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Augmented Reality Media Validity based on Tetrahedral Chemical Representation with Aiken Validation Index

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Abstract: The development of science and technology has brought significant changes to the world of education, especially in the teaching and learning process. In the learning process, there is an interaction between teachers and students to transform their knowledge in the learning environment. To convey this knowledge, a supporting factor in learning is needed, namely learning media. This study aims to determine the feasibility of chemistry learning media in the form of augmented reality (AR) media based on chemical tetrahedral representations on thermochemical materials. This study uses quantitative research methods, with data processing and analysis using the Aiken model. The instrument used is a validation questionnaire sheet to determine the feasibility of the media. The feasibility test itself is carried out by testing 1 chemist, 1 learning media expert, 1 learning technology expert, and 6 education practitioners. The results of the validation test of the feasibility of augmented reality media get the results of Aiken's V 0.9899, which means that the media is feasible to use. However, improvements still need to be made according to suggestions from the validator so that the finalized product can be used as a measuring tool that meets the criteria.

Keywords: Augmented reality; Chemical tetrahedral representation; Validation; Thermochemistry

Introduction

Chemistry learning is an important part of human life. Many problems in the real world require the role of chemistry in solving these problems. This is what underlies chemistry learning to be able to integrate contextual problems from the real world, train the thinking skills needed, and present the sophistication of 21st-century learning technology (Griffin et al., 2018). Chemistry is one of the most difficult subjects because of the many abstract concepts that make it difficult for students to understand the material without presenting real situations in learning (Ilyasa et al., 2020). Chemistry is studied through four levels of representation which include macroscopic, submicroscopic, symbolic, and human element levels. Phenomena in chemistry are closely related to real-life problems that can be observed macroscopically, explained submicroscopically, and represented symbolically. The tetrahedral representation must be applied as a whole and interconnected in the learning process (Mahaffy, 2006). At the human element level, it describes the representation of problems or phenomena that occur in real life. The macroscopic level explains that chemistry is studied through real representations of phenomena that occur in everyday life and in the laboratory that can be observed using the five senses and tools. While the submicroscopic level is an abstract representation of chemical phenomena characterized by concepts, theories, and principles at the molecular level such as the movement of electrons, molecules particles, and atoms. At the symbolic level, it explains representations that represent macroscopic phenomena and submicroscopic explanations using chemical equations, mathematical equations, graphs, reaction mechanisms, animations, or pictures. Various kinds and types of learning media that

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have the characteristics of being easy to manufacture in addition to textbooks and powerpoints such as e-books, flipbookmakers, and others, because the presentation is in the form of audiovisual, namely by adding text, images, and videos into a multimedia unit which can then be used on computers, laptops, or smartphones according to the operational system (Lasfika et al., 2022).

The understanding of chemistry which includes four levels of representation shows the integrity of the mental model of a person. Everyone builds a personal mental model when learning to understand and link the four levels of representation during learning activities (Chittleborough, 2014). Mental models are defined as simple representations that represent ideas in a person's mind that are used to describe and explain a phenomenon. Students use mental models to reason, describe, explain, predict phenomena, test new ideas, and present data based on their knowledge to communicate them to others or solve problems in learning chemistry. Practitioners and researches who focus on the educational aspect continue to strive to provide innovation to improve the quality of learning processes and outcomes (Lasfika et al., 2022).

The Ministry of Education and Culture (2019) states that the average achievement of the National Examination for Chemistry at the SMA and MA levels is 50.99 and 46.73, respectively. This achievement shows that chemistry learning outcomes are still relatively low. One of the factors causing low chemistry learning outcomes is the inappropriate learning process (Herwani, 2020). Government Regulation number 32 of 2013 article 19 paragraph (1) states that the learning process must be carried out interactively, inspiring, fun, challenging, and motivating for students, and to be carried out properly, it is necessary to have Information and Communication Technology (ICT) assistance which is integrated with the learning process. The integration of ICT in learning activities can make the learning atmosphere innovative and more interesting than conventional learning. Tafonao (2018) also states that the learning process will be effective and efficient if it is assisted by the existence of learning media. The use of technology in learning can influence students to learn more effectively (Saidin et al., 2015). One of the technologies used in the learning process is augmented reality (AR).

