The introduction of solar system using augmented reality technology

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Abstract. Current technological developments have had a huge impact on education, one of which is Augmented Reality technology. In this study, innovative and alternative media learning was made to understand the types of planets in the solar system. The solar system is one of the materials in natural science subjects in elementary schools. This media learning combines picture cards and virtual reality. Markers found on the card will be captured by the camera of the mobile device, processed and animated pieces will appear on the mobile screen in real-time. By using the concept of combining the real world, real images on the card and virtual, the application can stimulate imagination and a sense of desire and motivation to learn more and more. Planet estimates are made using the 3D Blender application, and the Augmented Reader process is created using Unity and Vuforia Software Development Kit. Based on the results of beta testing using the Likert scale, 86% of the 30 respondents stated that the application developed was effective as a medium for the introduction of the planet.

1. Introduction
Information technology and telecommunications are currently experiencing rapid progress. Likewise the current education system has progressed very rapidly [1]. This is indicated by the many ways used in the teaching and learning process for delivering material to students, with the hope that the material delivered can be easily understood by students [2]. Lately in the teaching and learning process there have been many who use information technology and telecommunications as one of the innovations in education, this is expected to advance the quality of education in line with technological advances [3,4].

Learning media always follows the development of existing technologies, ranging from print technology, audio-visual, computers to the combined technology of printing technology with computers [5]. At present learning media combined results of printing and computer technology can be realized with the technology of Augmented Reality (AR) [6]. AR technology or can be referred to as Increased Reality is the integration of digital elements that are added to the real world in real time (real-world data) and follow the environmental conditions that exist in the real world and applied to mobile devices [7]. The use of AR today has spread to all aspects of life and will experience significant developments in the future. Augmented Reality (AR) technology is a common thing today, widely used in various fields such as in the fields of entertainment, the field of advertising, health, military to the field of learning (education) [8].

The learning curriculum of Class X students in natural science (IPA) subjects, especially solar system material, most science teachers complained about the lack of response captured by students in the
material because the teacher had difficulty exposing the shape of the solar system. Although in the book there are already forms of the solar system, not all students have the textbook. Therefore multimedia learning media is very appropriate to use, so that teachers are expected to provide more detailed and communicative explanations [9,10].

The use of Augmented Reality Technology in the field of education has been widely carried out, including to design a concept of extension of information from printed promotional media to promotional media in the form of videos using AR technology. The system built can recognize markers and can display videos that load via URL [11]. The animation was built using Blender and the process of building Augmented Reality using Qualcomm Augmented Reality (QCAR) which was displayed using an Android smartphone, this application was able to display objects of human respiratory organs namely Nose, Larynx, Bronchus, Trachea, Lungs and the mechanism of breathing [12]. These results can be alternative multimedia learning solutions. Other research is about the application of augmented reality technology to the digestive system learning media using the Android platform [13,14].

The purpose of this study is to build a learning media using augmented reality technology to assist the process of delivering material about the solar system.

2. Methodology
This study uses Research and Development (R&D) methods by focusing on aspects of development. This is following the research that seeks to develop and develop a learning media for the solar system for Class X that can support learning activities and facilitate teachers in teaching material. The R&D method which includes Analysis, Designing, Development (Implementation), Implementation (Implementation), and Evaluation (Evaluation) or better known as ADDIE. The following is a chart of the development model used in research and development of learning media in the solar system.

![Figure ADDIE development phase.](image)

2.1. Information analysis and collection phase
In developing learning media for the solar system for Class X using Android-based Augmented Reality technology requires preliminary research in the form of performance analysis and needs analysis to find out whether the problems that occur require solutions in the form of learning media development and what is needed in developing the learning media. In analysing performance and needs, at this stage of research using the method of observation and interviews.

2.2. Planning phase
The AR Solar System Application as a learning media for the solar system with an Android-based Augmented Reality feature displays 3D objects of planetary types in the solar system. To find out whether this media has fulfilled the criteria, namely validity, practicality, and effectiveness, several evaluations were carried out. The feasibility test is conducted to find out whether this media is feasible to be tested on students through formative evaluation or due diligence conducted by media experts and material experts, if it has not been declared feasible then it must be revised. To find out the practicality of the media can be seen through easy-to-use aspects and instructional flexibility on the feasibility test questionnaire to experts and test the effectiveness of students. After being declared feasible then to find out whether this media is effectively carried out pre-test and post-test to find out whether there is an
increase in students' understanding of the material after using the media and student responses questionnaire conducted to determine students' responses to the media.

