



Developing Augmented Reality-based Learning Media to Improve Student Visual Spatial Intelligence

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Abstrak

Artikel ini menggambarkan upaya pengembangan media pembelajaran berbasis Augmented Reality (AR) untuk meningkatkan kecerdasan spasial visual siswa. Jenis kemampuan ini penting bagi siswa untuk memahami subjek atau topik yang berkaitan dengan konsep ruang, karena untuk sepenuhnya memahami gambar, siswa harus membayangkan bentuk dan ruang dari objek tersebut. Kurangnya media pembelajaran di banyak sekolah menyebabkan kurangnya pemahaman siswa tentang topik tersebut. Berdasarkan masalah di atas, penelitian ini menggunakan pendekatan Research & Development (R & D) untuk mengembangkan media pembelajaran berbasis AR untuk memfasilitasi siswa kelas 6 belajar tata surya secara lebih visual. Hasil post-test telah menunjukkan bahwa terdapat peningkatan kemampuan spasial visual siswa, terutama pada topik tata surya. Jadi, dapat disimpulkan bahwa media pembelajaran berbasis AR memiliki potensi besar untuk memfasilitasi siswa mempelajari topik-topik yang berkaitan dengan ruang dan sejenisnya.

Abstract

This article illustrates an effort to create a learning media based on Augmented Reality (AR) to improve student visual spatial intelligence. This type of intelligence is important for student to understand such subjects or topics like spaces, because to completely understand the image student should imagine the object's shape and space. The lack of learning media in many schools caused the lack of student understanding toward the topic. According to the problem above, this research employing Research & Development (R & D) approach to develop AR-based learning media to facilitate 6th grade student to learn solar system more visually. The post-test has shown that there is an increased number of student visual spatial intelligence, especially on solar system topic. So, it can be concluded that AR-based learning media has huge potential to facilitate student to learn such topics related to space and the like.

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INTRODUCTION

The “Making Indonesia 4.0” program reflects the country’s determination in adapting to various major changes in the fourth Industrial Revolution era. In addition, this program is an embodiment of the state’s obligation to prepare millennial generation into a competitive and productive workforce to face this industrial era. President Jokowi has instructed all elements or institutions to respond to the Industrial Revolution 4.0 era, including the education field. Data from the Indonesian Internet Service Providers Association (AJPII) states that the most active internet users are aged 15 to 19 years, the second highest are aged 20 to 24 years. However, 90% of internet use is only for social media (“2018, Penggunaan Internet Indonesia Paling Banyak di Usia 15-19 Tahun,” 2019).

Schools have an important role to educate young children to be able to use technology positively. According to Government Regulation No. 19 of 2005 concerning National Education Standards Chapter IV article 19 paragraph 1, “the learning process in the education unit is carried out actively, creatively, and pleasantly, motivating students to participate actively, as well as providing sufficient space for initiative, creativity, and independence in accordance with talents, interests, and physical and psychological development of students”.

Responding to the Industrial Revolution 4.0 era, active, creative, and fun learning must be applicable in the classroom (i.e. Mintasih, 2016). The active, innovative, creative, effective, and fun (Paikem) learning process supported by good media should make students easier to understand the lesson (i.e. Siregar, Wardani, & Hatika, 2017). However, some researches still indicate some problems in creating a pleasant learning atmosphere and in understanding the material, not to mention in understanding material that requires visual understanding (ie Hariastuti, Anita, & Setiawan, 2018; Syafrudin, Edwita, & Sarkadi, 2018; Wahyudi, Widiyanti, & Nurhadi, 2019; Wahyuni, 2012).

The researches show the need for visual understanding, including in studying space objects that tend to have three-dimensional features. In this case, one must indeed have the spatial ability to visualize images in their minds. In a more specific context, the media used by 6th grade elementary school students are still conventional. Therefore, students tend to have difficulty in visualizing solar system exploration lessons. In as much as in the three-dimensional

material there are many materials of the solar system that cannot be realized in their true form, it needs to be clearly visualized. Three-dimensional visualization in the form of images requires students’ imagination and abstraction in learning three dimensions about the solar system planets.

