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Apollo and Comet Media Design to Practice Science Literacy for Elementary School Students

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ABSTRACT

Science literacy is very important to be mastered by students. In the literacy process, students need learning media that are in accordance with the characteristics of students and materials. Media design is based on a game design framework, namely empathic or analytical (emphatic), defining (define), developing ideas (ideate), making prototypes (prototyping), and testing (playtest). The stages of the game design framework are in line with the steps for selecting learning media, namely ASSURE. The design of Apollo and Comet media that is in accordance with these stages can produce media games that are not only able to entertain children, but also facilitate students to train their literacy skills. This research used a nonequivalent pretest posttest control group research design used for Quasi Experimental Design. Data on increasing scientific literacy was obtained by giving a pretest and posttest using a scientific literacy test sheet by adapting the PISA test.. Students' scientific literacy increased by 74.8562 with a high category based on the results of the N-Gain.

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1. INTRODUCTION

The ability to create new habits by way of using technology in order to create a better life by applying behavior and attitudes according to society 5.0 standards as the impact of the the fourth industrial revolution can be realized by today's education. Obtaining education through school or formal education can be an effort to optimize academic potential (You et al., 2021). The big ideas put forward by the United Nations Educational, Scientific and Cultural Organization (UNESCO) are summarized in nine big ideas on the foundations of post-pandemic education which include ensuring the existence of scientific literacy in the curriculum structure (Valladares, 2021). Scientific literacy as described by the National Research Council (NRC) according to Toharudin (Asyhari, 2015) is the applicative ability of scientific knowledge by individuals as an effort to find solutions to problems that

occur. Scientific literacy is the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen (Yuniar et al., 2020). Based on this description, scientific literacy can be defined as possession of a set of abilities in applying the knowledge possessed to solve problems based on scientific attitudes and scientific principles according to relevant data analysis.

The Program for International Student Assessment (PISA) divides literacy into three domains, namely reading, numerical literacy, and scientific literacy. The scientific literacy intended by PISA is not only the mastery of scientific knowledge, but also the mastery of skills needed at an advanced level (Le Hebel et al., 2017). PISA provides several characteristics of scientific literacy, namely scientific knowledge, categorization of scientific knowledge, awareness of science and technology, and the ability to engage in scientific issues (Podgornik et al., 2017). The Organization for Economic Cooperation and Development (OECD) assesses literacy with the standard of how students construct and analyze material to be applied as a form of scientific literacy assessment results (Asyhari, 2015). Good mastery of scientific literacy can support determining steps in interpreting situations and conditions around students as the basis for key aspects of literacy development in science learning (Romance & Vitale, 2017). Mastery of scientific literacy can be optimized through the implementation of practical science learning accompanied by experiments and scientific investigations as a central part of scientific activity in the real world (Alneyadi, 2019). The intended science learning cannot be separated from the adaptation of the latest technology, the integration of technology also plays an important role in increasing students' scientific literacy.

The existence of science in the content of Natural Sciences (IPA) lessons can be used as initial capital to solve various obstacles in the future through inquiry, critical, logic-based, and creative learning steps that are student-centered. The learning process with the aim of optimizing scientific literacy skills must be in accordance with the stages of the nature of science learning. Science learning directs students to seek information according to the scientific stages which are ultimately able to form scientific attitudes (Widiana et al., 2019). The intended science learning is a combination of pedagogical abilities, models, media, and learning resources that have been sorted and selected by the teacher and adapted to the learning objectives (Lin et al., 2017). Media is defined as a means of distributing information so as to facilitate the delivery of material by optimizing the use of students' senses in achieving learning objectives (Marpanaji et al., 2018). The determination of the use of media must at least consider its suitability with the material and initial skills possessed by students supported by the accommodative ability of the teacher in using the media and the level of effectiveness. Media selection can also be based on Dale's conical theory of experience (Masters, 2020).

