Development of 3D Physics Learning Media using Augmented Reality for First-year Junior High School Students

Azhar 1, Poppy Herfana 2, Muhammad Nasir 1, Dedi Irawan 1, Nur Islami 1

1 Physics Education Study Program, FKIP, Riau University, Indonesia
2 Teacher Physics Education of SMPN 15 Pekanbaru, Indonesia

azhar@lecturer.unri.ac.id

Abstract. This study aims to produce 3D physics learning media in Indonesian first-year Junior High Schools (SMP/MTs) using Augmented Reality (AR). This research development uses the ADDIE (Analysis, Design, Development, Implementation and Evaluate) model. The development stage was carried out at the Physics Education Laboratory of the FKIP University of Riau and the implementation stage was carried out on 30 first-year students of SMPN 30 Pekanbaru. The 3D learning media validation sheet instrument by using AR consists of four assessment aspects, namely; (1) design aspects, (2) pedagogical aspects, (3) content aspects, and (4) technical aspects. Validation was carried out by six validators consisting of 2 material experts, 2 media experts, and 2 physics teachers. The results of six-validator assessment provide an average for each aspect as follows; (1) the design aspect has an average of 4.43 which is categorized as very valid, (2) the pedagogical aspect has an average of 4.42 very valid categories, (3) the content aspect has an average of 4.38 very valid categories, and (4) the technical aspect has an average of 4.51 which is also categorized as very valid. Overall the average validity for the four aspects of the assessment is 4.43 very valid categories. After the 3D physics learning media was developed, it was then declared feasible by the experts, the implementation phase of 3D physics learning media or small-scale trials on students was carried out to see the students’ responses to 3D physics learning media. The student response test was carried out using a student response questionnaire containing 10 statements consisting of 6 aspects of assessment. The results of the students’ responses at the implementation stage showed that 67% of the 30 students thought that 3D learning media using AR was very good for use in the learning process. Then 33% of 30 students think that 3D learning media using AR is good for use in the learning process. Certainly the 3D physics learning media product is suitable for use in the physics learning process in Junior High Schools.

1. Introduction
Education is a very important need for everyone, society and the state in improving the quality of human resources. Efforts to improve the quality of Indonesian human resources through the education sector have encountered many problems, some of which are the unequal distribution of education in Indonesia. Efforts to increase it can be realized in various aspects. One of them is in improving the quality of schools through the improvement and improvement of the learning process in the classroom. The learning process in this class is closely related to the interaction between students and educators/teachers in a learning environment. The interaction that occurs between teachers and...
students is very important so that the teaching and learning process delivered by the teacher can be accepted, understood and digested properly by students. This is in line with the opinion of Azhar [7] that in the implementation of physics learning, it can be said that the determinants of the success of multidimensional physics learning. This means that many factors, in addition to the teacher factor; the infrastructure factor is a sub-component that cannot be abandoned, including laboratory facilities. The limitations of laboratory facilities can be overcome at least by using learning media that are relevant to the material being taught. [1][2][3]

Teaching and learning interactions in the classroom cannot be separated from the influence of the media used by the teacher in delivering teaching materials. The use of learning media in the teaching and learning process can generate new desires and interests, generate motivation and stimulation of learning activities and even have a psychological effect on students. Media by utilizing information and communication technology in the era of the industrial revolution 4.0 is a promising factor in the success of a learning process. Entering the era of information and communication technology is now very felt the need and importance for the improvement and improvement of the quality of learning. It is hoped that with the information and communication technology, the learning mindset can change from being teacher centered to student centered [4][5].

The technological result of the industrial revolution 4.0 which is growing rapidly today is a smartphone/smartphone. The existence of technology, especially smartphones, which are now growing, must be addressed wisely. The benefits that exist from the existence of these technologies must continue to be explored for the sake of better human survival. The phenomenon of the high number of smartphone users is certainly a challenge and opportunity in the world of education. One of the benefits that can be taken from the existence of this technology is to use it as an effective, creative and educational medium. So that educational learning application media can continue to be developed, one of which is Augmented Reality (AR) technology [6][7]. The advantage of this Augmented Reality method is an attractive visual appearance, because it can display 3D objects as if they exist in a real environment. The Augmented Reality method also has advantages from the interactive side because it uses markers to display certain 3D objects that are directed to the webcam. In addition, the application of the concept to be used is expected to increase students' reasoning and imagination power [8].

