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Development of the 'Curious Scientist' Game to Practice Scientific Thinking Skills

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Abstract: This study aimed to develop an android-based game learning media by applying the steps of the scientific method. Methods: UsingThe development research was adapted the RnD method with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The data collection technique was a validation questionnaire of media experts, linguists, materials, teacher, and student responses. Findings: The validation results of media, language, and material experts were 92.00, 92.00, and 96.00%, respectively, with very feasible criteria. Student response questionnaires in the small and large group trials were 96.00, 94.00, and 89.70%, respectively, with very achievable benchmarks. The teacher's response questionnaire also got more than 80.00%, which was very decent. Conclusion: The result application of the 'Curious Scientist' game learning media is interesting for students. Indirectly, students have learned to use the scientific method approach and apply scientific thinking skills utilizing the learning media game' Curious Scientist.'

Keywords: Scientific thinking; Scientific method; Game; Android

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Introduction

Understanding science concepts for students is very important (Fuadi et al., 2020; Kim & Song, 2021; Yanti et al., 2019). Understanding the concept can be interpreted as the ability to capture a meaning that is considered abstract. Understanding the concept of the scientific method means being able to uncover a phenomenon through systematic, thorough, honest, and responsible investigation (Supeno et al., 2020). Understanding the scientific method concept will provide skills that stimulate problem-solving skills, scientific knowledge, scientific reasoning, and the ability to think at high levels in developing scientific knowledge (Kim & Song, 2021).

An understanding of the scientific way of thinking is formed through the steps contained in the scientific method including first, observing phenomena that occur in the natural environment. Second, asking questions based on observations of natural phenomena. Third, conducting observations and measurements to obtain data on natural phenomena. Fourth, process and analysis of measurement data. Fifth, answer questions based on the results of the data analysis. Sixth, communicate the results to the audience for criticism, suggestions, and further testing (Supeno et al., 2020). According to Musfiqon (2015), there are techniques for formulating problems and answering them through observation and testing in the scientific method. The steps for implementing the scientific method include; Questions, research, hypothesis, plan an experiment, experiment, report, and conclusion. The focus of learning that uses a scientific method approach is the ability of students to communicate so that they can find concepts and solve problems through the learning process (Hendra Saputra & Pasha, 2021).

Quoted from the CAS Future of Scientific Leadership, the ability to think that puts forward scientific aims to form a collaborative and innovative

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leader character has a character who likes challenges to find new things (Milić et al., 2020). The 2013 curriculum approach is designed to promote a scientific approach. The scientific approach is a learning model that uses scientific methods in its learning activities. The purpose of the scientific approach is that students are allowed to observe, ask questions, reason, and communicate what they have learned through direct experience (Kemendikbud, 2013). Learning relationships through scientific approaches or relevant scientific methods will positively impact current and future students (Kamila & Louise, 2021).

The reality on the ground shows that learning with the scientific method has indeed been applied at all levels of education, including elementary schools. However, based on the results of observations obtained data, students as the main subject do not understand the purpose of the scientific method's steps. One of the subjects closely related to efforts to strengthen the understanding of the scientific method is the subject of Natural Sciences. In science subjects, the water cycle material has a high potential to be the basis for practicing the steps of the scientific method because this concept is close to students' daily lives.

However, based on the results of the literature study and interviews with teachers and students, it was found that the use of media in conveying the water cycle material did not involve students at the experimental stage. The same thing was also expressed by Wisada et al. (2019) that students' scientific activities are still limited to observing, listening to explanations, conducting experiments (playing dioramas), taking notes, then discussing observations that have been made. Students have not been involved in physical creativity to take measurements, give treatment, and modify to see physical phenomena. Through interviews with several fifth-grade teachers in several elementary schools, it was found that the delivery of material on the water cycle used dioramas and posters more often. When learning is done online, the teacher only sends a video via the WhatsApp application; then, students are assigned to observe and conclude the water cycle material.

Based on observations of student learning outcomes from three schools in one city with 87 students and data from interviews with teachers in three schools, it is known that students can explain the meaning of complex terms such as condensation, precipitation, and evaporation because students repeat videos. When students were asked to explain the sequence of the water cycle, the students were still not quite right, and some did not understand at all. Therefore, it is necessary to present a learning media that allows students to be actively involved in experimental activities so that the concepts obtained by students become more meaningful.