2.3. Product design phase
The procedure for developing the AR Solar System application as a learning media for planets in the solar system follows the stages in the ADDIE development model. Here is a description of the five ADDIE stages adapted to this study.

2.3.1. Analysis. At this stage a performance analysis is carried out to find out whether the problem requires a solution in the form of developing learning media and needs analysis to find out what needs are needed in developing learning media.

2.3.2. Design. At this stage, storyboards, navigation structures, application pageviews and evaluation tools are designed.

2.3.3. Development. At this stage, we are making and collecting materials for applications, like markers, buttons, videos and other materials.

2.3.4. Implementation. At this stage, the application of the interface design results in the system built. Then the coding stage or the function of some of the commands in the form of program code so that the learning media can running by its functions.

2.3.5. Evaluation. At this stage the Functional Test (Alpha Testing) uses a black box and also Beta Testing uses questionnaires on students' responses with the score calculation technique using the Likert scale.

3. Result and discussion

3.1. Result
The results of this study are a learning media for the solar system for Class X using Android-based Augmented Reality technology called the AR Solar System application. The following is one-page view on the AR Solar System application:

![AR Solar System](image)

Figure 2. Main page menu.

3.2. Marker design
Markers are a very important part. Marker design should not be done carelessly, there are rules that must be met in designing a marker. These rules are:
• In this study markers must be black to make it easier in the process of detecting markers and rendering objects.
• The marker used must be rectangular.
• The size of the marker will affect the object to be displayed, the greater the size of the marker, the further the distance needed to render the object.
• The thickness of the marker is also very important in making a marker. The thickness of the marker is recommended at least 25% of the length of the marker edge.

The marker used in this study is described in Figure 3:

![Marker](image)

**Figure 3.** Marker.

### 3.3. Marker detection
After the markers are made, the next step is marker detection. Marker detection is the stage where the marker will be identified by the webcam as a target for the placement of objects to be rendered. One example of a marker that has been detected is described in Figure 4:

![Marker detection](image)

**Figure 4.** Marker detection.

### 3.4. Feasibility test by experts
The AR Solar System application that has been developed has been tested for its feasibility using Alpha testing using Black Box Testing. The test results are presented in Table 1.

| Input       | Expected output | Test Result |
|-------------|-----------------|-------------|
|             |                 |             |

**Table 1.** Applications testing with Blackbox.
3.5. Student feedback questionnaire results

Questionnaire of student responses filled by 30 students of class X Mipa 1 after using the AR Solar System application. Likert scale is used to measure the perception of a person or group of people about social phenomena [15] using formulas:

\[ Y = \frac{X}{\text{Ideal Score}} \times 100\% \]

Information:
- \( X \): The number of frequencies multiplied by the value of the answer category (N x R)
- \( N \): The value of each answer
- \( R \): Frequency
- \( \text{Score Ideal} \): The highest value is multiplied by the number of samples (5 x 10 = 50)
- \( Y \): The percentage value sought

Beta test results on the AR Solar System application are presented in table 2.

| Instrument | Percentage of Answers |
|------------|-----------------------|
| Easy to use application | 82,5% |
| The instructions in the application are clear and easy to understand | 80% |
| The application runs smoothly | 81,6% |
| Fun application to use | 85,8% |
| The application displays output according to navigation | 81,6% |
| Attractive and communicative UI design application | 90% |
| Media on the application (video, animation, 3D) is interesting | 85,8% |
| The application helps to learn about Solar Systems | 87,5% |
| The application motivates learning Solar Systems | 89,1% |

Average Percentage 86%

Based on student responses, the results show that each aspect has very good information with an average percentage of 86%.
3.6. Discussion

Development of learning systems for the solar system for class X SMA with Android-based Augmented Reality features packaged in the form of .apk which is ready to be installed in a Smartphone with the Android operating system as well as the specified minimum requirements. This learning media is called the AR Solar System application which contains the material of the solar system which includes the theoretical material of the structure, the structure of the solar system, and the planets in the solar system. This study took a case study at SMAN 11 Garut.