Augmented reality can be used without the need for expensive equipment and can strengthen its application in the educational environment. Augmented reality is the latest technique that represents the real world in a virtual form with contextual information assisted by computer technology which aims to give the user a feeling that is very similar to actual interactions with the real environment (Cai et al., 2014; Zhang et al., 2014). This technology can become a focus in the world of education because it has a significant effect in focusing students' attention on learning objectives. It is proven that augmented reality can provide an efficient way to represent models that require visuals and allow different teaching for all students including students with special needs (Annetta et al., 2019). In addition, several scientific phenomena in chemistry and constructions that underlie chemical knowledge which generally cannot be observed directly by students, make AR a way to overcome problems in teaching chemical concepts and representations to students (Lin et al., 2013).

Various studies have been carried out regarding the use of AR technology in chemistry learning, including the use of AR in elemental chemistry practicum (Chen et al., 2019), DNA deposition practicum (Ovens et al., 2020), and stereochemistry learning (Habig, 2020). In addition, research conducted by Candra et al. (2020) on the manufacture of interactive modules with AR technology on thermochemical materials is also able to provide 3D visualization so that students' interest and interest in the learning process can increase.

Because there are not many AR development studies that integrate chemical tetrahedral representations in the learning process, this is an opportunity to develop an augmented reality technology based on chemical tetrahedral representations that can help students to represent symbols and concepts that will encourage students to represent ideas fairly (Candra et al., 2020; Nurhayati et al., 2017). This development research will be able to make students have a high interest in learning in the chemistry learning process. Related this is to obtain quality, accurate, and appropriate learning media, it is necessary to validate the developed media. The importance of the validity of the developed media, it will be necessary to obtain valid learning media, and the function of the learning media can be achieved.

The use of an appropriate validation formula to validate the content of the developed media is very important. Lawshe's CVR (Content Validity Ratio), Aiken's validation index, Content Validity Index (CVI), and Gregory's formula are formulas that are intensively used to test validity. The Aiken validation index is one of the most appropriate formulas to be used in testing the content validity of the developed media because there is more than one judge/validator involved in this validation process. Thus, the purpose of this study is to determine the validity of the augmented reality media that has been developed. In developing media, a test is neede that aims to find out whether the media can be applied or not and find out which aspects are difficult and easy to achieve. The test is done through the validity test, is the method used to determine the feasibility of the developed media. In this study, the content validity test was conducted to determine the feasibility of the contest presented in the media (Yamtinah et al., 2021).

Method

This research uses the Research and Development (R&D) type of research. Research and Development is a method that produces a product and tests the effectiveness of the product. The product developed in this research is augmented reality media based on chemical tetrahedral representation on thermochemical materials. This study refers to the Akker model which applies 4 main stages, namely (1) preliminary examination, (2) theoretical adjustment, (3) empirical testing, (4) process and results of documentation, analysis, and reflection. However, this research is only limited to the empirical test stage, namely the product validation process.

It is important to do validity tests in development research to get the level of validity and validity of a measuring instrument, as well as to improve the measuring instrument through checking the items on the measuring instrument. This validity is based on the extent to which the content of the measuring instrument can describe the attribute to be measured. The object of this research is augmented reality media based on chemical tetrahedral representation. The subjects involved in the media validation process were 9 experts, namely 1 chemistry expert, 1 learning technology expert, 1 learning media expert, and 6 educational practitioners. In this study, validity was determined using the Aiken formula, as equation 1.

$$V = S / [n^*(c-1)] \text{ where } S = ni\ (r-\ell o) \quad (1)$$

Description:
V : validity index of Aiken
ni : the number of raters (raters) who choose criteria i
c : many categories/criteria
r : criteria to i
ℓo : lowest category
n : total number of appraisers