The development of learning media in Indonesia continues to experience innovation. This effort was made to meet the 2013 Curriculum targets in mastering 21st-century competencies, including critical thinking, creative, innovative, collaborative, communication, and literacy skills (Redhana, 2019). Learning in the 21st century has shifted following the times by utilizing technology and internet networks that can provide audiovisual and multimedia learning (Sari, 2017). The digital technology transformation for today's young generation can be seen in computer learning, programming, robotics, and science (Pienimäki et al., 2021). Games in learning that utilize technology are proven to attract interest in education. Audio and music in games can influence interaction, response, and enthusiasm (Munasti & Suyadi, 2021). The use of games as a learning base or so-called educational games is one of the innovative learning strategies to achieve effective learning. Aspects of the display on the media in the form of layout or layout, color display, text clarity, and attractive and clear images will display material that is easier for students to understand (Irwandani et al., 2017).

Research and effectiveness in learning water cycle material, including the development of problem-based learning E-comic learning media, the action of animated cartoon educational videos, puzzle learning media, pop-up book media, and audio-visual learning media (Febriyanita, 2020; Laksmi, 2021; Ningtiyas et al., 2019; Putri et al., 2020; Sumantri, 2021). Based on previous research and development, in this study, a new learning media was developed in the form of educational games on the water cycle material. Learning media is designed to apply the steps of the scientific method with the aim that students can use the steps of scientific thinking. The levels in the game are designed according to the order of the scientific method.

The learning media design was given the name 'Curious Scientist.' In this game, students act as scientists who are curious and conduct experiments to prove a hypothesis so that they can conclude. The stages of the game contained in this educational game follow the steps of the scientific method. This study was conducted to determine the feasibility and attractiveness of student responses to the development of the educational game media Curious Scientist'. This media applies the steps used in the scientific method and is combined with technological developments to provide a complete understanding and, at the same time, provide a pleasant learning experience.

Method

Research Design and Procedures

This research was conducted using the Research and Development (R&D) technique based on the ADDIE development model. R&D steps are limited due to limited human resources, funds, and time (Sugiyono, 2017). This model was chosen based on systematic considerations and the theoretical foundation of learning design. The ADDIE model (Figure 1) is programmed with an ordered sequence of activities to solve learning problems and learning resources that are by the characteristics of students. The development steps of the ADDIE model are Analyze, Design, Development, Implementation, and Evaluation (Tegeh, 2013).

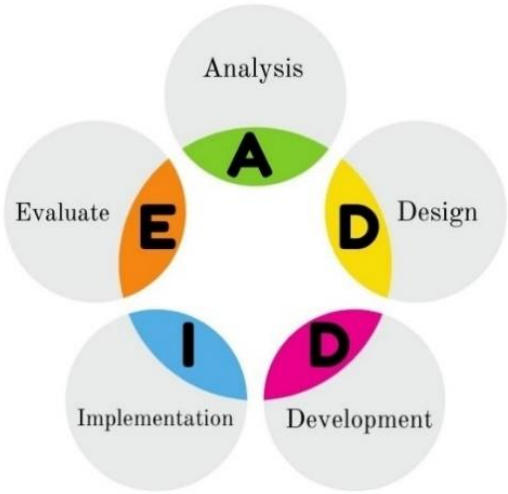


Figure 1. The steps for using the ADDIE model.

Participants

The subjects of this study were 87 elementary school fifth-grade students from three elementary schools. The small group trial phase was carried out on 26 students, and the large group trial phase on 58 students. The development stage consists of making flowcharts, storyboards, collecting supporting data, developing learning media, validating and revising the initial product. The repaired product can then be downloaded via the link for small and large group trials. The data from the trial were analyzed and evaluated.

Data Analysis Techniques

The data collection technique was through a questionnaire sheet validation of media experts, linguists, materials, teacher responses, and student responses. Using a questionnaire obtains quantitative data in suggestions and comments on the developed learning media.

The results of the validation questionnaire analysis by media, language, and material experts were used to determine the feasibility of learning media. The teacher and student response questionnaires were used to determine the developed learning media response. The results of the questionnaire analysis in the form of quantitative data will be interpreted using a Likert scale with a rating scale of 1-5. The score is assessed based on the appearance of the media assessment descriptors, as shown in Table 1.

Table 1. Score Interpretation Of Data adapted from Mahardika (2016).

Score	Category
X > 80.00%	Very feasible
60.00% < x ≤ 80.00%	Fairly feasible
40.00% < x ≤ 60.00%	Feasible
20.00% < x ≤ 40.00%	Not feasible
X < 20.00%	Very not feasible

Stage of Research Based on the Development of The ADDIE Model.