Based on the results of the study of daily assessment scores of 6th grade students in 25 elementary schools in Gedangan District, Sidoarjo Regency, on average students do not have good scientific literacy skills, which can be seen in their inability to explain scientific phenomena in essay questions given by the teacher and their lack of ability. students design simple scientific investigations during the learning process. This condition is due to the absence of learning media that is able supported the mastery of scientific literacy in the middle of limited face-to-face learning conditions as it is today. Traditional game-based media can facilitate the adaptation process of students in the learning process. The application of game media can generate experiences and involve students' emotions and senses actively in learning (Syawaluddin et al., 2020) . The preparation of game media that accommodates students to optimize their scientific literacy is still not widely available. One of the game media that can be used as an alternative is snake and ladder media.

The results of previous studies showed that snakes and ladders game media can increase science knowledge competence (Widiana et al., 2019) , student learning outcomes also increase after participating in learning using snakes and ladders game media (Saputra et al., 2019) , digital games can also improve information literacy and can also improve students' scientific literacy (Zou et al., 2021) , besides the snake and ladder game is also able to improve students' thinking skills (Meriyati et al., 2019) , and students will be more interested in learning to use the snake and ladder game so that the results learning increases (Syawaluddin et al., 2020) . The snake and ladder game which is used as an

alternative solution in this article was adapted into the Apollo and Comet game which was adapted to the learning content.

Apollo and Comet games can be played in two ways, namely online in the form of games and directly through the game board. In the game Apollo and Comet, there are questions to be answered by students and topics of experiments to be carried out. The student's ability to answer questions shows students' scientific literacy skills at level 1 and the ability to carry out simple scientific investigations shows scientific literacy skills at level 2. The application of Apollo and Comet media can be carried out with the Teams Games Tournament (TGT) learning model which allows students to collaborate and help each other among themselves. group members through discussion and question and answer in completing learning objectives so that students become more motivated and their abilities increase (Luo et al., 2020) . The TGT learning syntax also allows students to build knowledge connections and improve their communication skills (Muslim, 2020). Developing Apollo and Comet media is very important as an alternative solution to practice students' scientific literacy skills by considering the results of other relevant studies that have been carried out previously. Apollo and Comet media was developed by researchers from the modification of the snake and ladder game so that it will attract students' learning interest and is expected to increase students' motivation and scientific literacy.

2. METHODS

This research includes development research used a nonequivalent pretest posttest control group research design used for Quasi Experimental Design. Data on increasing scientific literacy was obtained by giving a pretest and posttest using a scientific literacy test sheet by adapting the PISA test, then analyzing the increase in N-Gain with SPSS 25 application.. Media design is based on a game design framework, namely empathic/analytical (emphatic), defining (define), developing ideas (ideate), making prototypes (prototyping), and testing (playtest) (Kearns et al., 2022) . The stages of the game design framework are in line with the steps for selecting learning media, namely ASSURE which, when combined, is shown in the following figure:

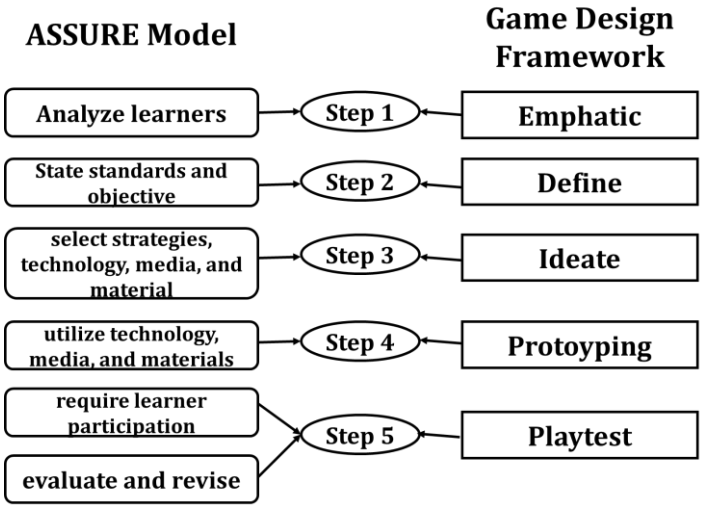

Figure 1. Apollo and Comet media design stages

3. FINDINGS AND DISCUSSION

3.1. Stage 1: Identifying student character and curriculum

Apollo and Comet 's media design is intended for 6th grade elementary school students, especially on the topic of Theme 9: Exploring Outer Space. Grade 6 students are in the age range of 11-12 years and are categorized at the level of concrete operational thinking where students should have been able to determine which steps or procedures are needed to achieve learning objectives, so that the media used