In developing this product there are supporting factors and inhibiting factors, supporting factors include: (1) Number of class X Android smartphone users as well as the ease of use of Android smartphones, (2) Second Class X Geography Teachers use Android smartphones, (3) High student enthusiasm using learning media, (4) Schools that are enthusiastic and willing to provide input in developing the AR Solar System application. While the inhibiting factors are: (1) Not all students of class X use Android smartphones and (2) AR shirts provided as markers do not meet the needs of all students so they must be printed on paper as well.

As a result of product development, the application of the AR Solar System has advantages and disadvantages. Its advantages include: (1) There is an Augmented Reality feature to display 3D objects of the digestive organs and videos of how the digestive system works which can increase understanding and attract students to study the human digestive system, in addition there is an explanation of organ information, digestive enzymes, and related diseases with the digestive system, (2) the AR Solar System application can be used anywhere, (3) the delivery of interesting packaged material with cartoon images and background music to attract students, (4) the AR Solar System application is easy to install and use, and (5) With the AR Solar System application students can learn independently.

4. Conclusion

Based on the results of the research and discussion that have been conducted, it can be concluded that AR technology is a technology that is beneficial in the teaching and learning process. With the use of AR technology, it is expected to help users both teachers and students to interact more real and interactive with virtual objects. The use of AR Solar System Application can be used as one of the effective and interesting learning media, this is indicated by the results of testing beta by 86% using a Likert scale which means that the media can replace the previous learning media. For the future the system can develop so that it can be used not only for Android but also for other mobile operating systems as well.

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References

[1] Blackwell C K, Lauricella A R and Wartella E 2014 Factors influencing digital technology use in early childhood education Comput. Educ. 77 82–90
[2] Domingo M G and Garganté A B 2016 Exploring the use of educational technology in primary education: Teachers’ perception of mobile technology learning impacts and applications’ use in the classroom Comput. Human Behav. 56 21–28
[3] Chauhan S 2017 A meta-analysis of the impact of technology on learning effectiveness of elementary students Comput. Educ. 105 14–30
[4] Gunawan A 2016 Pemanfaatan Teknologi Informasi dan Komunikasi Melalui Penggunaan Media Pendidikan dalam Pembelajaran IPS SD Pedagog. J. Penelit. Pendidik. 3
[5] Martin S, Diaz G, Sancristobal E, Gil R, Castro M and Peire J 2011 New technology trends in education: Seven years of forecasts and convergence Comput. Educ. 57 1893–1906
[6] Martin-Gutiérrez J, Fabiani P, Benesova W, Meneses M D and Mora C E 2015 Augmented reality to promote collaborative and autonomous learning in higher education Comput. Human Behav.
[7] Nincarean D, Alia M B, Halim N D A and Rahman M H A 2013 Mobile Augmented Reality: The Potential for Education Procedia - Soc. Behav. Sci. 103 657–664
[8] Saidin N F, Dayana N, Halim A and Yahaya N 2015 A Review of Research on Augmented Reality in Education: Advantages and Applications Int. Educ. Stud. 8
[9] Nugraha A P and Tresnawati D 2017 Rancang Bangun Game Edukasi Sistem Tata Surya J. Algoritm. 14 148
[10] Chen P, Liu X, Cheng W and Huang R 2017 A review of using Augmented Reality in Education from 2011 to 2016 (Springer, Singapore) 13–8
[11] Kato H and Billinghurst M Marker tracking and HMD calibration for a video-based augmented reality conferencing system Proceedings 2nd IEEE and ACM International Workshop on Augmented Reality (IWAR’99) (IEEE Comput. Soc) 85–94
[12] Perdana M Y, Fitrisia Y and Putra Y E 2012 Aplikasi Augmented Reality Pembelajaran Organ Pernapasan Manusia pada Smartphone Android J. Aksara Komput. Terap. 1
[13] Zulham Adami F and Budihartanti C 2016 Penerapan Teknologi Augmented Reality Pada Media Pembelajaran Sistem Pencernaan Berbasis Android J. Tek. Komput. AMIK BSI II
[14] Juannita and Adhi B P 2017 Pengembangan Media Pembelajaran Sistem Pencernaan Manusia Untuk Kelas 8 SMP Dengan Fitur Augmented Reality Berbasis Android (StudiKasus : SMPN 7 Depok) J. Pinter 1
[15] Budiaji W 2013 Skala Pengukuran dan Jumlah Respon Skala Likert (The Measurement Scale and The Number of Responses in Likert Scale) J. Ilmu Pertan. dan Perikan. Desember 2 127–133