The analysis stage is carried out on learning that applies scientific methods to the water cycle material, analyzes learning needs in the digital era, and develops a learning media framework. The design stage is carried out with flowcharts and storyboards based on the source material. Designing the instruments that will be utilized to create the media. Development is a step material expert validate the product development, media experts, and linguists, one expert each, to get suggestions and comments on media improvements.

The implementation step is experimenting was conducted in small groups and large groups with 87 students. After the trial, students filled out a questionnaire to determine their response to the developed learning media. The teacher also gave responses to the media through a questionnaire.

The evaluation stage is carried out at each step of the research. Evaluation at the analysis stage is used to check that the analysis is appropriate until the media developed meets learning needs. Evaluation at the planning stage is carried out by selecting game characters, images, content, and music. Evaluation at the development stage is carried out based on expert validation.

Result and Discussion

By the rules of the scientific approach in the 2013 Curriculum, students are expected to be able to think scientifically in solving problems. Scientific thinking skills are formed through the steps contained in the scientific method. The development of the scientific

method should follow technological developments that can make it easier for students to learn anywhere.

Based on the analysis of the problems in three elementary schools, the next stage is media development planning. Developing this media is based on the statement that providing a comprehensive experience in the learning process will make students understand the material as a whole (Nurrita, 2018). Choosing learning media is important in presenting quality learning activities (Sari, 2019). The selection of educational games is the right effort and developed according to technological developments in the 4.0 era. A series of game levels arranged in the order of the scientific method combined with a fun learning approach through games so that students are oriented to learning through a scientific approach according to the provisions of the 2013 Curriculum while providing a meaningful learning experience. The sources used are the thematic books for fifth-grade students and some information from websites that develop water cycle materials. The game application is designed using Unity 3D software and Adobe illustrator. The development of this educational game uses the type of adventure game in which the steps of the scientific method are applied.

Research on the development of learning media produces educational games that apply the steps of the scientific method. The game was given "Curious Scientist, a scientific Method of water cycle game." This game's material content (Picture 3) is about learning the water cycle with a scientific approach for fifth-grade elementary school students. This material is packaged in the form of an Android-based game. The steps of the scientific method appear in order of levels namely; Question, Research, Hypothesis, Plan an experiment, Experiment, Report, Conclusion.

Figure 2. Application view

Figure 3. Game level according to scientific steps

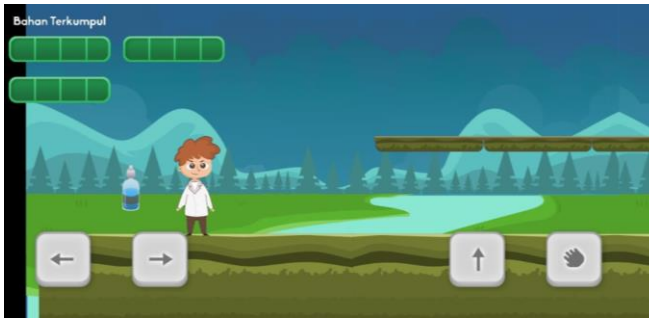
The level 1 (Question) display as presented in Figure 4, raises questions as an apperception of the water cycle topic. Furthermore, brief knowledge of the water cycle process is given so that students can develop a theoretical framework and a brief explanation of the water cycle (Figure 5). The material presented is in the form of animated videos at level 2 (Research).

Figure 4. Apperception questions

Figure 5. Animated video of the water cycle

Level 3 water cycle (Hypothesis). Students are presented with a hypothesis (Figure 6), a provisional conjecture in a study, and trials are needed to prove this conjecture. Experiments to demonstrate the process in the water cycle certainly require preparation. Level 4 (Plan an experiment) scientists collect objects to conduct experiments, as shown in Figure 7.

Figure 6. Hypothesis



Gambar 7. Finding objects for experiments

A level 5 Experiment was carried out to prove the process of evaporation, condensation, and precipitation (Figure 8). Level 6 (Report) generates reports on the water cycle through drag and drop games (Figure 9).

Figure 8. The experiment on the water cycle

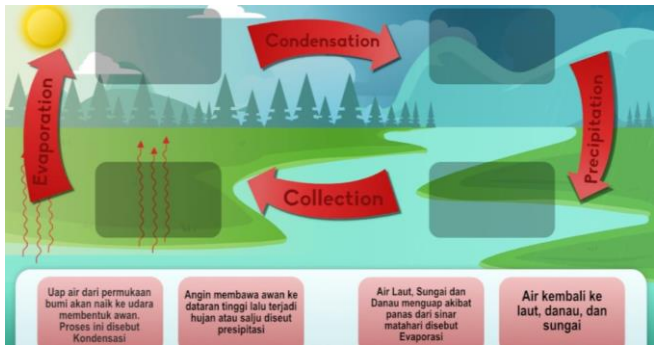


Figure 9. Making a report

The level 7 (Conclusion) report was carried out to help students write conclusions about the water cycle process to answer the hypothesis.

