

The Hungry Ant: Development of Video-Based Learning on Polyhedron

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Abstract—A polyhedron is a mathematical material studied from elementary to high school levels. At the elementary level, fundamental polyhedron significantly influences students' ability to learn the related material at the next level. This research focuses on learning media development and aims to answer the challenge of using technology that rapidly grows in the 21st century. The research develops a learning media in videos on primary school topics with polyhedron as the subject. The 4D model was used from the define up to the development stage. The small-scale try-out and dissemination of the learning video can be conducted in another research. With five material and media experts, the retrieval of validation data was conducted using a questionnaire. The results showed that the hungry ant video passed the validation and only needed a few revisions. The hungry ant video may help students visualize the shape of the polyhedron, find the diagonal space, and prove the area and volume formulas. Future research needs to analyze the effect of the hungry ant video on the students' mathematical ability.

Keywords—dynamic mathematics software, polyhedron, hungry ant, video-based learning

1 Introduction

Since knowledge and mathematics are related, most daily life problems are mathematical [1]–[4]. There is a need to master the polyhedron concept to solve most problems [5]–[7]. The polyhedron is taught to primary school students in the concrete thinking stage [8]. Primary students may understand relatively better when they visualize the formula rather than just memorizing it [9], [10]. When a concept is mastered, it is not easily forgotten and can be applied daily [11], [12]. For this reason, mathematical lessons for primary school students need to be closely related to daily life.

Studies show that a realistic teaching method is better than the conventional teaching method [13], [14].

According to some studies, teachers face challenges explaining the polyhedron concept due to misunderstandings and misconceptions [15]. It is difficult for students to understand when only given the formula and sample question to polyhedron without clearly explaining it using pictures because they cannot understand the formula's origin [16].

Learning mathematics is focused on answering questions correctly and instilling basic concepts in students [17], [18]. Abstract mathematics lessons require technical help to easily understand abstract basic mathematical concepts [19], [20]. There are various forms of learning media, though the most common ones for explaining polyhedrons are cubes and blocks. Technology can also be used to explain mathematical concepts [21]–[29]. There is various mathematics software that can be downloaded from the internet for free. Teachers may develop this software to make a unique, creative, and innovative learning media based on their needs [30], [31].

The objectives of this research are:

1. Describing students' difficulties with polyhedron material based on literature review.
2. Designing learning media using Hawgent and Camtasia to help students understand polyhedron material.
3. Validating and preparing polyhedron learning media material to be implemented in schools.

Based on the problems described, this research focused on developing the learning media for polyhedrons. The result is expected to produce a learning media that can help teachers explain polyhedrons, increases the students' learning interest, and improve teachers' creativity to develop the learning media for primary students.

2 Literature review

2.1 Polyhedron

A polyhedron is a three-dimensional geometric material studied from elementary to college with different difficulty levels. In 2008, Yim, Jaehoon et al. [32] used polyhedron material to analyze the ability of fifth and 6th-grade mathematically gifted students. According to Gowers [7], polyhedron problems exist and are developed at the International Mathematical Olympiad (I.M.O.). The mastery of the basic concepts of this material is essential for elementary students to work on different polyhedron problems efficiently. Therefore, a polyhedron is a complex material supporting research regarding the difficulties students face in mastering polyhedron material.

Studies show that polyhedron is a complex problem for students to solve. The student's biggest mistake is misinterpreting the story problem, calculating, and taking information from the picture [15]. The latest research in 2020 stated that 8th-grade students have reading, understanding, transformation, processing ability, and notation errors when working on polyhedron problems. This means that junior high school

students still faced several mistakes while working on 5th-grade elementary questions. Therefore, polyhedron material was challenging, and teachers needed to focus more on instilling the basic concepts of polyhedrons in students. If teachers only focus on student grades, senior high school students may still not work on polyhedron problems at the elementary and junior high school levels.

The researchers found several types of research developing learning media on polyhedron material. Andriani et al. [33] developed lesson plans, student worksheets, and pretest-posttest questions on polyhedron material using the 4D method. After going through the validation stage, developed lesson plans, student worksheets, and pretest-posttest questions improve mathematical problem-solving skills on polyhedron material.

Sugiarta and Nugraha [5] applied a blended learning strategy using Edmodo to teach polyhedron material at grade 8 in junior high school. However, this was an additional class outside the classroom through discussions. The results showed that blended learning could improve students' understanding of the polyhedron material.