Augmented Reality technology that is used as a learning media is expected to increase students' interest, motivation, and learning outcomes. Azhar suggests that Augmented reality has the potential to attract, inspire, and motivate students, because its use can explore and control from different perspectives that were not previously considered in the world of education. Based on research Azhar that by using Augmented Reality-based learning media there is a significant influence on student learning outcomes [9]. The average value of student learning outcomes using Augmented Reality-based learning media is higher than the average value of student learning outcomes without using Augmented Reality-based learning media. Learning media that can be developed is learning media using Augmented Reality technology on the Android platform. The development of learning media using Augmented Reality technology can be one of the right solutions to increase effectiveness in learning. This technology allows abstract things that are not visible, can be simulated in three dimensions or two dimensions in real time and seem real. It is expected that the use of Augmented Reality technology can improve students' learning achievement in taking Physics Science subjects [10][7].

2. Methodology
The method used in this study is research and development. Neneng et al (2020) states that the research and development is a research method used to produce certain products and test the effectiveness of these products. The design model used to design the 3D Physics learning media based on Augmented Reality (AR) is the ADDIE (Analyse, Design, Development, Implementation and Evaluation) model. The selection of the ADDIE model is very suitable for the type of research and development that produces products in the form of 3D Physics learning media [11][12].
This is support by Tegeh et al (2014) stated that this model has five stages as given in Figure 1 as follows;

A. Analisis
The collection of data or information is carried out by means of observation and interviews with physics subject teachers for first year students of SMPN 30 Pekanbaru which is related to 3 aspects of analysis, namely; (1) Needs analysis, (2) Characteristics analysis of students, and (3) Analysis of learning materials. Seconly is design stage, a design related to research is carried out based on the things obtained from the analysis stage. The activities carried out at the design stage include: (1) designing 3D Physics learning media using AR, (2) designing learning devices consisting of syllabus, lesson plans, question instruments, and (3) designing learning media validation instruments. 3D physics and student response questionnaires. [13]

B. Design
At the design stage of the instrument validation 3D physics learning media, it is necessary to create an instrument grid as a guide or guide in formulating the instrument statement items that are prepared to validate the 3D physics learning media which consists of 35 questions list in the validation sheet which describes four scoring aspects. However the student responses are recorded based on the following Tabel.

| No | Scoring aspects     | Item numbers | Question                                                   |
|----|---------------------|--------------|------------------------------------------------------------|
| 1  | User Manual         | 1            | User Manual was clear                                      |
| 2  | Content             | 2            | Content was systematically described                       |
| 3  | Language            | 3            | Content uses good language presentation                   |
|    |                     | 4            | Content are easy to be understood                         |
| 4  | Figure              | 5            | Figure was clear                                          |
|    |                     | 6            | 3D design was clear                                       |
|    |                     | 7            | 3D design was interested                                  |
| 5  | Easy used           | 8            | Media are easy to be used                                 |
| 6  | Learning motivation | 9            | The use of learning media improve students motivation     |
|    |                     | 10           | Students are very happy learning by using this media      |
C. Development.
The development stage includes the activities of making 3D learning media products on the material of the Solar System using Augmented Reality and learning devices. The manufacture of media products is adjusted to the initial analysis and design that has been determined. At this stage consists of: (1) The manufacture of 3D media begins with the creation of 3D solar system objects and markers. Making learning tools consists of making syllabus, lesson plans, and posttest pretest questions. (2) At this development stage, a team of validators will also form a validator team that will validate 3D physics learning media, the validator consists of 6 validators with details of 4 validators (Postgraduate Lecturer for Physics Education, University of Riau, 2 media experts and 2 material experts whose assessment aspects are design, pedagogic, content and technical aspects, while 2 more validators are from Physics teachers. After the media was developed, the researchers measured the results of the feasibility or validity assessment of the 3D physics learning media in terms of design, pedagogy, content and technical aspects. The assessment of the validation sheet is in the form of a Likert scale with a score of 1 to 5. Next, look for the average assessment of all validators who validate 3D physics learning media. The average validator is used as a criterion in the categorization of decision making whether or not the media that has been developed is valid. [13]

D. Implementation
After the 3D physics learning media is made and declared feasible by the experts, then the 3D physics learning media implementation stages or small-scale trials are carried out to see the students' responses. The student response test was conducted on 30 students at SMP Negeri 30 Pekanbaru. The student response test using a student response questionnaire contains 10 statements consisting of 6 aspects of assessment as shown in Table 2. The type of scale used is the Likert scale with a score of 1 to 4 [13].