Aiken's V coefficient value ranges from 0 – 1 and the criteria used to declare a measuring instrument is said to be content valid for the number of raters (appraisers) as many as 9 people is 0.72 (Aiken, 1980). The instrument used for data collection in this study was a questionnaire. The questionnaire was given in the form of a google form. The reason for using a questionnaire is that this instrument is easier to quantify. The data used in this study are qualitative data and quantitative data. The qualitative data used is data related to aspects of the validation assessment of the media in the form of suggestions and input. Quantitative data in this study is data from the results of the assessment through a quantified questionnaire. The data analysis technique used in this study used quantitative descriptive analysis techniques.

Results and Discussion

Augmented reality media based on chemical tetrahedral representations that have been designed, then validated by judges/validators. The validity test of the augmented reality media that has been developed is oriented towards 4 criteria aspects, namely (1) content criteria, (2) language criteria, (3) presentation criteria, and (4) graphic criteria. In Table 1, a grid of augmented reality media validation assessments based on chemical tetrahedral representations is described.

Table 1. Grid of Augmented Reality Media Validation Assessment Based on Chemical Tetrahedral Representation

Criteria	Rated Aspect	Instrument Items
Content criteria	The suitability of the material with basic competencies	1
	The suitability of the substance of the learning material	2; 3; 4
	AR media compatibility with chemical tetrahedral representation	5 to 16
	AR media suitability with students' science process skills	17 to 20
Language criteria	Suitability with the development of students	18; 19
	straightforwardness	20; 21; 22
	Motivating ability	23; 24; 25
	Coherence and coherence in the flow of thought	26; 27
Presentation criteria	Order of serving	28; 29
	Learning presentation interaction	30
	Complete information	31
Graphic criteria	Use of font type and size	32; 33
	Layout suitability or layout	34; 35
	Compatibility of illustrations, pictures, and photos	36 to 40

Quantitative data was obtained from the results of the assessment of 9 judges/validators through a questionnaire containing a rating scale for the augmented reality media that had been developed. Questionnaires are given to judges/validators in the form of a google form. This is because to simplify the assessment process due to the situation that is experiencing the Covid-19 pandemic. Then do the calculation of the validation of the results of the assessment by the validator. The analytical technique used to analyze the validation results is to use the following Aiken formula:

$V = S / [n*(c-1)]$ where $S = ni (r-\ell o)$

There are 9 validators, thus the criteria used to declare a measuring instrument is said to be content valid if the coefficient value of Aiken's V (V_{count}) is 0.72. The recapitulation of the results of the validation analysis is presented in Table 2. The validation carried out by 9 judges/validators obtained Aiken's V coefficient value (V_{count}) of 0.9899. Aiken's V coefficient value obtained (V_{count}) is greater than 0.72 (V_{table}). This means that the developed tetrahedral representation-based augmented media is valid and feasible to use for students in the learning process. Augmented reality media that has been developed has met the content criteria, language criteria, presentation criteria, and graphic criteria.

Table 2. Recapitulation of the Results of the Validation Assessment by 9 Judges/Validators on Augmented Reality Media Based on Chemical Tetrahedral Representations

Instrument Items	Aiken's V (V_{count})	V_{table}	Description
1 to 44	0.9899	0.72	Valid

Qualitative data were obtained from criticisms, responses, and suggestions from judges/validators on the quality of augmented reality media based on chemical tetrahedral representations contained in the questionnaire comment column. The recapitulation of the qualitative data results is presented in Table 3.