A few studies developed learning media using dynamic mathematics software plus Camtasia studio to teach polyhedron. The novelty of this research is the development of learning media using Hawgent dynamic mathematics software and Camtasia studio to become engaging learning media for 5th-grade elementary school students. It is used as a basic introduction to polyhedron at the junior and senior high school levels. Hungry ant is a learning video utilizing funny animation that is suitable for use and can also increase the learning interest of grade 5 elementary school students.

2.2 Technology in mathematics education

P.I.S.A. 2018 emphasized two necessary abilities in learning mathematics, specifically critical and creative thinking [34]. To improve these high-level abilities, teachers need to develop students' curiosity and interest in learning. When students have high curiosity, they will think creatively and critically.

In learning mathematics, teachers need to use appropriate learning media to help improve students' mathematical thinking abilities [35]. Technology use is currently the best way to improve mathematical abilities, optimize the interaction between students and teachers, and make lessons more meaningful [36], [37].

X Lan et al. [38] used dynamic mathematics software in triangle lessons to improve the problem-solving abilities of elementary school students on triangle material. This method helped successfully improve problem-solving abilities. Another research discussing the use of technology at the elementary school level concluded that there is a need to analyze and focus on this issue.

Apart from software, the iPad has been used as a medium for learning mathematics [39]. This research was conducted in a 1st-grade elementary school in Jordan. It proved that the use of an iPad in mathematics is beneficial for teachers. The experimental class that did not use the iPad had better scores than the control class.

The research concluded that technology use is needed to improve students' mathematical and high-level abilities and help them understand basic concepts.

2.3 Video-based learning

Teaching and learning activities using video-based learning have been widely used in various education fields, including medicine and science [40], [41]. Video-based learning makes teaching and learning activities more effective and efficient, improves students' abilities, and creates a different atmosphere than traditional classroom methods.

Pal and Patra [42] researched the coronavirus pandemic, where all students in India had to study at home. The results showed that video learning was easy to use and understand. This is in line with research by Tommy Tanu Wijaya [43] in China, which showed that all students during the coronavirus pandemic use video learning, apart from taking online classes.

Codreanu E et al. [44] found a relationship between Mathematical argumentation and video-based learning environments. Recent research in 2021 also showed that students who actively study and watch video learning have higher achievements than those who are passive and only take classes [45]. Another research examined how master's degree students are given the task of making video learning on statistical material [46].

Therefore, video-based learning has become a trend in teaching methods. Video learning media are continuously developed to facilitate teaching and learning activities and get satisfying results. This research develops fun, effective and efficient learning media on polyhedron material that can be used to teach elementary and junior high school students.

3 Method

The hungry ant video used the research and development (R&D) method based on the 4D model [47], [48]. The concept chosen was polyhedron for primary school students. Figure 1 shows the 4D model stages In this research using a BPMN diagram. The initial research involved collecting data on polyhedron material, student difficulties, technology in mathematics, and information about video-based learning. Based on all the available information, the innovations and novelties of the research were determined and summarised. The video-based learning media on the polyhedron material was then designed according to the initial observations. The learning video has a unique, engaging, and fun theme for students' learning interests. Therefore, learning media has many benefits apart from improving students' mathematical abilities. The hungry ant video learning was created and revised for six months from September 2019 to March 2020 before it was sent to 5 validators. In case the video passes the media expert validation, it is validated by the material expert. Suppose one of the criteria is not feasible, the video learning is redesigned again. In the final stage, the video can be implemented in schools (carried out in future research).