E. Evaluation
At this stage, the researcher made the final revision of the 3D physics learning media which was developed based on the input obtained from the student response questionnaire at the implementation stage. This is so that the 3D physics learning media developed is truly appropriate and can be used by a wider school [13].

3. Results and Discussion
The result of this research is the product of 3D physics learning media on the material of the Solar System using Augmented Reality (AR). Validation of 3D learning media using AR with a validation sheet instrument consisting of 4 assessment aspects consisting of; (1) design aspects, (2) pedagogical aspects, (3) content aspects, and (4) technical aspects. Validation is carried out by 6 validators. 3D physics learning media using AR which was developed on the basic competence of 3.11. The Solar System and consists of three confluences. The following are the overall validation results on 3D Physics learning media can be seen in Table 2.

| No | Aspect      | Score | Validity   |
|----|-------------|-------|------------|
| 1  | Design      | 4.43  | Very Valid |
| 2  | Pedagogic   | 4.42  | Very Valid |
| 3  | Content     | 4.38  | Very Valid |
| 4  | Technique   | 4.51  | Very Valid |
|    | Avarage Validity Score | 4.43  | Very Valid |
It can be seen clearly in Table 2 that the validity of 3D physics learning media as a whole has an average value of 6 validators is 4.43 with a very valid / very high category. This is inseparable from the suggestions for improvement for each aspect of the assessment. The suggestions and improvements provided by the validator for each aspect of the assessment are described as follows:

a. **Design Aspect**

In the design aspect, it consists of 10 assessment items (points 1 to 10) the average validation score is 4.43 with a very high category. From the results of the analysis for the validity of the design aspect that the highest score is 5 contained in item 1 with a very valid category, but getting suggestions by the validator to make instructions for using AR media in each marker because not all markers have the same instructions for use. The next improvement is in the component of the assessment item number 6 related to the images used to help the understanding of students who get a score of 4.50 with a very valid category. However, there are suggestions for improvement from the validator regarding student understanding. Suggestions for improvement for the 3D animation displayed on the moon marker around the earth and the earth around the sun at the confluence of two. Previously, the process of moving the moon around the earth and the earth around the sun was too fast, so it was recommended to make improvements by slowing down the movement a little. The assessment component number 7 related to the images used to help learning also get improvements. This component gets a score of 4.33 with a very valid category.

However, there are also suggestions for improvement from the validator, namely at the first meeting regarding the introduction of the solar system. Previously, the animation introduction of the solar system was only the planets that revolved around the sun and their orbits were suggested to make names of the members of the solar system above the planets so that students would know which planets are Earth and which are Saturn.

b. **Pedagogical Aspect**

The pedagogical aspect consists of 10 statement items with item numbers 11 to 20. The assessment of the pedagogical aspect of 3D learning media using AR gets some improvements. The first improvement in the assessment component of item number 11 related to teaching competence is written clearly. The average score for this assessment component is 4.67 with a very valid category, but the validator gets suggestions for making basic competencies, indicators, and learning objectives in order to direct students to find out what they will learn. The clarity of indicators and learning objectives will help students to learn more directed. This is in accordance with the opinion (Nasution, 2008) that one of the advantages of learning that is presented clearly and specifically is that student learning becomes focused. Each component of the assessment on the pedagogical aspect as a whole gets a score in the very valid category with an average of 4.42. 3D learning media using AR developed in accordance with the material. Learning materials in the media have the correct concept equipped with 3D AR animation to help the learning process. 3d animation in learning media is also clear and interesting to use.

