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Integrating Problem-Solving Skills in Developing Trigonometric Ratio Learning Videos for Right-Angled Triangles

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ABSTRACT

There is a need for innovative instructional media that incorporates technology to facilitate teaching for educators and enhance learning for students. This study aims to develop a valid and practical instructional video using the Renderforest application and the Discovery Learning method, integrated with mathematical problem-solving skills in teaching trigonometric ratios in right-angled triangles. The research follows a development approach focusing on mathematics instructional videos. The research and development methodology is based on product development steps. The product's feasibility is measured through validation and practicality testing. Data collection techniques include interviews, questionnaires, and surveys. Based on the research findings, the instructional video's validity was evaluated by experts, with a feasibility score of 78%, indicating its validity. Additionally, the media experts deemed it 80% feasible. The practicality test yielded a score of 80%, marking its practicality. Therefore, the developed instructional video using the Renderforest application and the Discovery Learning method, integrated with mathematical problem-solving skills in teaching trigonometric ratios in right-angled triangles, is considered valid and practical.

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Introduction

In the 19th century, education was primarily based on pen and paper, marking the era known as the industrial revolution. However, in the 21st century, education has been significantly shaped by the development of digital technologies such as the Internet, mobile phones, and computers [1]. High-level thinking skills have become increasingly essential in this new era [2]. High-level critical thinking skills encompass problem-solving, creative thinking, reasoning, argument formulation, and decision-making abilities [3]. Problem-solving skills are particularly emphasised in the 21st century [4]. In the digital age, all students are expected to possess critical thinking skills and the ability to use technology to identify and evaluate problems [5]. Computer-based learning materials are employed as collaborative tools between educators and students to enhance the understanding of subject matter more effectively and efficiently [6]. This is further supported by literature research demonstrating how technology can improve student motivation and engagement in the classroom. Animation videos are one type of mathematics instructional media that teachers can utilize to increase students' interest in learning [7]. The effectiveness of using videos as instructional media in mathematics can be observed through improved student motivation, response, and active participation levels [8]. Students' problem-solving skills can be enhanced through a blended learning model incorporating interactive videos [9].

In mathematics education, concrete experiences are crucial when students encounter contextual problems. To comprehend contextual issues in abstract learning, a systematic and appropriate strategy must be implemented to facilitate students' understanding [5]. One of the most effective strategies is a learning trajectory. A learning trajectory involves reflective thinking and teacher-student interaction, assisting teachers in presenting suitable models, teaching materials, and tasks for student-student interactions that cater to their individual needs. Teachers greatly benefit from using animated videos in the learning trajectory as they explain various concepts to students in a classroom setting [11]. In the digital era, learning through instructional videos has formed the foundation of nano-learning concepts [12]. Fast and engaging content provides students with the necessary information in an attention-grabbing manner [13]. Nano-learning refers to compressed information delivery in an attractive format, requiring minimal storage space for valuable and relevant content through platforms like TikTok, Twitter, and WhatsApp [14]. Nano-learning, or bite-sized learning, is a continuous learning process in which students acquire knowledge without spending an extended period, delivering clear and systematic instructions with the essential information concentrated into a single unit [12].

Specifically, students admit feeling bored and less interested in abstract learning materials. They also need help solving conceptual problems during the learning process. This corresponds to the feedback provided by mathematics teachers. So far, teachers have relied on textbook-based learning materials. However, these materials have yet to enhance students' motivation to solve problems effectively. Therefore, there is a need for educational media advancements that utilise state-of-the-art technology, enabling teachers to facilitate content delivery and students to comprehend better what they are learning. This is further supported by existing literature studies [15], emphasising the necessity for innovative mathematics instructional videos that create interactive experiences and enhance students' motivation in solving mathematical problems. Furthermore, the use of animated videos can assist teachers in explaining and illustrating key concepts in various learning environments [16]. Based on these considerations, this research aims to develop a valid and practical instructional video using the Renderforest application and the Discovery Learning method, integrating mathematical problem-solving skills in teaching trigonometric ratios in right-angled triangles.

Methods

The research and development process in this study was guided by the principles set forth by Borg and Gall. The main goal was to create an instructional video that integrated the Discovery Learning method with students' problem-solving abilities. The following steps were followed in the research and development process:

A. Step 1: Preliminary Study and Data Collection

To begin, observations and interviews were conducted with mathematics teachers at the selected school and with a group of students. These interactions aimed to identify the challenges faced by the students in their learning process. A suitable instructional model for the video was also developed based on the gathered information. A thorough literature review was conducted, focusing on the Discovery Learning model, which served as the foundation for the design of the instructional video.