Table 3. Recapitulation of Qualitative Data from Augmented Reality Media Based on Chemical Tetrahedral Representation

Criticism and Suggestions	Researcher Follow-up
The technique of writing questions is adjusted and can use more varied questions such as graphs or pictures	Fixed and added some questions in the form of graphics and images to make it more varied
The image appears horizontally so that the explanation is not visible	Improve the display of media so that images appear vertical and visible to the user
Not equipped with Instructions for Use in augmented reality media.	Added "Hint of Use" button on media
Font consistency and screen appearance in the "About" section	Improved font consistency and screen display to make it clearer and less overlapping
There is no option A, B, C, D, E in the answers to multiple-choice questions	Added options A, B, C, D, E to the answer options so that users can easily choose answers
There is no explanation regarding the material in the developed media	Adding an explanation of the material on the media so that it becomes easier for students to understand the visualization displayed by the media

Based on the validation results from 9 judges/validators, the augmented reality media that was developed was feasible to be used by students in the learning process. If a learning device including media is valid, then the device can be used as a measuring tool. Akbar (2013) explains that a learning device can be said to be valid if it is following the theoretical basis for its development and if it is used it can measure the expected abilities. The results of quantitative data analysis using the Aiken formula obtained Aiken's V coefficient value of 0.9899. However, there are still suggestions from the validator for media improvement.

One of them is the need for additional instructions for use of the media that has been developed. Instructions for use explain how to use the media, and it is important to display this section in the media so that it is easier for users to use the media.

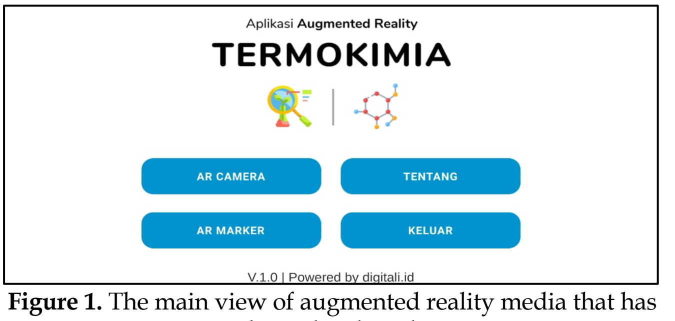

Figure 1. The main view of augmented reality media that has been developed

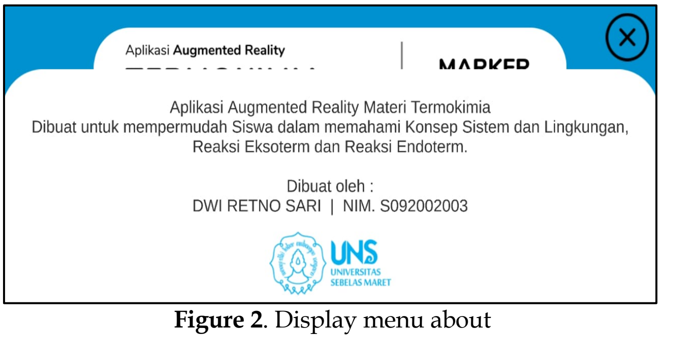

Figure 2. Display menu about

In addition, the advice from the media expert judges/validators is that the letters and screen displays in the "About" section have not been seen consistently. This causes the display on the media to overlap as shown in Figure 3. Then, in the "Problem" section there are no options A, B, C, D, E gave, only an explanation of the answers (Figure 4.). Thus, a revision will be made in accordance with the suggestions given by the validator.

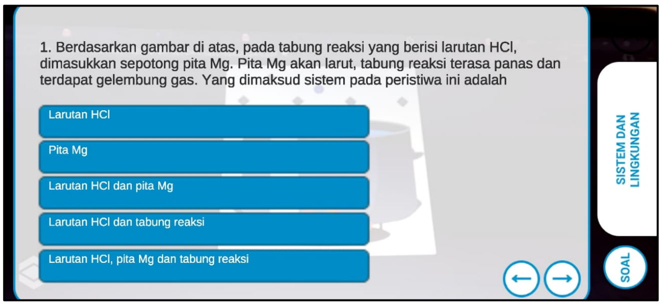

Figure 3. Display of questions on the media

Validators who come from education practitioners also provide suggestions related to the questions given in the media. Suggestions are given in the form of adding types of questions to make them more varied, such as questions in the form of graphs and pictures. Then the explanation on the media is also not very visible because the display appears horizontally, as in Figure 4.