in learning does not necessarily have to be concrete objects (Fioretti & Smorti, 2019) . The results of curriculum analysis related to competency analysis are in the following table:

Table 1. concepts and tasks analysis

Core Competencies	Basic competencies	Concept	Task
3. Understand factual, conceptual, procedural and metacognitive knowledge at a basic level by observing, asking questions, and trying based on curiosity about himself, God's creatures and their activities, as well as objects they encounter at home, at school, and at the playground.	3.7 Describe the solar system and the characteristics of the members of the solar system	3.7.1. The process of formation of the solar system and celestial bodies 3.7.2. The planets of the solar system and their constituent materials 3.7.3. The rotation and revolution of the planets in the solar system	3.7.1 Describing celestial bodies with their constituent materials 3.7.2 Interpreting the planets of the solar system 3.7.3 Projecting differences in rotational or revolution times between planets
4. Demonstrate creative, productive, critical, independent, collaborative, and communicative thinking and acting skills. In clear, systematic, logical and critical language, in aesthetic works, in movements that reflect healthy children, and actions that reflect children's behavior according to their developmental stages	4.7 Modeling the solar system	4.7.1 Position of the planets based on their characteristics 4.7.2 Solar system model design	4.7.1 Integrating planetary position based on features with appropriate 4.7.2 Designing the system model system Sun with appropriate

3.2. Stage 2: Setting learning objectives

The results of the analysis of students and the curriculum are then used as a reference to formulate learning indicators to be achieved to improve scientific literacy of 6th grade elementary school students, which are arranged in the following table:

Table 2. Learning competencies analysis

Core Competencies	Basic competencies	Indicator	Learning objectives
3. Understand factual, conceptual, procedural and metacognitive knowledge at a basic level by observing, asking questions, and trying based on curiosity about himself, God's creatures and their activities, as well as objects they encounter at home, at school, and at the playground.	3.7 Describe the solar system and the characteristics of the solar system members	3.7.1 Describing celestial bodies with their constituent materials (C4) 3.7.2 Interpreting the planets of the solar system (C5) 3.7.3 Projecting the difference in rotational or	3.7.1 Through online and offline snake and ladder media, students can describe celestial bodies with their constituent materials correctly (C4) 3.7.2 Through online and offline media, students can interpret the solar system planets correctly

		revolution times between planets (C5)	(C5) 3.7.3 Through online and offline media, students can project the difference in rotational or revolutions times between planets correctly (C5)
4. Demonstrate creative, productive, critical, independent, collaborative, and communicative thinking and acting skills. In clear, systematic, logical and critical language, in aesthetic works, in movements that reflect healthy children, and actions that reflect children's behavior according to their developmental stages	4.7 Modeling the solar system	4.7.1 Position of the planets based on their characteristics 4.7.2 Solar system model design	4.7.1 Integrating planetary position based on their characteristics correctly 4.7.2 Designing the solar system model correctly

