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Feasibility study of a solar system learning media based on merge cube augmented reality to embedding problem solving skills

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Abstract. Science learning activities in the era of the industrial revolution 4.0 need to be directed towards attitudes, skills, and mastery of all material in a comprehensive manner that equips students with 21st century skills which are very important, including problem solving skills. This research aims to determine the feasibility of learning media for solar system based on merge cube augmented reality to embedding problem solving skills. Research and Development (R and D) the ADDIE model has applied to achieve the objectives of this research. This research stage is planned through the steps of Analysis, Design, Development, Implementation and Evaluations. This research has produced a solar system learning media based on Merge Cube Augmented Reality (AR) to embedding problem solving skills. The results of validation of material experts were 82%, validation of media and technology experts was 86% and validation or response of teachers was 82%. The three validations reached the very feasible criteria. The average percentage of the validation score is 83.33% or the criteria are very feasible. It was concluded that the learning medio of solar system based on Merge Cube Augmented Reality (AR) was feasible to embedding problem solving skills.

1. Introduction

In today's digital era, the android mobile technology has become a priority requirement [1]. All people and institutions, from children to adults, school, university, and educational department cannot be separated from mobile technology. Likewise, learning activities are increasingly available in a variety of choices for learning media based on mobile technology or mobile learning technology. Learning media is a tool or intermediary that is useful for facilitating the teaching and learning process, to streamline communication between teachers and students [2-5]. Learning media also functions as a tool or tools that really help teachers or lecturers in teaching and make it easier for students to receive and understand lessons in a more comprehensive manner.

In science learning activities in the era of the industrial revolution 4.0 and it should be directed to build attitudes, skills, and mastery of all material both concrete and abstract in natural sciences to then expand science learning that equips students with 21st century skills which are very important, including problem solving skills. Learning on complex and abstract science concepts that only rely on media in the form of static images, while animation or video is less interactive, so it is often ineffective [6-7].

The solar system is an astronomical material that is taught from elementary to tertiary education. In learning the solar system requires teachers or lecturers to teach creatively. In addition, in learning this topic, the media is needed to help students understand the concept or knowledge comprehensively. The media used in the learning process is currently considered inadequate due to the limitations of teaching aids and learning media [8-9]. Therefore, based on technological developments, there are many multimedia technologies. One of them is Augmented Reality (AR) technology which is currently developing rapidly.

Augmented Reality (AR) as learning media has previously developed 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 [10]. This technology has a great opportunity to develop its use into innovative learning media where the details of complex and abstract concept material can be visualized interactively so that it is easier for students to understand [11-13] and provides real-time interaction with what is displayed in the application [14]. For this reason, a learning media design for the solar system based on merge cube augmented reality was developed. This research focused to help students who are studying these lessons to have a better understanding of the lessons because they can interact directly with what they are learning.

However, the AR-based solar system learning media that are widely available today still have weaknesses in the "marker" of AR objects in the form of two-dimensional images, so they are static and do not allow users to physically hold and interact. Meanwhile, Merge Cube is a cube-shaped holographic media that allows users to physically hold and interact with 3D objects using augmented reality (AR) technology [15]. This research aims to develop a valid and feasible solar system learning media based on merge cube augmented reality to embedding problem solving skills.

2. Methods
Research and Development (R and D) is applied to achieve the objectives of this research through the steps of Analysis, Design, Development, Implementation and Evaluations (ADDIE). The ADDIE development model cycle [16] used in this research can be seen in Figure 1. Each stage of the ADDIE cycle is then developed into several technical research work steps [17].
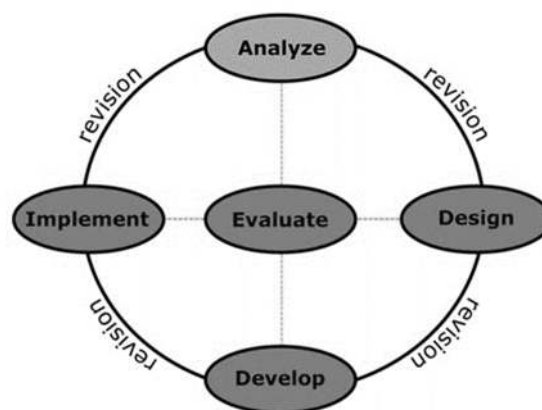