Hence, media are needed to support the implementation of scientific learning process with innovative learning media. Augmented Reality-based educational media is a new media in education field. This media offers 3D facilities that can combine the virtual world with the real world so that students can see objects from various angles. Scientific learning using AR in the learning space themes is expected to be able to help students visualize the material of various planets in the solar system complete with its three-dimensional visualization. Therefore, it is hoped that students’ visual spatial abilities can improve.

Some previous researches results have revealed some results from the use of Augmented Reality (AR). Research by Estapa and Nadolny (2015) from Lova State University explains that Augmented Reality makes it easy for students to accept mathematics and increase motivation. Another similar study conducted by Kaufmann & Dünser (2007) showed that AR can improve students’ spatial abilities in learning geometry. Research by Cheng (2017) states that AR ease children to understand and be more motivated in the learning process between parents and children. According to Bacca et al. (2014) AR is a trend in the education area. AR makes explanations more effective when applied in demonstrations in the laboratory. Various studies on the use of AR technology encourage researchers to examine more deeply the use of AR for basic education.

Grounded from these problems and phenomena, this article describes the development of AR-based learning media and its potential in improving students’ visual spatial abilities. This research is quite urgent because it plays a significant role in encouraging innovation in learning media for the advancement of education as a form of response to the Industrial 4.0 era, especially in improving students’ visual spatial abilities.

METHOD

This research applied the Borg & Gall (1989) Research and Development (R&D) met-

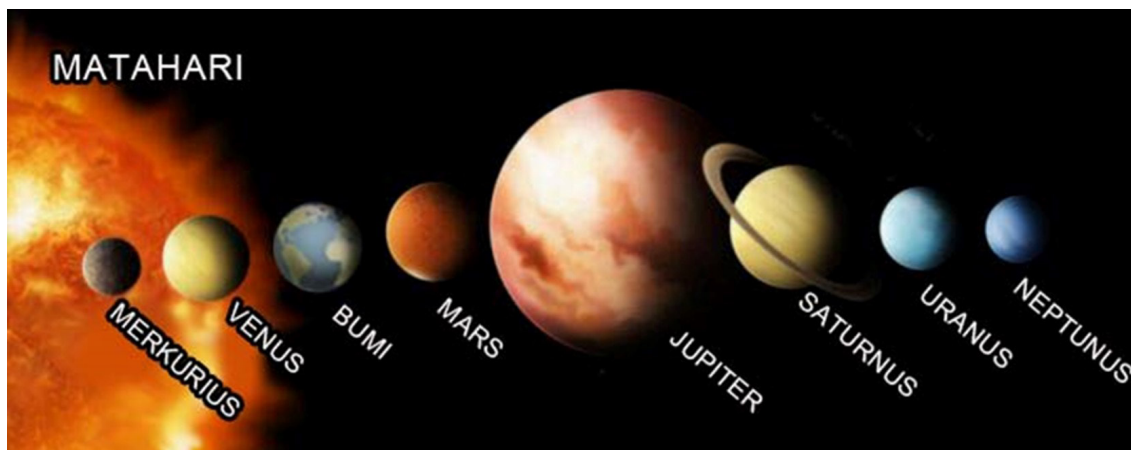


Figure 1 The marker media

hod. This design comprised nine stages, namely (1) research and information collection; (2) planning; (3) product development; (4) product validation; (5) revisions to major products; (6) main trials based on preliminary trial results; (7) revision of operational products; (8) field trials; (9) revision of the final product; and (10) dissemination and implementation. The product development itself used the waterfall model including the stages of requirements, design, coding, and maintenance testing.

The study was conducted in April to July 2019 at SDN Tegal Panggung, Danurejan District, Yogyakarta City with the sample of 6th grade students. The independent variable in this study was AR-based solar system media and the dependent variable was the students' visual spatial ability. To collect the data, researchers used questionnaires and interviews. The instruments used in this study were expert validation sheets, observation sheets, students' questionnaires, and test. Media evaluation used experimental research with pretest posttest-control group design that compared learning outcomes between the experimental class and the control class. The type of data used in this study were in the form of quantitative data and qualitative data, so there were two kinds of data analysis techniques performed, namely descriptive statistical analysis and inferential statistical analysis.