3.3. Stage 3: Preparation of media rules, materials, and initial ideas

Based on the results of the identification of student characteristics and curriculum as well as the preparation of learning objectives, learning materials related to the solar system and the characteristics of its members are prepared with reference to the literacy skills to be developed, namely students are able to explain scientific phenomena, are able to interpret data, and are able to design simple scientific experiments. The media's initial idea was the Apollo and Comet board game which was designed on a board coated with zinc sheets and sticker paper. The rules of the game follow the rules of the snake and ladder game in general, namely the game time will run out if there is a player who is in the last box of the game. However, the winner of the game is the player who gets the highest score during the game. The score is obtained from the correct answers to each question in the box occupied by the player. Media design needs to consider the use of images to minimize the possibility of material misconceptions among students (Galano et al., 2018) . The main purpose of using Apollo and Comet media is to stimulate students to learn more about science material through games so that it is hoped that students' interest in studying astronomy will continue to increase (Colantonio et al., 2021) . The use of astronomical instruments can also increase students' self-efficacy to study scientific phenomena based on analysis of facts and data as well as simple scientific inquiry designs (Freed et al., 2022) . The scientific experiments process should be designed with regard to the length of the game and the learning time. If possible, the scientific experiments included in the media are merely scientific experiments, but can still be added to the level of difficulty of advanced learning.

3.4. Stage 4: Designing the media

Apollo and Comet media is designed to facilitate students to practice science literacy skills level 1 through a variety of questions on the game box and scientific literacy level 2 through experimental topics. The Apollo and Comet media developed with its supporting equipment can be seen in the following figure:

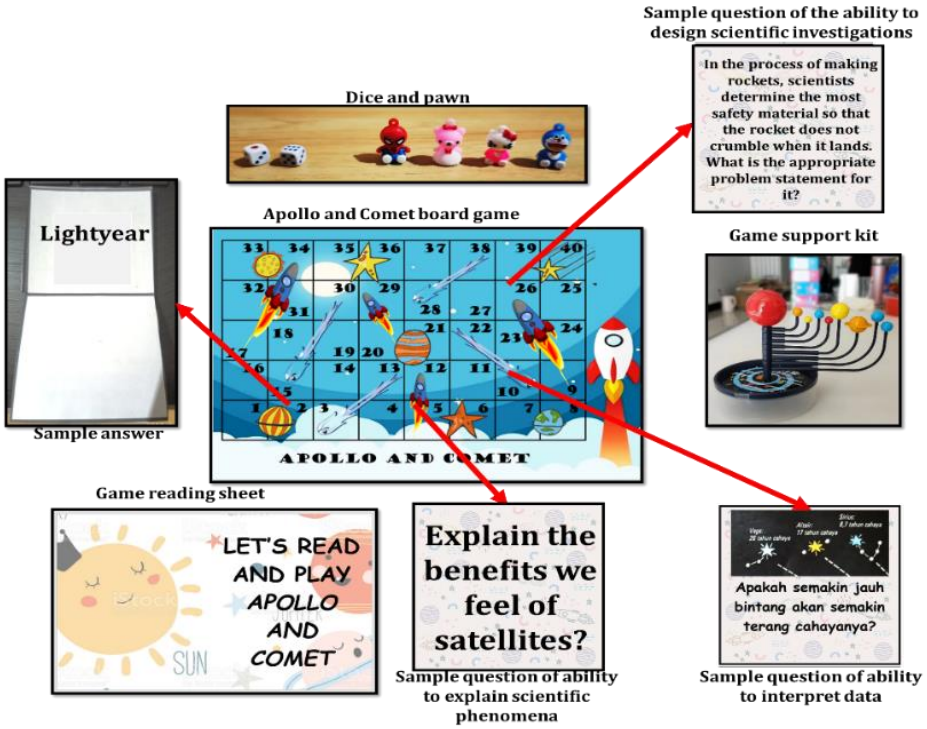

Figure 2. Apollo and Comet Media Design

Based on the figure, level 1 students literacy ability, namely the ability to remember can be trained in the form of questions in the form of the ability to explain scientific phenomena. The example of a question explaining about scientific phenomena is the cause of comet tail always facing away from the sun. Students can get answers to these questions through reading sheets as a source of literature, it's just that the answers will not be obtained easily, because students also need to interpret the readings to find the answers. In addition, students can also be trained to interpret data from images or infographics contained on the reading sheet to answer questions about interpreting data in the question box as shown in the following figure:

