



Development of Augmented Reality Nervous System (ARSaf) Learning Media to Improve Student Understanding

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Abstract

To optimize the learning process in the midst of the Covid-19 pandemic, it is necessary to have appropriate learning supports students to learn from home. Augmented Reality (AR)-based learning media can involve students in the learning process and help improve visualization skills on complex and abstract concept such on the nervous system topic. The purpose of this study was to analyze the feasibility of Augmented Reality Nervous System (ARSaf) learning media to improve students' understanding. This study used a 3-D model which is modified from the 4-D model involving the define, design, develop, and disseminate stages. Validation of ARSaf learning media was carried out by media experts, materials experts, and biology teachers using a modified questionnaire from the 2014 BSNP and the book "Visual Usability Principles and Practices for Designing Digital Applications". Limited field trials were conducted at SMAN 2 Ungaran online. The research subjects were 18 students with different categories of cognitive abilities, namely upper, intermediate, and lower level from three different classes. The results of the validation of material experts are 86.76%, media experts are 95.19%, validation of material by biology teachers are 94.12%, and validation of media by biology teachers 91.35%. The results of the evaluation of learning meets the minimum standard (KKM) with the highest score of 100 and the lowest score of 75. The results of student responses are 82.85% and teacher responses are 89.13%. The results showed that the ARSaf learning media that was developed was feasible to be used to improve students' understanding.

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INTRODUCTION

Learning from home in the midst of the Covid-19 pandemic is one of the big challenges for the world of education. This means that schools, students, and teachers must adapt to new learning practices. The Circular of the Minister of Education and Culture number 4 of 2020 regarding the implementation of education policies in the emergency period of the spread of Covid-19 states that learning from home through online/distance learning is carried out to provide meaningful learning experience for students. Learning activities from home are expected to support the learning process and facilitate the mastery of the material by students. Therefore, it is necessary to have the right learning support and allow students to learn from home.

Based on the 2018 national exam results by Pusat Penelitian Pendidikan on the coordination system material, the percentage who answered correctly based on the national, provincial, district, and SMAN 2 Ungaran scales respectively were 37.77%; 43.97%; 48.39%; and 54.78%. In line with this, the results of interviews with class XI teachers at SMA Negeri 2 Ungaran indicate that the biology material that is difficult for students to understand is the coordination system material on the grounds that the coordination system material is too complex and abstract for students. This is supported by data from student questionnaires which stated that as many as 80.95% of grade 12 students felt that the coordination system material was difficult to understand. One of the subsections on the coordination system that is difficult to understand is the nervous system.

Interactive learning media, easy to transfer to students and make the learning process meaningful is one of the needs in today's learning. Learning at SMA Negeri 2 Ungaran based on the results of student questionnaires still tends to use learning media in the form of student worksheets (LKS) and power points. This learning media is not able to make students understand and motivated to learn. Abstract material cannot be illustrated with this learning media. Both worksheets and power points are only able to show objects in 2D so they are still not helpful for students to understand abstract nervous system material.

Learning media that has been discussed a lot lately is learning media based on Augmented Reality (AR) because the learning media has been proven effective in various lessons. Augmented Reality refers to a broad spectrum of technologies that project computer-generated materials, such as text, images, and videos onto the user's perception of the real world (Yuen, Yaoyuneyong, & Johnson, 2011). Saidin, Halim, & Yahaya (2015) mention the advantages of using AR features, which can involve students in the learning process and help improve their visualization skills.

This fact encourages the need for innovation in learning that can be a bridge for teachers to provide experiences to students in the learning process. One of them by developing Augmented Reality Nervous System (ARSaf) learning media. ARSaf learning media can improve visualization by converting 2D objects into 3D so that they can help students learn abstract material. The design by taking into account the competencies that students must have assisted with the AR feature is expected to be able to help students achieve KD 3.10 and KD 4.10 (Kemendikbud, 2018). Based on this background, it is necessary to study how the feasibility of Augmented Reality Nervous System (ARSaf) learning media to improve students' understanding.