Learning media products have been validated by media, language, and material experts. Validation is carried out first to determine the feasibility of a media (Dewi et al., 2018; Ibrahim & Ishartiwi, 2017). The benefits obtained from expert validation are that suggestions will be accepted in the form of suggestions and comments about the weaknesses and strengths of the developed product (Solihudin, 2018). Suggestions for improvement are given to improve the product. The scores and suggestions from the three experts were followed up to improve product performance and used as a basis for feasibility for further trials, which are presented in Table 2.

As shown in Table 2, the assessment results show that the percentage of products is 81.00%-100.00% and is included in the "outstanding" category. Thus, the product developed is declared valid. Based on the validation results, there were several revisions related to unclear instructions, writing errors, and the function of the buttons contained in the game. For this reason, stage 2 validation was not carried out because it was not related to the primary material and substance of the game. Media that is said to be feasible and representative is in accordance with the learning material (Rezeqi & Handayani, 2018). Figures 10-14 present the revisions made based on input from experts.

Table 2. The results of the media validation assessment by media, language, and material

Indicators	Score
Media Experts	
Conformity with the material	4
Attractiveness	5
Easeused	4
Communicative	5
Quality of display	5
Percentage	92.00%
Category	Very feasible
Linguist	
Sentence structure easy to understand	5
Conformity	5
Effectiveness	4
The appearance of text and images	5
Communicative	4
Percentage	92.00%
Category	Very feasible
Learning material experts	
Relevant to competence	4
Apply scientific thinking skills	5
Clarity, Coherence, logicality,	5
suitability of images	5
Abstract concepts become concrete	5
Percentage	96.00%
Category	Very feasible

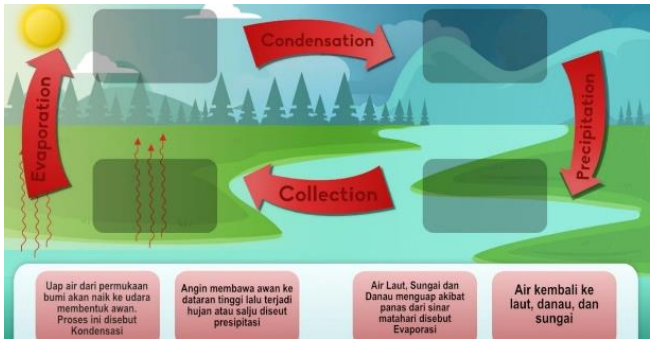


Figure 10. No clue

Figure 11. There are hints

Figure 12. Typo of the word solar cycle

Figure 13. No typo

Figure 14. No button hint

Figure 14. There is a hint button

Validator button to give appreciation to learning media because it presents steps of the scientific method in a game that supports independent learning and is by 21st-century education. In addition, this technology-based learning media is also expected to assist teachers in facilitating the learning styles of their students who are different at one time. After validation, the next stage is testing on students.

This stage aims to obtain empirical evidence about user responses. The trial was conducted in three elementary schools with 87 students. In the first stage, small group trials were conducted on 26 students in one class to identify initial problems in the application of learning media. In the second stage, a large group trial was conducted on 58 students in two classes. The results obtained are that students are interested in learning to use the game learning media 'Curious Scientist' because they get a new experience of learning through games. Besides that, students better understand the material presented, so they are more motivated to learn. Student responses to the satisfaction of using games in learning show that there are no difficulties in using games, game instructions and language are easy to understand, and the use of attractive colors and images. Student interest in the form of interests, attitudes, motivation, beliefs, and beliefs that will affect the level of understanding (Wibowo & Ariyatun, 2020) is presented in Table 3.

Tabel 3. Student response questionnaires

Indicators	Small group trials (%)	Large group trials (%)
Learning design	96.30	89.30
Operational	95.40	89.50
Visual Communication	97.70	90.30
Average	96.40	89.70

Interviews were also conducted with several students regarding the understanding of the steps of the scientific method. Students said that they now understand the steps of the scientific method and feel happy doing experiments to prove hypotheses. The application of the game learning media 'Curious Scientist', which was carried out in small and large group trials, showed that the media could facilitate students applying scientific steps in learning the water cycle. Indicators in learning design, operations, and visual communication used in the game obtained very feasible criteria with an average of 96.40% in small group trials and 89.70% in large group trials. The existence of a game level based on the scientific method's steps can bring students oriented to learning through a scientific approach. Using suitable media in learning will improve students' critical thinking skills (Yuniarti, 2020). The results obtained showed differences because the number of subjects in the large group was more.