Figure 1. The ADDIE model research step

The analysis step of the development of learning media for the solar system based on Merge Cube Augmented Reality (AR) is a needs assessment process, identifying problems (needs) and performing a task analysis. Design is to design learning media products for learning media for solar system based on Merge Cube AR. Product design is still conceptual and underlies the subsequent development process. Development in it contains activities to realize the design of learning media products for learning media for the solar system based on the merge cube augmented reality. At the design stage, a conceptual framework has been prepared for the application of learning media for learning media of the solar system

based on merge cube augmented reality. In the development stage, the conceptual framework is realized into a product that is ready to be implemented. Implementation or implementation, namely implementing the design of learning media for learning media of the solar system based on merge cube augmented reality that has been developed in real situations in class or in a location that allows testing/ testing the results of this development. After the application of learning media for solar system learning media based on merge cube augmented reality, then an initial evaluation was carried out to provide feedback on the application of learning media for learning media for the solar system based on the next merge cube augmented reality. This evaluation stage is also extensively carried out at each ADDIE step. The evaluation results are used to provide feedback to the users of the solar system learning media based on the merge cube augmented reality. Revisions are made if and only in accordance with the results of the evaluation or the unmet needs of the augmented reality merge cube based solar system learning media product.

The data collection instrument used a questionnaire to determine the feasibility of learning media for the solar system based on merge cube augmented reality. Feasibility study through expert judgment consisting of material experts, media and technology experts, and teacher or lecturer users.

The data analysis technique used descriptive analysis to assess the characteristics of the data. The data were analyzed descriptively in the form of development data and questionnaire responses. This study uses a Likert scale questionnaire with 5 scales, namely very feasible, feasible, decent enough, less feasible, and not feasible, can be seen in Table 1.

Table 1. Assessment with a Likert scale

Statement	Score
very feasible	5
feasible	4
fairly feasible	3
less feasible	2
not feasible	1

The results of the questionnaire response scores were analyzed by calculating the average answer based on the score of each answer from the respondents which was calculated using the formula:

$$P = \frac{n}{N} x100\%$$

Information
P: Percentage of responses
n: The total score obtained
N: Total criteria score

The results obtained are then presented according to Table 2 below:

Table 2. The feasibility score and criteria

Percentage (%)	Criteria
81 - 100	very feasible
61 -80	feasible
41- 60	fairly feasible
21 - 40	less feasible
0 - 20	not feasible

3. Results and Discussion

Based on the analysis stage, the development of learning media for the solar system based on Merge Cube AR results in a needs assessment, namely: (1) the material characteristics of the solar system include understanding that the Earth is one of several planets orbiting the Sun in our solar system, observing various planets and objects in our solar system, and gain an understanding of the scale when comparing the sizes of the planets; (2) Merge Cube media specifications developed include dimensions, sizes and types of materials; (3) identify problems (needs) for learning media for solar system based on Merge Cube AR and perform task analysis to develop learning media for solar system based on Merge Cube AR.

The design stage is to design a learning media product for the solar system based on merge cube augmented reality. The design of learning media products for learning media for solar system based on merge cube augmented reality is a holographic cube-shaped media that allows users to physically hold and interact with 3D objects using AR technology. Product design is still conceptual and underlies the subsequent development process.

The development stage has made the realization of the learning media product design for learning media for the solar system based on the merge cube augmented reality. The development of an augmented reality merge cube in this study with a dimension of 7x7 cm printed by a black dry printing method printer (CMYK: 60/60/40/100) on 260-gram Ivory paper, A3 size. The media design for the merge cube that was built is called the Paper Merge Cube Augmented Reality. This differs from having the advantages of being lightweight, affordable, and providing soft skills for students or users when assembling paper merge cube, in contrast to the Merge Cube design which has been manufactured from soft rubber which is of course heavier and less economical. Although Merge Cube AR hold great potential in education, currently there are limitations, including ergonomic limitations from prolonged use, relatively high costs for adoption and use, and limited availability of content [18-19].
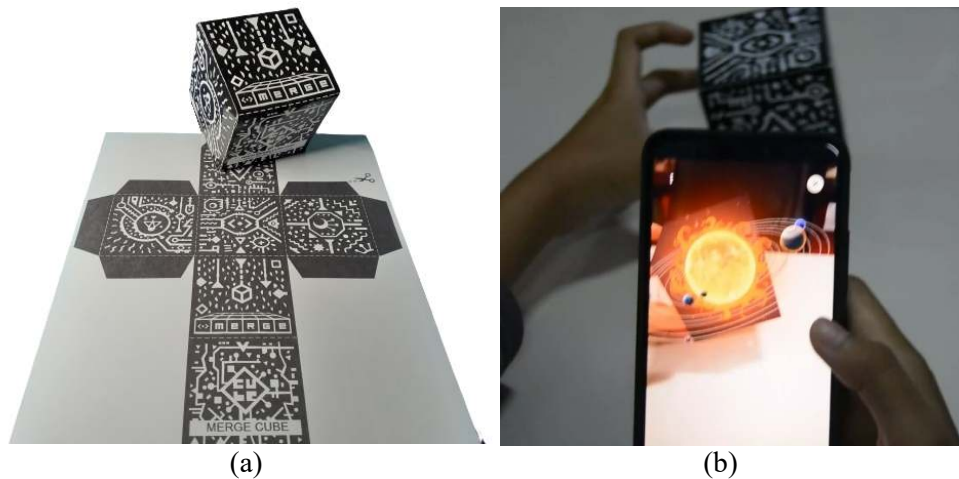