RESEARCH METHOD

The type of research used is development research (RnD). The research steps used a 3-D model (define, design, develop) which was modified from the 4-D model from Thiagarajan et al. (1974). The stages of the 4-D model are defined, design, develop, and disseminate. Modification is done by not carrying out the last stage, namely, disseminate. This research was conducted in November 2020 at SMA Negeri 2 Ungaran online using Google Classroom. The subjects of this research include material expert lecturers, media expert lecturers, biology teachers' class XI SMAN 2 Ungaran, and class XII MIA 5, 6, and 7 students of SMAN 2 Ungaran totaling 18 people. Each class consists of 6 students with different ability levels, namely 2 upper-level students, 2 intermediate level students, and 2 lower-level students. The data from this

research is the validity of ARSaf learning media. Validation was carried out by media expert lecturers, material expert lecturers, and biology teachers using a modified questionnaire from the 2014 BSNP and the book "Visual Usability Principles and Practices for Designing Digital Application" by Schlatter & Levinson (2013). Responses to the ARSaf learning media by students were taken using a questionnaire to determine aspects of the material, language, attractiveness, user usability, and understanding. Responses to ARSaf learning media by teachers were taken using a questionnaire to determine aspects of the material, language, attractiveness, user usability, and understanding. Student learning evaluation data is taken after the learning process by using test questions arranged with cognitive level C4 (Analyzing). The data obtained were analyzed by descriptive quantitative percentage technique.

RESULTS AND DISCUSSION

The purpose of this study was to analyze the feasibility of ARSaf learning media to improve students' understanding. The feasibility of the product is seen from, (1) Validation of materials and media on ARSaf learning media by material experts, media experts, and biology teachers who reach a percentage of 69% in the valid category. (2) The response to the use of ARSaf learning media by students and teachers who reached a percentage of 70% in the good category. (3) The value of the results of the evaluation of learning by students reaches KKM 70. The learning media developed in the form of AR-based applications on nervous system materials that work on android devices. The ARSaf learning media contains material on the nervous system with AR features, practice questions, videos, and instructions for using the application. The interactivity of the ARSaf learning media includes easy navigation and responsive AR objects.

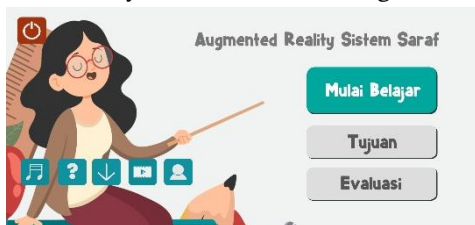


Figure 1 Main menu display on ARSaf learning media

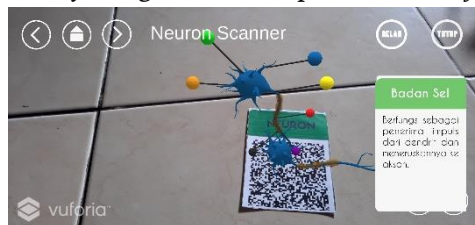


Figure 2 Augmented reality display on ARSaf learning media

ARSaf Learning Media Validity

The validation of the ARSaf learning media was carried out by media experts, material experts, and biology teachers at SMAN 2 Ungaran. Media validation of ARSaf learning media is carried out by media experts, hereinafter referred to as V1 validators. Material validation on ARSaf learning media is carried out by material experts, hereinafter referred to as V2 validators. Material validation and media validation of ARSaf learning media by biology teachers hereinafter referred to as V3.

Results of Media Validation on ARSaf Learning Media

The results of media validation on ARSaf learning media by media experts (validator V1) show that all indicators get a maximum score of four, except the indicators of motivating ability, consistency, and imagery. The results of media validation on ARSaf learning media by media experts can be seen in Table 1.

Table 1 Results of Media Validation on ARSaf Learning Media by Media Experts

Indicator	Total score	%
Straightforwardness	8	100
Legibility	4	100
Suitability with the development of students	8	100
Conformity with Indonesian language rules	8	100
Use of terms, symbols, or symbols	12	100
Motivating ability	6	75
Consistency	15	93.75
Color	8	100
Layout	8	100
Typography	12	100
Imagery	10	83.33
Overall score		95.19
Criteria		Very valid

The results of media validation on ARSaf learning media by biology teachers can be seen in Table 2.

Table 2 Results of Media Validation on ARSaf Learning Media by Biology Teachers

Indicator	Total score	%
Straightforwardness	8	100
Legibility	4	100
Suitability with the development of students	7	87.50
Conformity with Indonesian language rules	8	100
Use of terms, symbols or symbols	9	75
Motivating ability	8	100
Consistency	15	93.75
Color	7	87.50
Layout	7	87.50
Typography	11	91.67
Imagery	11	91.67
Overall score		91.35
Criteria		Very valid

The straightforwardness indicators in Table 1 and Table 2 get validation results with very valid criteria. The validation that gets maximum results is because the terms and sentences used can represent the content of the message conveyed and are adapted to the agreed large Indonesian and scientific dictionary. Effective, standard, and not too long sentences will facilitate the delivery of material information in teaching materials to students (Rahmawati, Roekhan, & Nurchasanah, 2016).