B. Step 2: Planning

The research was carried out at a particular vocational high school in Magelang, Jawa Tengah, with the participation of students from two different classes, comprising 11 and 13 students, respectively. The next stage involved redesigning the teaching materials used by the teachers, such as the syllabus and lesson plans, to ensure they were aligned with the instructional video. The specific topic covered in the video was trigonometric ratios in right-angled triangles. Validation instruments were prepared, including expert validation sheets for content and media. Additionally, questionnaires were distributed to teachers and students to assess the practicality and effectiveness of the instructional materials.

C. Step 3: Initial Product Development

In this phase, an instrument for validating the instructional video was created. This instrument was a guide to ensure the video's accuracy and effectiveness. Following the validation process, the instructional video was developed according to the design plan established in the previous steps—the video aimed to provide the students with an engaging and interactive learning experience.

D. Step 4: Testing

The validated instructional video, focusing on the trigonometric ratios, was then tested on a group of students. This phase allowed for evaluating the video's impact on students' learning outcomes and problem-solving abilities. The aim was to create a valid and practical instructional video that effectively integrated the Discovery Learning method and improved students' problem-solving skills. The development steps were visually represented in Figure 1, illustrating the overall research scheme.

Results

The preliminary study and data collection phase revealed several observations. Most students were passive in answering questions during the learning process. When given trigonometry problems, students needed help analyzing, evaluating, and solving them correctly. They required more concrete experience with mathematical concepts, relying instead on instant problem-solving techniques. The mathematics textbook used in the 10th-grade curriculum was found to be challenging for students to understand due to its uncommunicative and complex language. Although the Discovery Learning model was implemented in teaching, teachers faced difficulties applying contextual problems in the classroom. Additionally, students' focus was often diverted by their gadgets. The interviews with teachers provided suggestions for using appropriate teaching models and media to motivate and engage students in mathematics learning.

Based on the findings from the preliminary study and data collection, the development of instructional videos using the Renderforest application was chosen. The videos focused on trigonometric ratios in right triangles using the Discovery Learning method integrated with students' problem-solving abilities. The following steps involved creating a syllabus and lesson plans as guidelines for teachers in the learning process. Validation instruments by subject matter experts and media experts were developed to validate the developed instructional videos. A questionnaire was also prepared to assess the practicality of the produced videos.

The initial product development phase involved collecting relevant materials on trigonometric ratios in right triangles. Three video scripts were created, each focusing on the sine, cosine, and tangent ratios. The Discovery Learning model scripts included the title,

learning objectives, and conceptual learning steps. Finally, instructional videos on sine, cosine, and tangent ratios in right triangles were produced and uploaded to YouTube. The videos consisted of an opening section to present learning objectives and contextual problems, a content section containing the instructional videos and the syntaxes of the Discovery Learning method, and a closing section summarizing the learned material on trigonometric ratios.

The validation and practicality testing phase included both qualitative and quantitative analyses. The comments and suggestions from the validators were quantitatively analyzed using a Likert scale to guide improvements in the instructional videos. The validity of the videos was assessed by subject matter and media experts, calculating the percentage scores for each validator. The total validation score was then interpreted according to the given criteria. The assessment involved the validity of content, presentation, and contextual aspects. The results indicated that the developed videos were valid in content, production, and contextual elements, allowing them to proceed to the testing phase.

The testing phase included validating the instructional videos by subject matter experts, who assessed the materials using a questionnaire with 32 statements. The results showed that the instructional videos were considered highly valid based on the criteria of content, presentation, and contextual aspects. Media experts then validated the videos and used a questionnaire with 21 statements. The assessment criteria included visual media, functionality, audio media, typography, and language. The results indicated that the videos were highly valid regarding visual media, functionality, audio media, typography, and language.

The practicality of using the instructional videos was analyzed based on user responses. The scores for each question were converted into percentages, and the overall scores were interpreted according to the practicality criteria. The practicality testing involved students from two classes. The results of the practicality testing, based on user response validation, showed that 80% of the respondents considered the videos practical.