c. **Aspects of Learning**

Content in the aspect of learning content, it consists of 9 statement items with statement item numbers (21 to 29) on the validation sheet. From the results of the analysis for the validity of the content aspect, it is found that the highest score is 4.83 on item 24. Meanwhile, there are 3 lowest items with a score of 4.17, namely on items 23, 26 and 27. Even so, this item is still valid. The number of items that get 4.17 points proves that there are still many things that can be developed in this learning media. Both in terms of design or delivery of material to users. The achievement of the learning content aspect is able to make learning media easy to describe the substance of facts, concepts, principles and theories contained in the competency standards (SK) and basic competencies (KD), and can make students to concretize abstract material. (Depdiknas, 2008) explains that a good product or media is a product that generally meets the quality aspects of the objectives and content/feasibility of the content and presentation on the developed media.
d. Technical Aspect

On the technical aspect, it consists of 6 items of assessment component (item number 30 to item number 35. Based on the analysis on the technical aspect, the highest score is 4.87. It is found on item 32. While the lowest score is 4.00, namely the statement item number 16 and 34. These items are "The information conveyed is easy to understand" and "Users are easy to find the required information." After the correction, the final score given to this item is still greater than the minimum data. So this item is still valid. Based on Table 2, the overall learning media that has been developed obtained an average final validity value of 4.43, so AR physics learning media on the solar system material for junior high schools is declared to be valid in the very valid category. The media was concluded to be valid because the media that had been made met all aspects of the validity assessment criteria. Based on the total value of the validation, the media is feasible to use for students. This opinion is supported by (Sinurat, Syahputra, & Rajagukguk, 2015) who concluded that learning media are of good quality and appropriate to use if they meet the standards of validity assessed by expert validators [14-17]. Furthermore, at the implementation stage, trials were carried out to determine the response of students to the learning media that had been developed. The response assessment was carried out using a questionnaire. Response questionnaires to learning media were given to 30 students. The results of the students' responses to 3D learning media using AR in more detail can be seen in Figure 2.

Figure 2. Student response percent age

Figure 2 shows that 67% of 30 students think that 3D learning media using AR is very good for use in the learning process. Then 33% of 30 students think that 3D learning media using AR is good for use in the learning process because it is interesting. The following is the final view of 3D learning media on the Solar System material using AR which was developed as shown in Table 3 [18-19]. As the general it can be seen that the media can increase the spirit and motivation of the student in learning [20-21]. The other researchers also show that the use of media results the student wish in the learning especially in the learning of Physics [22-24].
Table 3. Solar system model

| Object Name | Model 2D | Model 3D |
|-------------|----------|----------|
| Sun         | ![Model 2D](sun_2d.png) | ![Model 3D](sun_3d.png) |
| Mercury     | ![Model 2D](mercury_2d.png) | ![Model 3D](mercury_3d.png) |
| Venus       | ![Model 2D](venus_2d.png) | ![Model 3D](venus_3d.png) |
| Earth       | ![Model 2D](earth_2d.png) | ![Model 3D](earth_3d.png) |
| Asteroid    | ![Model 2D](asteroid_2d.png) | ![Model 3D](asteroid_3d.png) |

4. Conclusion
Based on the research that has been done on the development of 3D physics learning media on the Solar System material using AR for SMP/MTs students, it can be concluded that 3D physics learning media is suitable for use in physics learning at the junior high school level.

Acknowledgement
We would like to thank LPPM, Universitas Riau for a great support in this research.
References

[1] Azhar A, A S M, Aris D, Susilawati S and S A 2021 Digital Calorimeter for Measuring the Specific Heat of Liquids. Digital Calorimeter for Measuring the Specific Heat of Liquids (IoP, Journal of Physics conference series)

[2] Azhar A, M F L, Aris D, Susilawati S and S A 2021 DIGITAL-BASED THERMOELECTRIC GENERATOR. DIGITAL-BASED THERMOELECTRIC GENERATOR (Pekanbaru: IOP, Journal of Physics Conference Series)

[3] Azhar A, Fuadi H, Doyan A, Susilawati S and Ayub S 2021 Innovation of simple binoculars as a teaching aid for optical practicum at school. J. Phys. Conf. Ser.

[4] Azhar A, Herfana P, Nasir M, Irawan D and Islami N 2021 Development of 3D Physics Learning Media using Augmented Reality for First-year Junior High School Students. Development of 3D Physics Learning Media using Augmented Reality for First-year Junior High School Students (Pekanbaru: IOP, Journal of Physics Conference Series)

[5] Irawan D, Saktioto T, Iwamoto, Minarni, Juandi and Ali J 2015 An optimum design of fused silica directional fiber coupler. Optik (Stuttg).