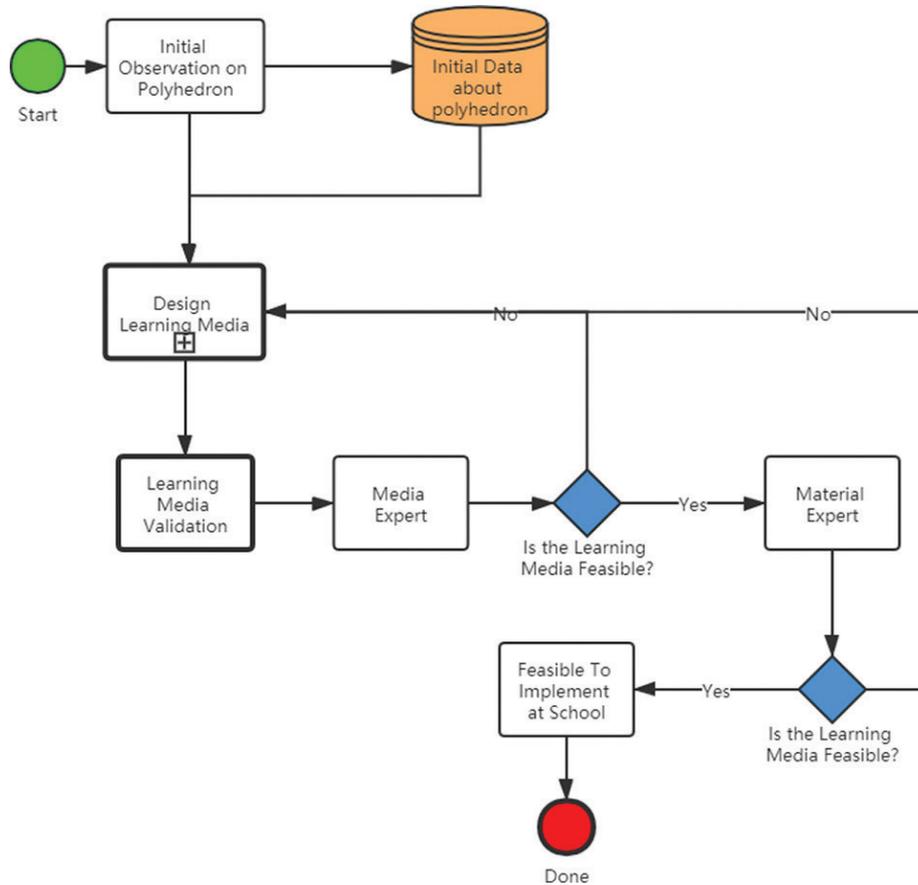


Fig. 1. BPMN Process

The hungry ant video was validated by five experts, including the professor, lecturer, and primary school teachers. The assessment aspects include the curriculum, learning goal, interest, the ability to increase students’ interest, ease of use, understandability, and an exciting display. The validation criteria are shown in Table 1.

Table 1. Validation criteria

Percentage	Validation category	Explanation
0 < 26%	Invalid	Learning media is not feasible
26–50%	Less Valid	Need much revision
51–75%	Quite Valid	Need a little revision
76–100%	Valid	No revision needed

4 Results

4.1 Product design

The hungry ant video is a learning media on a polyhedron, as shown in Figure 2. A total of 3 versions of the hungry ant video were designed, each explaining specific topics, including diagonal cubes, diagonal blocks, and tubes. The hungry ant video aims to prove the formula of diagonal polyhedron space and help students visualize geometry, achieve deep learning, improve mathematical high order thinking skills, and increase teachers' creativity when making the learning media.



Fig. 2. The hungry ant, learning video on polyhedron

This learning video uses a contextual approach to its development, utilizing cute animals found in students' daily lives. Students become more curious and focus during class time. Furthermore, a contextual approach can be combined with technology that improves students' mathematical ability.

The hungry ant video encourages students to think even in the introduction. On a cylindrical stone bench, a hungry little ant is searching for food at point A. There was a message from a friend saying that there is food at point B. The hungry little ant wanted to climb from point A to B. Where is the best route for the ant to arrive faster? Students feel that the question is unique and exciting, making them curious about solving the problem. While trying to answer the question given, their creative and critical thinking abilities improve. In general, students will try various ways to reach that point as teachers pause the video to let them answer. When students dare to answer questions, their mathematics communication skills and self-confidence also improves.

Teachers collected various answers from students, though none was wrong because their mathematical thinking process needed to be developed further. The communication between teachers and students needs to be effective. Furthermore, teachers should

make sure that all students are active during classes. After the discussion, the hungry ant video will sum up four routes. Students may guess which of the four routes is the fastest and shortest. All the routes are shown in Figure 3. Students are expected to give their answers with clear explanations. Alternatively, teachers can also ask which route is the longest and furthest. This will provoke students to think critically and creatively.