RESULT AND DISCUSSION

This section is divided into two parts, namely (1) the process of research and development of instructional media and (2) the analysis of the results of media products. Following to the procedure proposed by Borg and Gall (1989), there are ten stages in the research and development of products used in this study.

A. Media Development

The first stage was research and information collection. At this stage, researchers conducted field observations first. Then, collected the data about needs analysis, including school analysis, user analysis, subject matter analysis, and analysis of facilities and infrastructure. The researchers wanted to know whether Augmented Reality has been used before and teachers' and students' understanding about Augmented Reality. Based on this preliminary information, researchers compile content that would be conveyed in media material. Based on information obtained at this stage, SDN Tegal Panggung had never used AR to support learning.

Second, the researchers arranged the activity plan. At this stage, researchers organized the content for the media as needed. After the content had been created, the researchers designed the product plan. The researchers tried to design a product which was able to attract the attention of elementary school children. Next, the researchers prepared a marker design. Markers are images that will be the base or target of the mobile camera. This marker is the barcode that gives rise to three-dimensional images. The Augmented Reality media was planned to be implemented by students in a group system accompanied by the teacher. The subject being targeted was the thematic learning with the theme of exploring the outer space for elementary school students. The following is the appearance of the product that has been made.

The third stage was development. This Augmented Reality media was developed with the waterfall model which had passed the stages of requirements, design, coding, testing and maintenance stages. Figure 2 shows the application that had been made as follows.

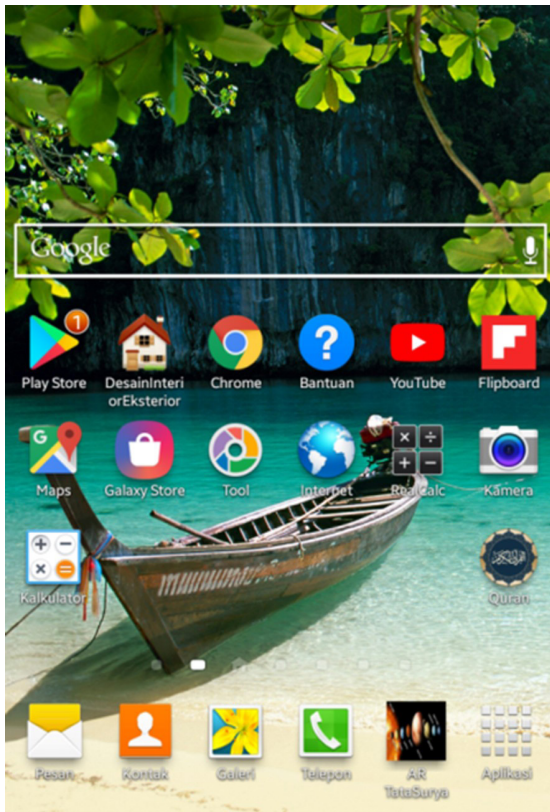


Figure 2 The application had been installed on the mobile phone

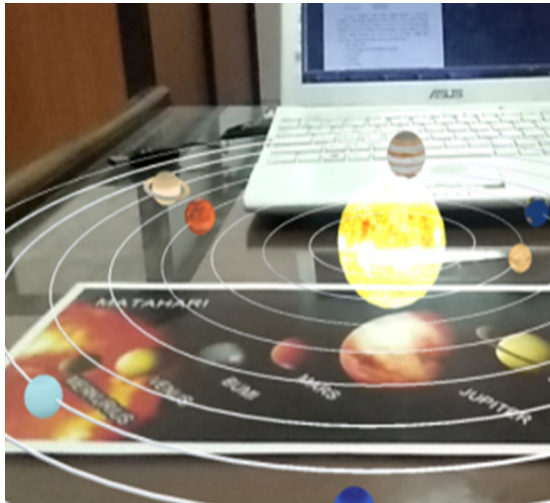


Figure 3 The implementation of solar system application using the mobile phone

The validation of the solar system AR-themed media was the fourth stage. The validation process involved two experts. The first expert was a media expert at the Information and Communication Technology Research Center (PPTIK) of the Universitas PGRI Yogyakarta, the second was a material expert, i.e. the teacher of SDN Tegal Panggung. The results of the validation showed that the material within the media, particular-

