teacher)	Presentation of materia	3	15	67.3	95.8%	Very good
	Material	5	24			
	Language	2	9.3			

	Uselfulness	2	9.7			
	Software engineering	2	9.3			
Senior High School students grade X MIPA	Visual communication	1	10	99	99%	Very good
	Presentation of the material	2	19			
	Material	3	30			
	Software engineering	1	10			
	Language	2	20			
	Uselfulness	1	10			

Based on the research data results, aspects of the material presented in the products developed are very good and follow the core competencies and KD in the applicable curriculum. According to Rahmawati (2022), the suitability of KD will affect student development and material presentation. The systematic and straightforward presentation of material on this media is very good; the material is arranged systematically, there is no overlap in the delivery of material, and the material delivered is per the indicators. If the material presented is correct, it can prevent misconceptions and understanding for students (Azmi, 2022). Media that can be used anytime and anywhere is very good flexible media used anytime, anywhere can be applied offline and is up to date following the latest developments in science and technology. Using learning media through the development of science and technology can improve student learning outcomes (Lestari et al., 2020). This is also following research conducted by Arum (2022), obtaining an average result of 98.3% in the very good category so that the AR produced is suitable for use as a learning medium.

The results of the research data show that the material aspect of the developed product is very good with the criteria of images presented clearly and attractively, 3D images introduce students to atoms, emphasize direct experience to students, writing chemical terms is correct, and 3D images of atoms have presented their original form. The resulting product follows research by Rahmawati (2022) that the image is presented clearly and attractively, namely a precise 3D image, appropriate image size, and picking image design. So that the quality of images in the media can help understand the material and support the material. In addition, 3D drawings introduce students to atoms so that they can visualize their shape, explain their development, and facilitate the understanding of atomic matter. According to Azmi (2022), displaying interesting 3D objects can increase learners' attention. The products developed also emphasize direct experience to students so that students can operate applications, scan barcodes, view 3D images directly, and study atomic matter independently. The research by Azmi (2022) shows that students will be able to find their knowledge and develop critical thinking skills. In addition to direct experiences that students can feel, students also experience new experiences using augmented reality technology learning media (Mongilala et al., 2019). Writing chemical terms on products uses chemical terms and symbols that have been learned and uses terms that are easy to understand so that they do not cause double meaning, so do not cause debate, do not have many interpretations, and do not cause misconceptions and doubts (Rahmawati, 2022). Using 3D images on products helps students better understand atoms and can prevent misconceptions about the material (Hilda et al., 2021).

The linguistic aspects of the products developed in this study are very good with PUEBI and communicative suitability criteria. In the developed product, the language used follows PUEBI, including writing letters, sentences, punctuation, and hyphenation of syllables. This shows that the language follows rules (Ramadani et al., 2020). In addition,

the language used in communicative products is easy to understand, so it can clarify the sentence to be conveyed. According to Azmi (2022), using easy-to-understand language will clarify the sentence's meaning, and compliance with Indonesian rules will make it easier for students to understand the material.

The results of the research data show that the usefulness aspect of the product developed is very good with the criteria for using the product to make it easier for teachers to deliver material, and the use of products can increase student learning interest. The use of products greatly facilitates teachers in delivering material. This follows research by Asnawati (2019); efforts and use of learning media in schools still need improvement. The learning material teachers deliver only explained conventionally so that the products developed are beneficial and facilitate teachers' learning process. The products developed can also increase student interest in learning, where the product can be used as an alternative to independent learning, add references to learning resources, and foster enthusiasm for learning. Using attractive products can generate new desires and interests in students, generate learning motivation, and even psychologically influence students (Rif & Nur, 2021).

The results of research data show that the product's visual communication aspect is very good with the criteria of creativity, ideas, and appearance. The creativity of ideas used in products is very good by providing an attractive, original look and following the needs of the times. An attractive media display will make it easier for students to understand the material so that students do not feel bored and can foster enthusiasm for learning (Wibowo & Koeswanti, 2021). In addition, a very good display of products with attractive application designs, clarity and readability of material, appropriate font types and sizes, and using exciting colors. This shows that the design is attractive, the content is proportional, and the typography of the content is not excessive (Arum, 2022).

The software engineering aspect of the products developed in this study is very good with the criteria for learning media installation, learning media operation, and file size. The installation of the developed product is very good; it can be installed on Android, the installation process is easy, it does not interfere with other operating systems, and the application does not bug/errors. This shows that the operation is easy and does not hang (Azmi, 2022). The operation of the product is excellent so that the application is easy to use and the instructions are displayed. According to (Azmi, 2022), media use must be easy and accessible anytime and anywhere so that students are helped in its use. The product file size is categorized as good, and this is because the file size is quite large but still at an average level and does not exceed the size limit of an application.

Conclusion

Android-based AR learning media has been developing on the chemistry of atomic matter. Android-based AR learning media contains a home page, a menu page containing instructions, competencies, materials, AR cameras, quizzes, developers, and exit menus. AR learning media is equipped with AR cards to display 3D objects contained in the database. Android-based AR learning media on the atomic matter can be accessed anytime and anywhere without an internet network. The developed media can be an

alternative learning media to help students learn and understand the abstract atomic matter. Media development follows the material presentation, material, language, usefulness, visual communication, and software engineering. The product obtained good validation by material experts and excellent validation by media experts. The teacher's assessment also obtained a very good category. It shows that the media can be used in the learning process. Students' overall response to the product development assessment aspect also obtained a very good category. Thus, Android-based AR development has the potential to be a quality learning medium to help students understand atomic.

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