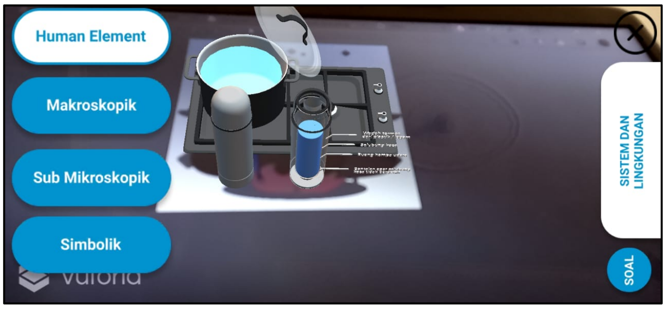

Figure 4. Media display that displays images in a horizontal form

The results of validation, suggestions, and revisions are still needed for media improvement. According to Sugiyono (2010), improvements are made to produce a better product. Revisions will be made taking into account the results of the validation as well as suggestions from the validator to achieve product perfection. Depdiknas (2008) describes revisions or improvements including the process of product improvement after receiving input from validation activities. The revision aims to finalize or comprehensively improve the product by the input obtained from the validation activities.

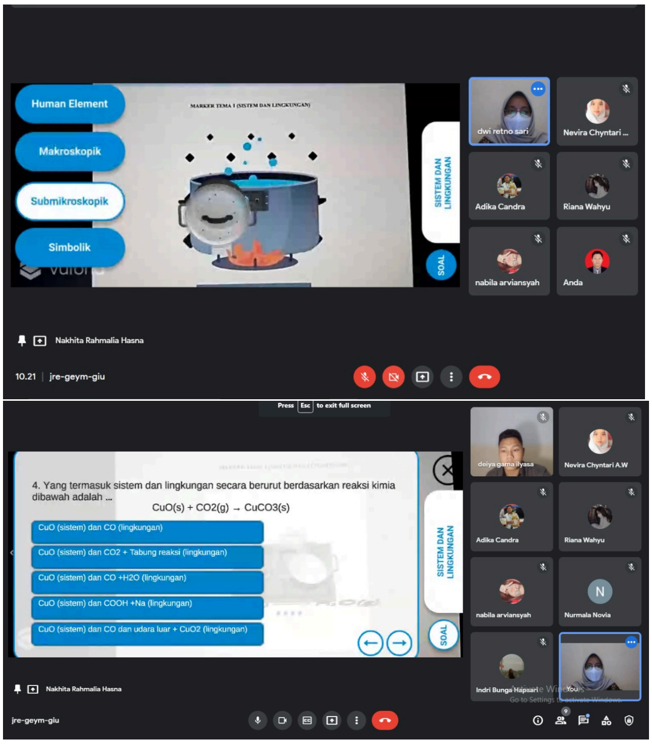

Figure 5. Research process

Presentation in AR media must be using an attractive appearance with a match between text color, font, and background that considers aesthetic and functional aspects in order to make it easier for students to use it as a learning resource. The combination of colors and backgrounds used is designed to be comfortable and easy to read in order to produce an attractive appearance so that it can influence the reading interest of students (Mumpuni, 2019).

Augmented reality is a three-dimensional medium that supports such a tangible interface, and enables a seamless interaction between people and information. Augmented reality technology differs from virtual reality technology in that it maintains the information of the user's real environment. Augmented reality also increases the user's sense of reality, by adding virtual information to his or her real environment (Kye et al., 2008).

The positive impact that augmented reality experinces have been shown to have on learners (Radu, 2014):

Increased Content Understanding

A large proportion of the surveyed papers indicate that for certain topics, AR is more effective at teaching students than compared to other media such as books, videos, or PC desktop experiences.