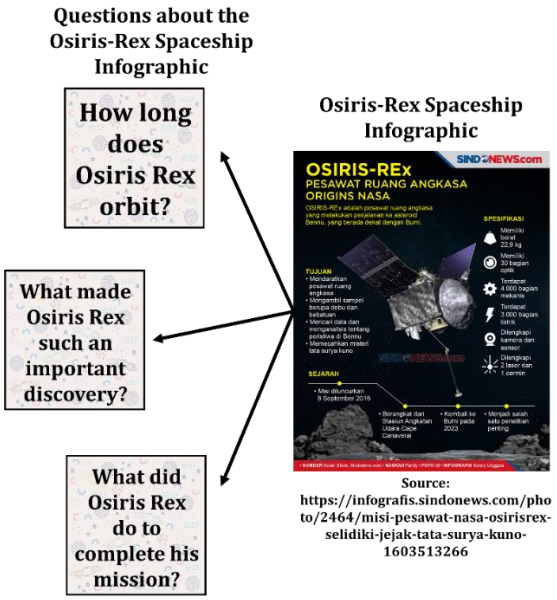

Figure 3. Examples of Infographics and Data Interpreting Questions

Steps to train level 2 scientific literacy ability is done by giving a simple experimental topic in a question box intended for students to be trained to design simple scientific investigations to understand more about the concept or material being studied. The examples of experimental topics that can be given are the planet's surface temperature differences based on the color of the planet and safe protective materials for rocket would not be destroyed when landing, such as the experimental design as shown in the following figure:

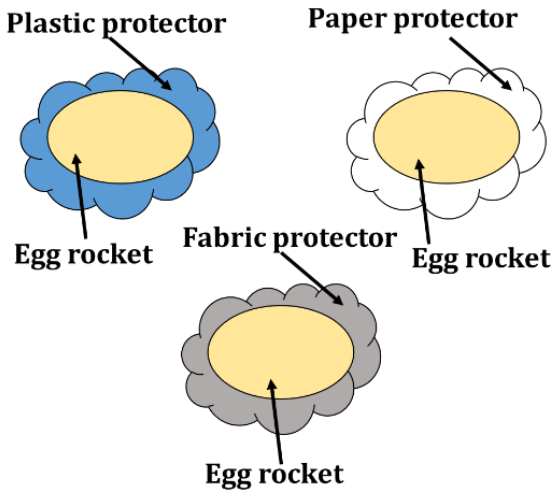

Figure 4. Experimental Design Example

The experimental design that has been prepared by the students is then investigated further with a worksheet that has been prepared previously. Simple experiments such as rocket shielding materials carried out by students can use any material as long as the material is relevant to the specified research topic. Students can use other materials other than the sample material as shown in Figure 4, but the entire material used must be included in the table of research results. Worksheets that can be used to accommodate the experimental process carried out by students as shown in the following figure:

WORKSHEET
ROCKET PROTECTOR MATERIALS

Group : .....
Member : .....

Instruction:
1. Make sure you have the following test kits:
2. Make an experimental design in the box provided!
3. Let's try which material can protect the egg rocket so that it is safe and does not break when it lands!
4. Complete experimental result table!

Experimental design

Experimental result

Number	Protector material	Safe	Not safe
1			
2			
3			
4			

Conclusion

.....
.....
.....

Figure 5. Rocket Protective Material students worksheet

3.5. Stage 5: Playtest and Evaluation

In this section, the results of research on the development of Apollo and Comet media will be described to improve motivation and scientific literacy of students in the sixth grade Elementary School. This study involved 80 students of the sixth grade SDN Keboansikep 1, Gedangan District, Sidoarjo Regency. The initial stage of this research is the development of Apollo and Comet media. The next stage after the media has been made is the media validation stage by experts. The results of media validation are used to improve the media, according to the validator's suggestions. The next process is a limited trial phase involving 20 students in one meeting. The results of observations and tests at the limited trial stage were then used as reflection material for the implementation of further research. The research was conducted for five meetings. The first meeting was used to carry out a pretest to determine the level of scientific literacy possessed by students. The second to the fourth meeting carried out learning using Apollo and Comet media accompanied by observations of student motivation. At the fifth meeting it was used to measure students' scientific literacy skills after learning with Apollo and Comet media through posttest.