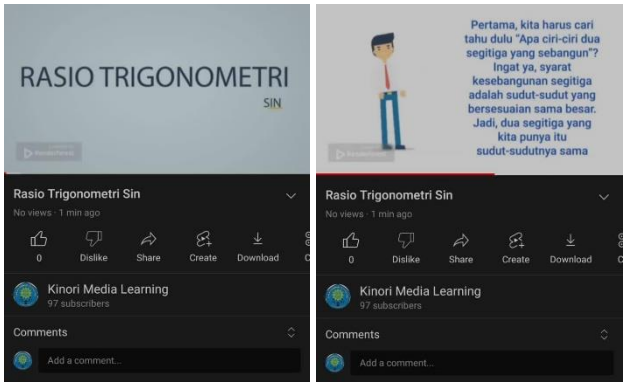


Fig. 1. Discovering Trigonometric Ratios in Sine (https://youtu.be/_KUCMaVxCOg)

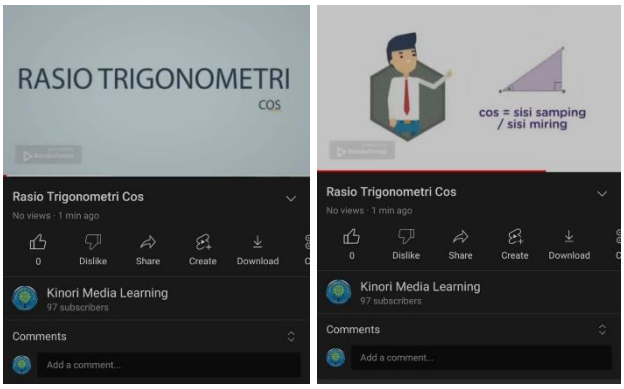


Fig. 2. Discovering Trigonometric Ratios in Cosine (https://youtu.be/PkUrhLe7TA0)

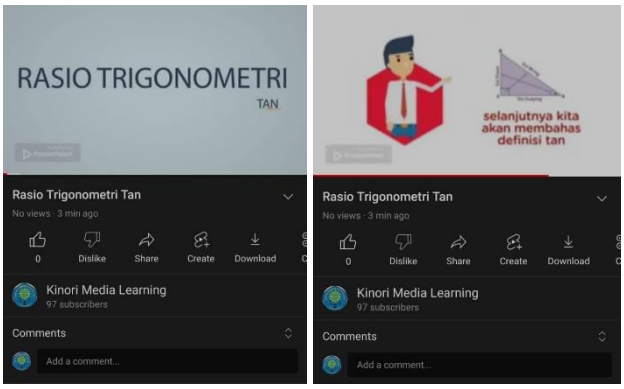


Fig. 3. Discovering Trigonometric Ratios in Tangent (https://youtu.be/0b8nFuUcF1M)

Discussion

Using video animation in mathematics education has great potential to improve learning performance. This approach utilizes visual and auditory stimuli to engage learners, enhance their understanding of mathematical concepts, and promote active learning. By incorporating learning and communication theories, we can further understand how video animation can positively impact mathematics education.

One theory that supports video animation in mathematics is the Cognitive Load Theory (CLT). According to CLT, learners have limited cognitive resources, and excessive cognitive load can hinder learning [17],[18]. Video animations effectively reduce cognitive load by presenting information in a visually and verbally appealing format. The dynamic visuals, narration, and text help students process and integrate mathematical details more efficiently. By offloading some cognitive burden, learners can focus on understanding and applying mathematical concepts, leading to improved learning performance.

Moreover, the Dual Coding Theory (DCT) explains why video animation benefits mathematics education. DCT suggests combining visual and verbal information enhances learning by engaging multiple sensory channels and facilitating information processing [19].

Video animations leverage this principle by synchronizing visual representations (such as geometric shapes, graphs, or diagrams) with verbal explanations. Integrating visual and verbal cues strengthens the connections between abstract mathematical ideas and concrete visual representations, making concepts more accessible and memorable for learners.

The Theory of Multimedia Learning (TML) also supports using video animation in mathematics education. According to TML, students learn better when presented with multimedia materials that cater to their visual and auditory preferences [20]. Video animations fulfil this requirement by delivering information through dynamic visuals, spoken explanations, and accompanying text. Combining these elements appeals to different learning styles, accommodating visual and auditory learners. This multimedia approach enhances engagement, motivation, and information retention, ultimately improving learning outcomes.

Conclusion

Based on the expert validation, the developed instructional videos were deemed valid with a percentage range of 74% to 82% and an average validity of 78%, according to subject matter experts. Similarly, the media experts validated the instructional videos with a percentage range of 78% to 83% and an average validity of 80%. Furthermore, the practicality test confirmed the practicality of the developed instructional videos. Therefore, the instructional videos developed using the Renderforest application and the Discovery Learning method, integrating problem-solving skills in trigonometric ratios in right-angled triangles, are valid and practical. Based on the findings, it is recommended that the use of instructional videos should be combined with effective teaching techniques to create diverse and engaging learning experiences.

Conflict of Interest

The authors should declare that there is no conflict of interest.

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