(a)   (b)

Figure 2. (a) Design of paper merge cube; (b) Galactic explorer app. scan on paper merge cube

The implementation stage of the design of learning media of solar system based on Merge Cube AR that has been developed in real situations in the classroom or location that allows testing/ testing of the results of the development carried out. However, in this research the implementation was limited to expert testing through a validation questionnaire for the solar system learning media based on Merge Cube AR to embedding problem solving skills. The results of the feasibility study through expert judgment consisting of material experts, media and technology experts, and teacher as users are presented in Table 3, Table 4, and Table 5, respectively.

Table 3. Results of material expert validation

No	Aspect	Percentage Validation Score (%)	Criteria
1	Content Quality	85	very Feasible
2	Content Compliance	80	Feasible
3	Language	82	very Feasible

Table 4. Validation results of media and technology experts

No	Aspect	Percentage Validation Score (%)	Criteria
1	Visual Communication	87	Very feasible
2	Technology	84	Very feasible

Table 5. Teacher response results

No	Aspect	Percentage Validation Score (%)	Criteria
1	Learning Process (Embedding Problem Solving Skills)	83	Very Feasible
2	Learning Material	80	Feasible
3	Visual Communication	84	Very Feasible

The average percentage of the results of the validation of material experts was 82%, validation of media and technology experts was 86%, and the response of teachers or potential users was 82%. Based on the results of the validation, an average percentage of 83.33% was obtained or it reached a percentage between 81-100 so that it was considered very feasible.

After the application of learning media learning media of solar system based on Merge Cube AR, then an evaluation is carried out to provide feedback on the application of learning media of solar system based on Merge Cube AR from notes or suggestions by experts and respondents. The lowest percentage of validation scores from material experts on the Content Compliance aspect. In this aspect, the media has material that is wider than the content mandated by the curriculum. This is intended so that the learning material content is more comprehensive. The results of the media and technology expert's validation in each aspect are very feasible, but the experts provide suggestions for the media to be equipped with usage guidelines and activity sheets. Results of the lowest teacher response in the learning material aspect. According to the teacher, the material on the media can be summarized and added to a list of terms so that it helps students understand more easily the material of the solar system.

Based on the teacher's response, the product of solar system learning media based on Merge Cube AR has an influence on embedding students' problem-solving skills. Students can explore the material themselves by using the media of learning media products for the solar system based on the merge cube augmented reality. This media also trains students to practice solving problems.

AR-based media is very useful as an interactive and real learning media for students [20]. By utilizing AR media, it can combine the virtual world that can increase students' imagination with the real world directly [21-22]. The use of AR-based learning media can stimulate students' mindsets in thinking critically about problems and events that occur in everyday life because learning media is very helpful for students in the learning process [23]. So that the use of educational media with augmented reality can directly provide learning wherever and whenever students want to carry out the learning process [24].

4. Conclusion

The conclusion of this research is that the solar system learning media based on Merge Cube Augmented Reality (AR) has a very feasible criteria to embedding problem solving skills, but still requires a little revision for improvements in the aspects of compliance and learning content comphrehenshion of the solar system. The learning media products of solar system based on Merge Cube Augmented Reality (AR) are recommended to be used as an alternative to science learning media that facilitate the embedding of problem solving skills for students.

Acknowledgments

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