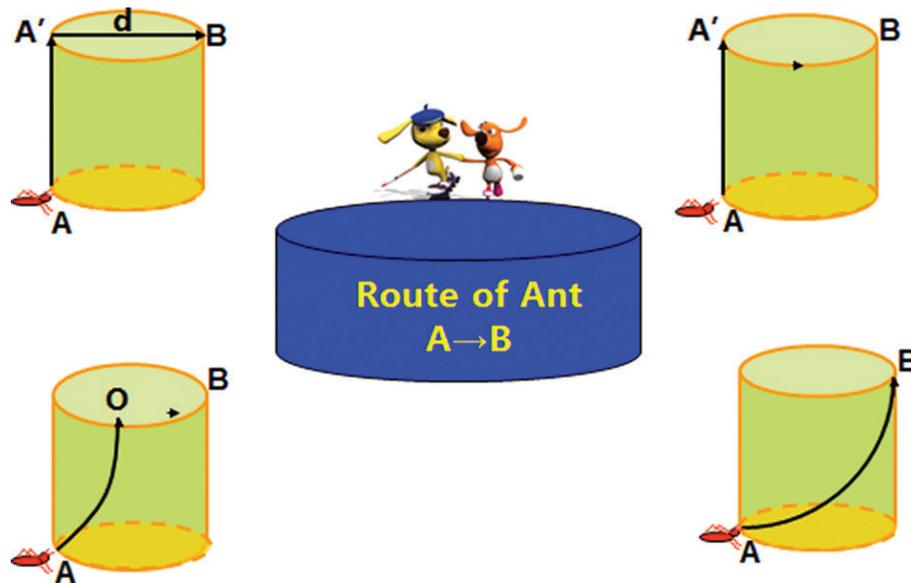


Fig. 3. Student answers about the ant route

4.2 Product validation

The hungry ant video was validated by several experts, as shown in Table 2. These experts include one professor specializing in technology development in learning, one doctor specializing in mathematics learning for primary schools, one lecturer who deals with mathematics software, and two lecturers specializing in the primary school mathematics curriculum.

Table 2. Validation expert background

No	Expert Title	Nationality	Expertise
1	Media expert (TJ)	China	T.P.A.C.K., T.P.M.K., S.T.E.M., mathematics learning media development
2	Lecturer (Z.Y.)	China	SOLO, Van Hiele, six-questions cognitive model
3	Material expert (NH)	Indonesia	Mental Model, Child psychology, Childs' thinking process
4	Lecturer (M.B.)	Indonesia	The primary school mathematics curriculum
5	Lecturer (A.P.)	Indonesia	Mathematics media development using mathematics software

Based on the validators' background, the validation for this learning media was conducted professionally. The learning video produced was accounted for and could produce a learning media with high quality and positive effect on primary school students. Table 3 shows the validators' scores.

Table 3. Percentage of Experts' score

No	Assessment Aspect	T.J.	Z.Y.	N.H.	M.B.	A.P.	Percentage
1	According to the curriculum	1	0	1	1	1	80%
2	According to the learning goal	1	1	1	1	1	100%
3	Interesting	1	1	1	1	0	80%
4	Can increase students' learning interest	1	1	0	1	1	80%
5	Easy to use	1	1	1	1	1	100%
6	Easy to understand	1	1	1	1	1	100%
7	It has an exciting design	1	1	1	1	0	80%
Average percentage							88.57%

The validators' average score percentage on the hungry ant video is 88.57%, with a bit of suggestion and revision. In other words, the learning video can be implemented in schools and can be disseminated after the revision. Table 4 shows the suggestions and revisions.

Table 4. Validators' critics and suggestions on the hungry ant video

Validator	Part	Critics and Suggestions	Conclusion
T.J.	Display	The shape of the geometry is not too big. It would be better to choose a smaller animal.	It can be used after the revision
Z.Y.	Learning video quality	The Learning video is too monotone. Interesting music can be added	Video better after the revision
N.H.	Display	Some words need to be changed as it is too hard for primary students	It can be used after the revision
M.B.	Teachers' response	The video duration is too long, can be compressed no more than 10 minutes	Video better after the revision
A.P.	Based on the students' response	Some parts can use colors so that it is more interesting	Video better after the revision

The video was revised based on the suggestions given by five validators. To respond to validator T.J.'s suggestion, the ant animation is changed into a smaller ant that is also more interesting. The learning video quality is repaired based on the suggestions from validator Z.Y., A.P., and N.H. Soft background music was added to the video, and some words were made clear and modified with exciting colors. To respond to validator M.B.'s suggestion, the initial duration of the video was 10 minutes and 39 seconds. It was changed and compressed without altering the content but minimizing the unneeded animations. The new video duration is 9 minutes and 51 seconds. According to previous researches, a learning video cannot be over 10 minutes. After 10 minutes, students will feel tired and may not concentrate on watching the video [49]. This means students cannot fully understand the concept taught in the learning video. However, suppose

video learning is short; students will understand all the information and be encouraged to watch the next one. Figures 4 and 5 show before and after the learning media revision process based on the experts.