The validity results show that the Apollo and Comet media is declared feasible at 91.33%. The reliability of the Apollo and Comet media using Cronbach's Alpha obtained a score of 0.759 with a high category interpretation. The results of the validity shown by indicate that the material on the Apollo and Comet media is declared feasible at 90.5%. Material reliability using Cronbach's Alpha obtained a score of 0.8 with a high category interpretation.

	Kelompok			Statistic	Std. Error
NGain_Persen	Kontrol	Mean		45.2313	1.95660
		95% Confidence Interval for Mean	Lower Bound	41.2737	
			Upper Bound	49.1889	
		5% Trimmed Mean		45.3935	
		Median		50.0000	
		Variance		153.131	
		Std. Deviation		12.37463	
		Minimum		21.05	
		Maximum		64.52	
		Range		43.46	
		Interquartile Range		22.29	
		Skewness		-.404	.374
		Kurtosis		-1.033	.733
	Eksperimen	Mean		74.8562	1.79782
		95% Confidence Interval for Mean	Lower Bound	71.2198	
			Upper Bound	78.4927	
		5% Trimmed Mean		74.3352	
		Median		75.6757	
		Variance		129.286	
		Std. Deviation		11.37041	
		Minimum		59.09	
		Maximum		100.00	
		Range		40.91	
		Interquartile Range		19.51	
		Skewness		.380	.374
		Kurtosis		-.409	.733

Figure 6. Scientific Liretacy N-Gain Test Result

Based on Figure 6, data on the results of the students' scientific literacy test in the control class and experimental class were analyzed using the N-Gain method with the help of the SPSS 25 application and produced the following data:

1. In the control class, the minimum N-Gain value is 21.05 and the maximum value is 64.52 with an average N-Gain value of 45.2313, so that the increase in literacy test results in the control class is categorized as moderate.

2. In the experimental class, the minimum N-Gain value is 59.09 and the maximum value is 100.00 with an average N-Gain value of 74.8562 so that the increase in literacy test results in the experimental class is categorized as high.

Based on the overall data obtained, it can be stated that the Apollo and Comet media can improve students' scientific literacy. This is in line with Patmanthara's research that the use of interactive multimedia Apollo and Comet which is a kind of snake and ladder media can improve student learning outcomes, especially students' scientific literacy skills (Patmanthara et al., 2019) and Syawaludin's research that students become interested in participating in learning with snakes and ladders media so that their learning outcomes increase (Syawaluddin et al., 2020). This result also in line with Suryanti's result research that local wisdom-based teaching materials could be implemented as an alternative source of learning natural science in elementary schools and improve students' scientific literacy (Suryanti et al., 2020). Apollo and Comet media are also a game based on local wisdom that has been modified so that it is easy for students to play and improve their scientific literacy skills because it is applied to learning.

4. CONCLUSION

Science literacy ability is an important ability that must be mastered by students to be able solving problems faced with alternative solutions supported by scientific attitude and valid data. During learning process, of course student should be facilitated by the teacher to optimize their science literacy ability. One of possible steps that can be used is by applying learning media that can support activity to train student science literacy ability such as the Apollo and Comet media. Learning using Apollo and Comet media can increase students' scientific literacy. Students' scientific literacy increased by 74.8562 with a high category based on the results of the N-Gain.. The limitation of this research is that the content of the learning material has not been thoroughly accommodated by the media, the form of the media is also still in the form of a board game in general. If possible, this research can be developed by preparing media designs in the form of game applications that are more flexible to be played through gadgets or similar devices.

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Conflicts of Interest: The authors declare no conflict of interest.

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