Referring to Table 1 and Table 2 regarding readability indicators, ARSaf learning media is included in the very valid criteria. High validation results on the readability indicator indicate that the teaching materials contained in the ARSaf learning media can make students understand what the author means by presenting messages in interesting, easy-to-understand language, and not causing multiple interpretations. Gumono (2016) stated that the readability of an appropriate text can avoid depression and boredom from students while reading.

The three indicators of conformity with the development of students based on Table 1 and Table 2 are included in very valid criteria. This is because the language used is following the emotional maturity of students by explaining concepts and illustrations of concept applications, describing concrete examples that can be found by students from the closest environment to the global environment, even abstract examples that students can imagine imaginatively.

The fourth indicator that is validated is conformity with the rules of the Indonesian language. Based on Table 1 and Table 2, the validation of ARSaf learning media obtained very valid criteria. Nugraha, Yulianti, and Khanafiyah (2013) stated that the use of language in teaching materials that are in accordance with the rules of the Indonesian language will facilitate the delivery of the author's intent so that it is easily understood by students.

The fifth indicator is the use of terms, symbols or symbols. Looking at Table 1 and Table 2, the validation results on these indicators get very valid and valid criteria. The validation results that are very valid and valid cannot be separated from the consistent use of terms and symbols or symbols that describe a concept, principle, principle, or the like arranged consistently between sections in ARSaf learning media and writing scientific/foreign names correctly/exactly.

In Table 1 and Table 2 regarding the motivational ability indicators of ARSaf learning media, validation results are obtained with valid and very valid criteria. AR features can provide motivation, entertainment, and an interesting environment that is conducive to learning (Iftine & Trandabat, 2018). In line with the previous opinion, Khan, Johnston, and Ophoff (2019) stated that AR-based learning media can engage students and increase their motivation to explore.

The sixth indicator is consistency that gets validation results with very valid criteria. The validation results can be seen in Table 1 and Table 2. Hamzah, Syarief, & Mustikadara (2013) argue that consistency in using color, typography, icons, images, navigation, and layout will help comfort in browsing.

The seventh indicator, color, gets validation with very valid criteria. The results of the validation can be seen in Table 1 and Table 2. Choosing the right color according to Siburian (2016) can increase students' interest in learning.

The next indicator is the layout that gets the very valid criteria. The validation results can be seen in Table 1 and Table 2. Schlatter & Levinson (2013) state that a consistent layout makes it easier for users to find the navigation bar and other components.

Typographic indicators in ARSaf learning media are seen in Table 1 and Table 2 get validation with very valid criteria. Typography on ARSaf learning media in terms of font size, font style, and writing color has paid attention to screen size, visually appealing style, and legibility. The choice of color type in the text contrasts with the background used.

The last indicator on media validation is imagery which gets validation results with valid and very valid criteria. The results of the validation can be seen in Table 1 and Table 2. Schunk (2012) reveals that imagery can be used to improve the quality of student learning.

Results of Material Validation on ARSaf Learning Media

Material validation on ARSaf learning media by material experts (validator V2) got very valid results. The results of material validation on ARSaf learning media by material experts are presented in Table 3.

Table 3 Results of Material Validation on ARSaf Learning Media by Material Experts

Indicator	Total score	%
Material coverage	9	75
Material accuracy	7	87.50
Updating and Contextual	11	91.67
Presentation Technique	13	81.25
Material presentation support	8	100
Presentation of learning	11	91.67
Overall score		86.76
Criteria		Very valid

The results of material validation on ARSaf learning media by biology teachers (validator V3) are included in very valid criteria. The results of material validation on ARSaf learning media by biology teachers can be seen in Table 4.

Table 4 Results of Material Validation on ARSaf Learning Media by Biology Teachers

Indicator	Total score	%
Material coverage	10	83.33
Material accuracy	8	100
Updating and Contextual	11	91.67
Presentation Technique	15	93.75
Material presentation support	8	100
Presentation of learning	12	100
Overall score		94.12
Criteria	Very valid	

Looking at Table 3 and Table 4, the material coverage indicators get validation with valid criteria, meaning that ARSaf learning media has the completeness, breadth, and depth of material that has been adjusted to core competencies (KI 3) and basic competencies. Examples of functional disorders that can occur in the nervous system are written briefly and clearly in each sub-discussion. Materials from ARSaf learning media can help students to be able to analyze the relationship between the nervous system. Plus the 3D visuals of Augmented Reality that help students understand concepts. This is in accordance with the opinion of Kiryakova, Angelova, & Yordanova (2018) that using AR in learning can help speed up and make it easier for students to explore and learn about theories and concepts.