Problem situation

On a cylindrical stone bench, there is a hungry little ant searching for food at point A. It received a message from its friend saying that there is food at point B. The hungry little ant wanted to climb from point A to point B. Where is the best route for the ant so that it can arrive faster?

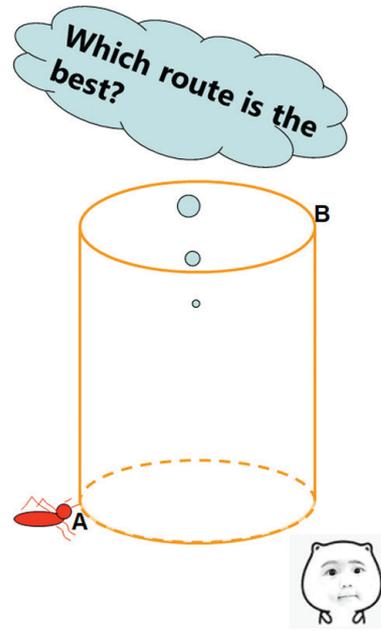


Fig. 4. Learning media before revision

Problem situation

On a can of coca-cola, there is a hungry little ant searching for food at point A. It received a message from his friend that there is food at point B. The hungry little ant wanted to climb from point A to point B. Where is the best route for the ant that the ant can arrive faster?

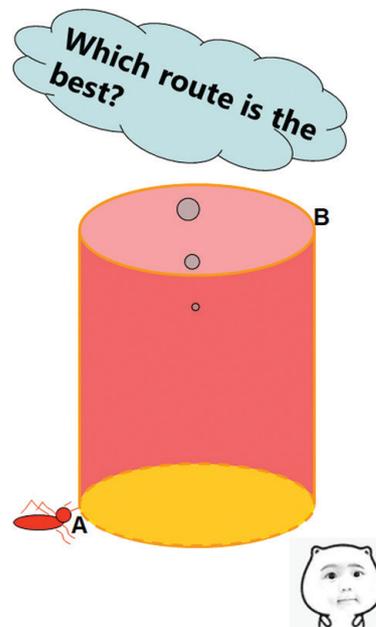


Fig. 5. Learning media after revision

An animal was chosen for this learning video because primary school students like cute and exciting themes. From ants, they may learn that ants work together to catch an object or food and learn some morals. This video teaches students how to make friends and help one another when they have difficulties learning mathematics.

Practice

An interesting problem is taken from the ancient Chinese mathematics book. The problem is: there is a pool, the water surface is a square with a side of 10 feet, and there is a new reed in the center of the pool. It is 1 foot above the water surface. If you pull this reed vertically to the shore, its top just reaches the water surface on the shore. What is the depth of the pool and the length of the reed?

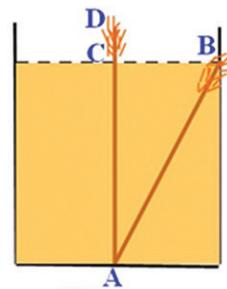


Fig. 6. Practice review question

The hungry ant video has three series, including an ant and a block and an ant and a cube. The learning video is characterized by high quality and being interesting without eliminating essential aspects. The basic concept is the primary purpose of making the learning video [43]. Learning media can help improve students' concentration and various aspects [50]–[55]. Primary school teachers need to be more creative in using learning media for students to understand mathematics better.

The development of this learning media contributes to mathematics lessons at the elementary school level. Specifically, it adds interesting and ready-to-use mathematics learning media for elementary school teachers in Indonesia. The hungry ant learning video will be distributed publicly to help elementary school teachers during the coronavirus pandemic. This is because video-based learning media needs to be used as a supplement for students when reviewing the material.

The use of the hungry ant video needs to be assessed continuously, even when elementary school teachers implement it in schools. It may also be revised if a teacher has input that can increase the quality of the video.

5 Conclusion

Primary school students are still in the concrete thinking stage, where they may study better by seeing, feeling, and trying something independently. For this reason, teachers need to create exciting and interactive learning media to catch the attention of

primary school students. This helps them concentrate and easily understand the lesson given taught. For instance, the hungry ant video helped students to master polyhedrons. The research was conducted from the define to validation stages. The video passed the validation with a little revision. The implementation and dissemination stages will be discussed in the following research. Primary school teachers need to be more creative in using learning media for students to understand mathematics better.

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