Long-term Memory Retention

Research indicates that content learned through AR experiences is memorized more strongly than through non-AR experiences.

Improved Physical Task Performance

Many studies have showed tnat when users must train or perform a physical task, AR is more effective using traditional media. Through an AR experience, maintenance tasks are performed with higher accuracy, and students are able to better transfer their learning tooperate physical machinery.

Improved Collaboration

AR experiences have been shown to cause imrpovements in group collaboration, as indicated by several papers surveyed. In the AR group, the students collaboration was determined to be more effective-suing AR application, they created a shared space where team members could collaborate and create shared meanings.

Increased Student Motivation

The users' hogh enthusiasm to engage with AR experiences is noted in multiple papers, where users report feeling higher satisfication, having more fun, and being more willing to repeat the AR experience. Interestingly, user motivation remains significantly higher for the AR systems even when the AR experiences is deemed more difficult to use.

Conclusion

The augmented reality media developed is classified as valid. The results of the validity test show the level of validity of augmented reality media based on chemical tetrahedral representations on high-class thermochemical materials and are feasible to be used by students in the learning process. Although the augmented reality media that has been developed is feasible to be used by students, some revisions are still needed according to the criticisms and suggestions were given by the validator. Product revisions will be carried out to produce a better product so that it can be used as a measuring tool to measure the expected skills by the objectives.

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References

Aiken, L. R. (1980). Content validity and reliability of single items or questionnaires. *Educational and Psychological Measurement*, *40*(4), 955–959. https://doi.org/10.1177/001316448004000419

Annetta, L. A., & Shapiro, M. (2019). Augmented Reality Applications for Teaching Chemistry across the K-20 Curriculum [Chapter]. In *ACS Symposium Series* (Vol. 1318, pp. 23–30). American Chemical Society. https://doi.org/10.1021/bk-2019-1318.ch002

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. *Computers in Human Behavior*, *37*, 31–40. https://doi.org/10.1016/j.chb.2014.04.018

Candra, F., & Syafii, M. (2020). Pembuatan Aplikasi Modul Interaktif Chemistry Magazine dengan Teknologi Augmented Reality pada Materi Termokimia Kelas XI SMA/MA Berbasis Android. *SATIN - Sains Dan Teknologi Informasi*, *6*(1), 62–69. https://doi.org/10.33372/stn.v6i1.614

Chen, L.-T., & Liu, L. (2019). Content Analysis of Statistical Power in Educational Technology Research: Sample Size Matters. *International Journal of Technology in Teaching and Learning*, *15*(1), 49–75. https://doi.org/10.37120/ijttl.2019.15.1.04

Chittleborough, G. (2014). Learning with Understanding in the Chemistry Classroom. In I. Devetak & S. A. Glažar (Eds.), *Learning with Understanding in the Chemistry Classroom*. Springer Netherlands. https://doi.org/10.1007/978-94-007-4366-3

Depdiknas. (2008). *Peraturan Pemerintah RI No.19 Tahun 2005 tentang Standar Nasional Pendidikan*. https://pelayanan.jakarta.go.id/download/regulasi/peraturan-pemerintah-nomor-19-tahun-2005-tentang-standar-pendidikan-nasional.pdf

Griffin, P., Care, E., & Wilson, M. (2018). Educational Assessment in an Information Age. In *Assessment and Teaching of 21st Century Skills*.