The next indicator is the accuracy of the material, referring to Table 3 and Table 4 this indicator gets validation with very valid criteria. ARSaf learning media presents facts in accordance with the existing reality and is effective in increasing students' understanding. The writing of the definition is adjusted to the rules of the field of biology correctly so that it does not cause many interpretations for its users.

The third indicator is recency and contextuality which get validation with very valid criteria. Concrete examples presented in learning resources will increase students' motivation in learning. This is in line with the opinion of Gita, Annisa, & Nanna (2018) which states that linking daily life in teaching materials can cause students to be motivated and increase their curiosity to deepen the material being studied.

The fourth indicator is the presentation technique which can be seen in Table 3 and Table 4. This indicator is validated with very valid criteria. Schunk (2012) asserts that organized material will improve memory because the items are systematically linked to one another. The more organized presentation of information, the easier it will be to remember.

The next indicator is supporting material presentation. The complete validation results can be seen in Table 3 and Table 4. The validation results are included in the very valid criteria. It can be stated that the ARSaf learning media has met the suitability and accuracy of the illustrations with the material and the advance organizer (generator of learning motivation) at the beginning of the chapter. Schunk (2012) states that advance organizers can help students connect new material with previous learning.

The last indicator is the presentation of learning, the results of the validation can be seen in Table 3 and Table 4. Validators V2 and V3 provide validation with very valid criteria. It can be stated that ARSaf learning media can be a means of providing student-centered active involvement with a scientific approach. Interactive communication with the use of sentences arranged in the material allows it as if the author is communicating with students.

Based on the results of the validation of ARSaf learning media by media experts, material experts, and biology teachers, several responses and suggestions were obtained for improving ARSaf learning media. Validator V1 provides feedback and suggestions that in general the ARSaf learning media is good but still needs to pay attention to the proportion of the image to match the actual size. The responses and suggestions given by the V2 validator, among others, are good and can be used for data collection. Validator V3 stated that the ARSaf learning media was good and technology-based but still needed attention in typing.

Student Response

After the learning process students were given a response questionnaire on the use of ARSaf learning media. The results of the responses to the ARSaf learning media by students can be seen in Table 5.

Table 5 Results of Responses to ARSaf Learning Media by Students

Aspect	Percentage	Criteria
Theory	82.78%	Good
Language	82.29%	Good
attractiveness	84.26%	Good
User usability	82.78%	Good
Understanding	81.02%	Good
Overall score	82.85%	Good

Based on the results of responses to the ARSaf learning media by students, the ARSaf learning media received suggestions to improve the appearance of the eye structure material so that it is not cut off. The responses to the ARSaf learning media by students, among others, the ARSaf learning media in terms of quality, usefulness, appearance, and effectiveness are good. The display presented in the ARSaf learning media is very interesting. The use of ARSaf learning media is very good in increasing students' understanding of the material that has been presented, by presenting 3D objects, making students easier and clearer in understanding. Students become interested and not bored in studying the material of the nervous system because it is presented with a more attractive appearance.

The first aspect of the questionnaire is the material, the students' responses to see Table 5 are included in the good criteria. This shows that the existence of ARSaf learning media can help students find their own concepts and understand abstract concepts. The material in the ARSaf learning media is arranged in a coherent and directed manner, besides the ARSaf learning media also contains a collection of questions that can encourage students to think and test how far students' understanding of the nervous system material is.

The second aspect is the language that gets student responses based on Table 5 is included in the good criteria. It is very important to pay attention to the language aspect in learning media. All factors in learning to use language as a communication tool to achieve the desired goal (Wicaksono, 2016).

The next aspect is attractiveness which gets student responses with good criteria based on Table 5. The factors that make ARSaf learning media interesting are one of them because the display provided by ARSaf learning media is very good. The attractiveness of the ARSaf learning media causes the material in the ARSaf learning media to encourage students' curiosity and make students happy and not bored in studying the nervous system material. ARSaf learning media can increase students' desire to learn, and the presence of illustrations in each sub-material can increase motivation to learn the material.

The next aspect is user usability who gets student responses with good criteria seen from Table 5. Lacey (2018) states that by paying attention to usability, it will be seen that it is easy to use the application.

The last aspect of student responses is understanding, referring to Table 5 this aspect gets good criteria. Arsyad (2014) states that learning media will help speed up understanding and remembering the messages displayed. 3D objects from the AR feature will also make it easier for students to translate abstract concepts.