The teacher's response questionnaire obtained an outstanding category. Table 4 shows the scores obtained for the relevant material, the application of the steps of the scientific method, the attractiveness of the image, and the simplification of abstract concepts.

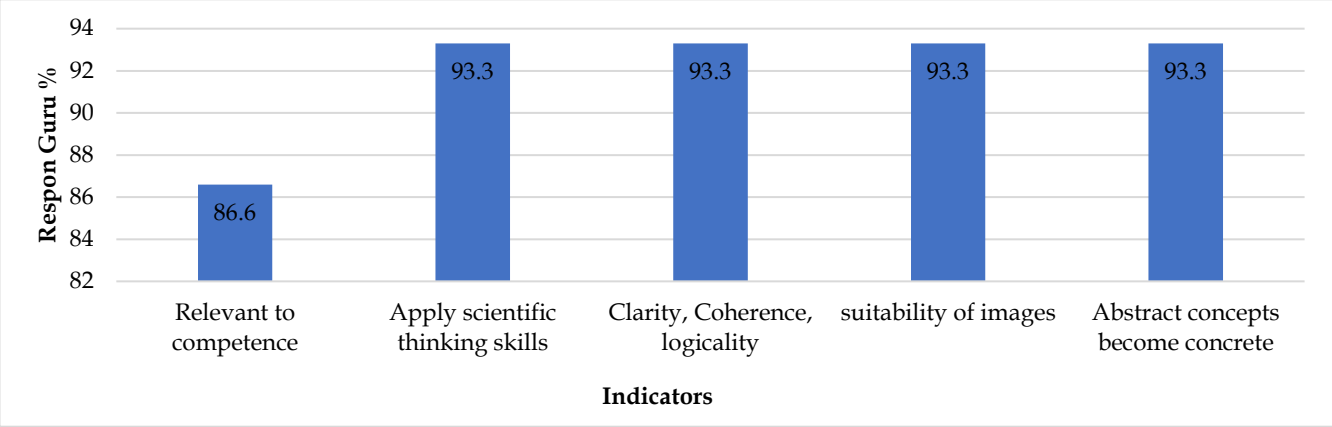


Figure 15. Teacher's response questionnaire

The teacher's assessment of the indicators of media relevance to competence, application of scientific method steps, clarity, coherence, logic, attractiveness of images, and simplification of abstract concepts obtained very feasible criteria with a score above 80.00%. One of the teachers suggested that competence in the media be added to the impact and benefits of the water cycle.

The results showed that the application of the game learning media 'Curious Scientist' was attractive to students, as evidenced by the results of trials carried out by obtaining appropriate criteria. This is in accordance with the research conducted by Kusumawardhani (2019) that the use of Android-based audio-visual media can lead to better learning motivation in students. Game-based learning can not only motivate and increase students' enjoyment of learning but can also increase knowledge and skills (Hooshyar et al., 2021). Learning through games is able to increase interest and pleasure in students when using it (Plecher *et al.*, 2018). Ariyani's research (2021) that media combined with text, images, animation, and sound/audio can attract students' attention so that students can better understand the learning material. The use of audio and music contained in the game is able to influence the dynamics of the class in terms of interaction, response, and enthusiasm (A. I. Wang & Lieberoth, 2016). Games are considered to have the potential to increase students' learning motivation, make learning more interesting, and improve cognitive skills (Prensky, 2002). Educational game media are also considered effective, flexible, and provide space to build their own learning concepts (Nicolawhitton, 2012). Hamari (2016) states that game challenges can improve learning abilities. Indirectly by using the learning media game 'Curious Scientist,' students have learned to use the scientific method approach and apply scientific thinking skills.

Conclusion

Games *(games)* in learning that utilize technology attract interest in learning. The development '*Curious Scientist*' *game* on the water cycle material for grade V elementary school obtained feasible criteria from the three validators. The results of the student response questionnaire for the small group trial of 96.40% and the large group trial of 89.70% showed that the learning media was very feasible. The teacher's response questionnaire showed results above 80.00%, so it was categorized as very feasible. The media is in accordance with the 2013 Curriculum, which uses a scientific approach. Students are expected to think scientifically in

solving problems. Scientific thinking skills are formed through the steps contained in the scientific method.

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