[6] Julianti N, Azhar A and Nasir M 2020 IMPLEMENTATION OF PEER INSTRUCTION INTEGRATED GUIDED INQUIRY LEARNING TO INCREASE ARGUMENTATION SKILL OF SCIENCE JUNIOR HIGH SCHOOL STUDENTS. J. Geliga Sains J. Pendidik.

[7] Azhar A 2008 PENDIDIKAN FISIKA DAN KETERKAITANNYA DENGAN LABORATORIUM. J. Geliga Sains

[8] Irawan D, Saktioto, Ali J, Fadhali M and Erwin 2012 Estimation of coupling parameters for auto-motorized fabrication of fused fiber coupler. Microw. Opt. Technol. Lett. 54.

[9] Irawan D, Saktioto and Ali J 2010 Linear and triangle order of NX3 optical directional couplers: Variation coupling coefficient. Proceedings of SPIE - The International Society for Optical Engineering vol 7781

[10] Susanti N, Yennita Y and Azhar A 2020 Development of Contextual Based Electronic Global Warming Modules Using Flipbook Applications as Physics Learning Media in High Schools. J. Educ. Sci.

[11] Tegeh I made and Kirna I M 2013 PENGEMBANGAN BAHAN AJAR METODE PENELITIAN PENDIDIKAN DENGAN ADDIE MODEL. J. IKA

[12] Sugiyono 2012 Metode Penelitian Kuantitatif, Kualitatif dan R & D Bandung:Alfabeta. Metod. Penelit. Kuantitatif, Kualitatif dan R D Bandung:Alfabeta.

[13] Irawan D, Fakhrudin Z, Mustakim, Vebrianto R and Saktioto 2020 Nanostructure Fusion Region of Single Mode Fiber Coupler. J. Phys. Conf. Ser. 1655

[14] Sinurat M, Syahputra E and Rajagukguk W 2015 PENGEMBANGAN MEDIA PEMBELAJARAN MATEMATIKA BERBANTUAN PROGRAM FLASH UNTUK MENINGKATKAN KEMAMPUAN MATEMATIK SISWA SMP TABULARASA. 12

[15] Irawan D, Saktioto, Ali J and Defrianto 2011 Breakdown voltage effect on coupling ratio fusion fiber coupling. Physics Procedia 19.

[16] Pfalzner S, Davies M B, Gounelle M, Johansen A, Münker C, Lacerda P, Zwart S P, Testi L, Trieloff M and Veras D 2015 The formation of the solar system. Phys. Scr. 90 68001

[17] Irawan D, Saktioto, Ali J and Fadhali M 2013 Birefringence analysis of directional fiber coupler induced by fusion and coupling parameters. Optik (Stuttg) 124

[18] Irawan D and Saktioto 2019 Quantum Interpretation of Light Normalization at the Coupling Region Single Mode Fiber Coupling. J. Phys. Conf. Ser. 1351

[19] Irawan D, Saktioto T, Ali J and Yupapin P 2015 Design of Mach-Zehnder interferometer and ring resonator for biochemical sensing. Photonic Sensors 5 12–8

[20] Islami A P 2020 Environmental Education in Grammar Learning Process for Junior High School students by using Multifunctional English Learning Media (MELDe). Journal of Physics: Conference Series 1655 012062
[21] Islami A P, Novitri N, Syarfi M, Masyhur M, and Afrianto A 2019 Increasing the Environment Feel in Learning through the Double S Application Journal of Physics: Conference Series 1351 012111

[22] Pramudya C T, Islami N, and Rahmad M 2020 Development of Static and Kinetic Friction Coefficient Experiment Device Based on Arduino Uno Journal of Physics: Conference Series 1655 012049

[23] Sartika M, Islami N, and Rahmad M 2020 Development of Mechanical Energy Trial Devices in Rotation Motion Based Arduino Uno Microcontroller Journal of Physics: Conference Series 1655 012073

[24] Ali R H, Rahmad M, Islami N, and Syafii M 2020 Design of Straight Motion Experiment using Electric Motor Ticker Timer Based on Microcontroller Journal of Physics: Conference Series 1655 012004