Teacher's Response

The teacher also gave responses to the use of ARSaf learning media. The results of responses to ARSaf learning media by teachers can be seen in Table 6.

Table 6 Results of Responses to ARSaf Learning Media by Teachers

Aspect	Percentage	Criteria
Theory	90%	Very good
Language	93.75%	Very good
attractiveness	87.5%	Very good
User usability	85%	Very good

Understanding	91.67%	Very good
Overall score	89.13%	Very good

The teacher's response to see Table 6 as a whole is in the very good category. Based on the results of Sural's research (2018) to prospective teachers who were asked to use AR, prospective teachers were very excited and stated that AR had great potential use in teaching and learning materials. In addition, they stated that they would like to see AR technology in their learning.

The first aspect in the questionnaire is the material, see Table 6 this aspect gets a response from the teacher with very good criteria. The existence of AR can make students explore and learn abstract theories and concepts more quickly and easily accompanied by increased aspirations and motivation to deepen their knowledge (Kiryakova et al., 2018).

The second aspect is the language that gets teacher responses based on Table 6 is included in the very good criteria. Based on the opinion of Supriyani (2016) language forms the human mind, the framework of knowledge in the form of concepts in a person is formed by language. Therefore, it is very important to pay attention to aspects of language in learning media.

The next aspect is attractiveness which gets teacher responses with very good criteria based on Table 6. The factors that make ARSaf learning media interesting are one of them because the display provided by ARSaf learning media is very good. The use of AR-based virtual objects also adds to the attractiveness of ARSaf learning media. The results of research by Ifine & Trandabat (2018) show that the use of AR can make lessons more interesting.

The next aspect is user usability which gets teacher responses with very good criteria based on Table 6. The results of good user usability responses indicate that teachers like the interface on ARSaf learning media. ARSaf learning media is easy and convenient to use and easy to learn.

The last aspect of the teacher's response is understanding, looking at Table 6 this aspect gets very good criteria. This means that using ARSaf learning media can help students improve their understanding. Puspitarini & Hanif (2019) convey that the use of learning media can clarify learning materials, so students can easily understand the material and enable students to master the learning objectives. Based on the results of research conducted by Pujiastuti & Haryadi (2020) shows that the use of AR-based learning media in learning can improve students' understanding.

Evaluation of Learning by Students

In addition to providing responses, students were also given evaluation questions after explaining the nervous system material with the help of ARSaf learning media. The results of the evaluation of learning by students can be seen in Table 7.

Table 7 Learning Evaluation Results by Students

No	Respondent	Average score	Description
1	High ability students	89.50	Good
2	Medium ability students	83.67	Good
3	Low ability students	76.50	Enough
Average		83.22	Good
The highest score		100.00	
Lowest value		75.00	
Number of students who completed KKM (≥ 70.00)		18 (Total= 18 students)	

Based on the results of the learning evaluation which can be seen in Table 7, it is known that all students reached the KKM with test questions arranged based on the C4 cognitive level (analyzing). Students' mastery shows that by using ARSaf learning media students can achieve KD 3.10, which is to analyze the relationship between the structure of the network making up organs in the coordination system (nerves, hormones, and sense organs) in relation to coordination and regulation mechanisms as well as functional disorders that can occur in the system. human coordination. The use of AR in learning has a positive effect on learning outcomes (Weng et al., 2019; Shiue et al., 2019). When compared to other learning activities, using AR-based learning media leads to better learning outcomes (Geroimenko, 2020).

Based on the implementation of the learning process, it can be seen that using ARSaf makes students more active in participating in learning, from students who only listen with the help of ARSaf, students actively respond. Augmented Reality can make students more active when learning which results can improve learning (Kiryakova et al., 2018; Jesionkowska, Wild, & Deval, 2020). Augmented Reality supports student interactivity in learning (Shiue et al., 2019; Jesionkowska et al., 2020). In the end, AR can help improve students' understanding (Aliyu & Talib, 2020; Khan et al., 2019).

CONCLUSION

The ARSaf learning media received material validation with very valid criteria by the material validator. ARSaf learning media get media validation with very valid criteria by media validators. ARSaf learning media get material validation with very valid criteria by biology teachers and get media validation with very valid criteria by biology teachers. ARSaf learning media get responses with good criteria from students. ARSaf learning media received a response with very good criteria from the teacher. The results of the learning evaluation by students of high ability students, medium ability students, and low ability students exceed the KKM (70.00). The Augmented Reality Nervous System (ARSaf) learning media that was developed is feasible to be used to improve students' understanding.

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