ly the content and accuracy of the material/relevance of the material to the curriculum, were both very good, respectively the percentage was 88 and 86. Meanwhile, based on the media category, the validation results showed very good results, i.e. in the aspects of program quality (88%), the aspects of media design (87.7%), and communication aspects (81%). Thus, the AR media of the solar system was ready to be tested with minor suggestions or revision before the trial.

Fifth, product revision. At this stage, the researchers revised the product in accordance with the suggestions and input by experts to perfect the media. Sixth, the implementation of media in the pilot class. The number of participants in the trial class were 10 students from class A. These participants were no longer included in the experimental class or the control class at a later stage.

Seventh, product revisions. After a small trial activity, in its implementation, there were some obstacles or problems from the media that had been used. Therefore, to develop the product perfectly, the researchers sought to maximize again and revise the product as needed. Eighth, trials in a broader scope. In order to know the students' responses and know the effectiveness of the solar system AR media in improving students' visual spatial abilities, extensive trials were conducted. Extensive testing was carried out in the experimental class.

Based on the evaluation results after giving treatment, the results obtained that the visual spatial ability of students could be categorized into very well category or with a percentage of 86.2%, while the effectiveness reached 84.75% which included in good category. Through this description, it could be concluded that the AR-based learning media for solar systems was effective in helping students to visualize the solar system and ease students to draw and memorize the solar system.

Ninth, revision of the final product before mass production. Tenth, dissemination and implementation, because this program was still a prototype, the AR application had not yet reached the stage of mass production.

B. Discussion

The research dimension in this R&D approach used the experimental research, i.e. one group pre-test post-test design models, in which



Figure 4 The tryout activity in the classroom

the experiment was conducted in one group without a comparison group. Subjects studied were students at SDN Tegal Panggung Danurejan District, Yogyakarta. The number of students were 20 students consisting of 12 male students and 8 female students. The data analysis technique used in this study was the Wilcoxon Test. Rostina Sudayana (2014) state that if the data are ≤ 25 pairs then compare the value of W_{count} with the value of W_{table} with the criterion H_0 is accepted if $W_{count} > W_{table}$.

Table 1 The schedule of the treatment

Date	Day	Treatments	Place
5 April	Friday	School Observation	School
6 April	Saturday	Pretest	School
9 April	Tuesday	Treatment 1	School
10 April	Wednesday	Treatment 2	School
11 April	Thursday	Treatment 3	School
12 April	Friday	Treatment 4	School
13 April	Saturday	Postest	School

Based on the initial identification, students' visual spatial intelligence before using the AR solar system theme were in very well developed category, students in the developed according to expectations category were 8 students with the percentage of 30%, students in early developed category were 12 students with a percentage of 60%, and there were no children in the underdeveloped category. Meanwhile, after the treatment, students' visual spatial intelligence improved. There were 7 students or 35% in the very well-developed category, 11 students or 55% in developed according to expectations, and there were no students in the early developed category and under developed or 0%.



Figure 5 The students used AR in solar system-themed material

Table 2 The comparison of students' spatial visual intelligence before and after the implementation of AR

No	Category	Score range	Before		After	
			F	%	F	%
1.	BSB	76-100 %	0	0	7	35
2.	BSH	51- 75%	8	40%	11	55%
3.	MB	26- 50%	12	60%	0	0
4.	BB	< 25%	0	0	0	0
Total			20	100%		

Based on the table above, most children experienced an increase in visual spatial intelligence after using AR media.