Habig, S. (2020). Who can benefit from augmented reality in chemistry? Sex differences in solving stereochemistry problems using augmented reality. *British Journal of Educational Technology*, *51*(3), 629–644. https://doi.org/10.1111/bjet.12891

Herwani, F. (2020). Faktor-Faktor Penyebab Rendahnya Hasil Belajar Siswa: Studi pada materi Qur'an Hadist di MA Ar-Rahma Desa Air Meles Atas. *Al-Mau'izhoh*, *2*(1), 37–49. https://doi.org/10.31949/am.v2i1.2185

Ilyasa, D. G., & Dwiningsih, K. (2020). Model Multimedia Interaktif Berbasis Unity untuk Meningkatkan Hasil Belajar Ikatan ION. *Jurnal Inovasi Pendidikan Kimia*, *14*(2), 2572–2584. https://doi.org/10.15294/jipk.v14i2.21501

Kye, B., & Kim, Y. (2008). Investigation of the Relationship between Media Characteristics, Presence, Flow, and Learning Effects in Augmented Reality Based Learning. *International Journal for Education Media and Technology*, *2*(2), 4–14. https://jaems.jp/contents/icomej/vol2/IJEMT2.4

-14.pdf
Lasfika, Y. T., Widyastono, H., & ... (2022). Digitalization Android-based Interactive Learning Media in Geography for High School Students. *Journal of Education …*, *6*(2), 207–216. https://ejournal.undiksha.ac.id/index.php/JET/article/view/44674%0Ahttps://ejournal.undiksha.ac.id/index.php/JET/article/download/44674/22183
Lin, T.-J., Duh, H. B.-L., Li, N., Wang, H.-Y., & Tsai, C.-C. (2013). An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system. *Computers & Education*, *68*, 314–321. https://doi.org/10.1016/j.compedu.2013.05.011
Mahaffy, P. (2006). Moving chemistry education into 3D: A tetrahedral metaphor for understanding chemistry: Union carbide award for chemical education. *Journal of Chemical Education*, *83*(1), 49–55. https://doi.org/10.1021/ed083p49
Mumpuni, A. (2019). Analisa Faktor yang Mempengaruhi Minat Baca Mahasiswa PGSD. *Dwija Cendikia: Jurnal Riset Pedagogik*, *3*(2), 123. https://doi.org/10.20961/jdc.v3i2.35229
Nurhayati, D. M., Herman, T., & Suhendra, S. (2017). Analysis of Secondary School Students' Algebraic Thinking and Math-Talk Learning Community to Help Students Learn. *Journal of Physics: Conference Series*, *895*(1), 12054. https://doi.org/10.1088/1742-6596/895/1/012054
Ovens, M., Ellyard, M., Hawkins, J., & Spagnoli, D. (2020). Developing an Augmented Reality Application in an Undergraduate DNA Precipitation Experiment to Link Macroscopic and Submicroscopic Levels of Chemistry. *Journal of Chemical Education*, *97*(10), 3882–3886. https://doi.org/10.1021/acs.jchemed.0c00481
Radu, I. (2014). Augmented reality in education: a meta-review and cross-media analysis. *Personal and Ubiquitous Computing*, *18*(6), 1533–1543. https://doi.org/10.1007/s00779-013-0747-y
Saidin, N. F., Abd Halim, N. D., & Yahaya, N. (2015). A Review of Research on Augmented Reality in Education: Advantages and Applications. *International Education Studies*, *8*(13), 1–8. https://doi.org/10.5539/ies.v8n13p1
Sugiyono. (2010). *Metode Penelitian Pendidikan Pendekatan Kuantitatif*. Alfabeta.
Tafonao, T. (2018). Peranan Media Pembelajaran dalam Meningkatkan Minat Belajar Mahasiswa. *Jurnal Komunikasi Pendidikan*, *2*(2), 103. https://doi.org/10.32585/jkp.v2i2.113
Yamtinah, S., Ariani, S. R. D., Andriyanti, M., Saputro, S., Susilowati, E., Shidiq, A. S., Ramadhani, D. G., & Fakhrudin, I. A. (2021). Examining the Content Validity of Android-Based Augmented Reality Media for Chemical Bonding using Rasch Model. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 320–325. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1094
Zhang, J., Sung, Y. T., Hou, H. T., & Chang, K. E. (2014). The development and evaluation of an augmented reality-based armillary sphere for astronomical observation instruction. *Computers and Education*, *73*, 178–188. https://doi.org/10.1016/j.compedu.2014.01.003