In the context of this solar system learning, substantially, visual intelligence becomes a prerequisite to understand matter as well as to be developed. Basically, the solar system is a space concept that requires visual intelligence to be able to understand it. For instance, to understand where the position the Earth among other planets, how the motion of rotation and circulation of each planet, including the composition of large and small of each planet.

Eclipse and the like also require visual intelligence to understand them (ie Abdussalam, Sulthoni, & Munzil, 2018; Andriani & Praherdhiono, 2016; Hapsari & Nurcahyanto, 2017; Marwiyah, Rusijono, & Arianto, 2019; Prayudha, Wiranatha, & Raharja, 2017; Hapsari & Nurcahyanto, 2017; Marwiyah, Rusijono, & Arianto, 2019; Prayudha, Wiranatha, & Raharja, 2017;).

Learning solar system material can thus also improve students' visual spatial intelligence. However, this research does not explore further because this type of intelligence does need further elaboration (i.e. Armstrong, 2009; Phillips,

2010). Things that must be considered in this study or the like are: not only focus on efforts to increase visual intelligence because the actual substance of the material is the solar system, while spatial intelligence is part of the realm of intelligence of students who are also honed. In other words, pay attention to the material first, then observe the students' visual intelligence. In addition, it should be noted about the measurement of learning success, namely the mastery of material about the solar system - or similar topics related to visual spatial intelligence and spatial intelligence that can be observed.

Further, basically the existence of AR is very potential to be able to support learning on material related to visual appearance - in the context of this research is the solar system. Nevertheless, each learning media, as a product of educational technology - including AR - has its own limitations and accuracy in supporting learning (Subkhan, 2016). In other words, not all materials are appropriately facilitated by AR. More than that, in the context of education in Indonesia, there needs to be a study of student ownership for gadgets in order to be able to access AR-based learning material. Schools with a social background of students who come from the lower middle class would be constrained if forced to use AR.

On the other hand, not all teachers are able to develop learning media based on digital technology, including AR. The overwhelming errands of teachers in the class in terms of administrative and learning matters will affect their opportunities to be able to develop AR-based media (Ichsan, 2014; "Pakar: beban administrasi guru perlu dikurangi," 2019). Therefore, if schools want to develop AR-based learning media, practitioners need to be supported in this field, especially learning technology developers who not only master application development techniques but also master the right pedagogical concepts to develop and use them.

Moreover, there is a need for further studies and considerations regarding the use of AR-based learning media in schools, considering that not all schools are permissive about the use of mobile phones to support learning ("Disdik Depok Larang Siswa Membawa Ponsel ke Sekolah, Kenapa?," 2018; "Siswa SD Dilarang Bawa Handphone," 2018). In fact, there are philosophies and educational movements that do not allow the use of gadgets as learning media from an early age (Richtel, 2011). This is based on the

consideration that childhood is a time of building and developing character. Therefore, learning should bring students closer to other people and the natural environment, not mediated by artificial learning media.

CONCLUSION

Based on the results of the research and development of educational media based on Augmented Reality on the material of the solar system at SDN Tegal Panggung, it can be concluded that (1) AR-based learning media has good quality based on the assessment of material and media experts and (2) there is an increase in the form of quality improvement learning outcomes in students studying the solar system. Thus, it can be said that AR-based learning media can improve students' visual spatial intelligence in general, or specifically in this context for 6th grade elementary school students. The process of installing software to a mobile phone or tablet that is very easy, inexpensive, and practical to operate, and can save costs, time, and energy can be a further consideration for recommending the development and use of AR in facilitating learning.

Besides, the use of AR as a basis for the development of instructional media certainly needs to consider a number of things related to the theoretical conception of educational technology and the context of education in Indonesia. Among others, regarding the principle of accuracy, that not all materials are appropriately facilitated by AR-based learning media, the capacity of teachers and the ability of schools to develop digital technology-based media, conditions of ownership of gadgets by students, educational policies and schools that limit the use of gadgets or even completely prohibit them, and some philosophical, theoretical, and movement concepts to minimize gadgets that also need to be taken into account.

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