Refractor telescope design using web camera

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Abstract. The purpose of this study was to develop a refractor telescope using a web camera as learning media. It was the Research and Development (R&D) study which referred to the model modified by Sugiyono. The product was evaluated by a media expert and undergraduate students of Sub-Department of Physics Education, Tadulako University using questionnaires with a 4-point Likert scale. The product quality data obtained were analyzed using descriptive analysis. The quality of the product based on the analysis of the media expert's assessment was good with the average score of 2.92. Meanwhile, the results of student responses to the limited trial obtained a score of 3.20 which indicated the agreement of usability. The test results and questionnaire analysis showed that the refractor telescope using the developed Web Camera (WebCam) is feasible to be used as learning media.

1. Introduction

Physics requires a complex of scientific skills. Physics learning requires students to observe, measure, and analyse natural phenomena, scrutinize them with their knowledge, and draw conclusions based on these processes [1]. It involves the skills in the three domains of learning, namely cognitive, affective and psychomotor [2,3]. Students need sufficient cognitive skill to understand the theories, principles and concepts of physics. Meanwhile, the affective and psychomotor skills are required especially during hands-on activities [4,5]. These skills enable students to work in active and collaborative learning during experiments [6,7]. However, the science learning activities mostly still prioritize the achievement of cognitive domain [8,9].

Accordingly, science learning cannot be separated from laboratory activities since it was the media for the development of scientific skills [10–12]. Students need practical work to solve problems, especially those that are closely related to everyday life. In addition, there are some abstract physics concepts that are difficult to understand. Experiments help students to not only remember the concepts, but also understand its application in real life. Direct observation and experiment will give students the opportunity to see and prove the theory that they have learned. This will certainly increase creativity, and skills and consequently boost their learning motivation [13,14].

The use of pictures in learning is imperative, both in the realm of understanding new words or new concepts [15–18]. The use of pictures and images in science becomes more crucial owing to many natural phenomena, objects or processes are too small, too far, too fast and too slow to observe and study directly [19]. In addition, since the scientific process consists not only of understanding and discovery, but also of communication [19], the use of any type of visual media allows the visualization and illustration of abstract concepts [20–22].

On that account, this study aimed to develop a refractor telescope using a web camera as learning
media. The relevant research has been conducted by Robin et al [23] who designed a telescope with two webcams to acquire data. Our study only used one webcam thus it would be more affordable. The product is also easy to move and light thus we hope that it can be used as a tool in science learning.

2. Methods

2.1. Types of Research

This research belongs to the Research and Development (R&D), which is used to produce certain products and to test the effectiveness of these products [24].

Refractor telescope design research using a web camera for learning media adapted the steps of the development research model by Sugiyono [24]. The general research steps are shown in Figure 1.

![Figure 1. Steps of research and development method](image)

2.2. The steps in the research are only up to the product revision stage

The preliminary activity was to investigate the potential opportunities and problems. The next step was gathering the materials needed to make media. The third step was product manufacturing. We started with drawing the circuit of the device, and eventually developed the product. After that, the developed product was sent to the validator for assessment. This validation was used to find out whether the product made is worth testing or not. Validation was done through discussion with the experts. The expert here was a media expert who is competent in their fields. Revision was conducted to the product based on the evaluation before the product underwent field-test. The revision step was the last step of this research.

2.3. Field-test Data Collection Procedures

Since the field-test was only a limited testing, the subjects of this study involved only 11 undergraduate students of the Sub-Department of Physics Education in Tadulako University who enrolled in 2015 academic year. This evaluation aimed to assess the feasibility of the practicum tool using a questionnaire [25].

The analytical technique used to analyze the data from the validation results is the calculation of the average value. It was based on Arikunto's opinion that the final score for each research questionnaire item was the average score [26], then use the scores to allocate the product into categories based on the interpretation of Widoyoko [27].
3. Results and Discussion

3.1. Tool Quality Assessment by Expert

The aspects assessed by the expert included the quality of the tools and the effectiveness of the tools, the availability of second-hand goods that are easily affordable, and the suitability of the tools with the concept of physics. The aspects assessed include the aspects of tool quality and tool efficiency, the affordability of tools and materials as well as the suitability of the tool with physics concepts. The results of the assessment of all aspects were in the good category. The results of the assessment by experts are presented in a diagram as shown in Figure 2.

From the assessment of media experts, there are several notes that were still considered lacking, including the criteria for the ease of tool operation in accordance with the working principles, the ease in the tool management, the portrayal of abstract to more concrete abstract by the tool, and the conceptual knowledge demonstrated by the tool. The expert pointed out that the tool was still sensitive during its application. The users should be careful when adjusting the focus of the telescope and webcam. Moreover, there were several inputs stating that the tool was not yet clear in showing abstract concepts to be more concrete. In addition, the expert suggested placing the camera on the lens permanently so that it is easy to operate.

3.2. Response Results on Limited Test

Limited test was conducted to measure some aspects, including the physical appearance of the practicum tool, aspects of learning motivation with tools, aspects of tool operation, aspects of tool quality and aspects of observation. The assessment on the limited trial was carried out after the product underwent the revisions based on the expert validation. The results of the responses in the limited trial showed that students were interested in the developed telescope. They were enthusiastic because they have never used a tool similar to the product. The data indicated that most agree to use the refractor telescope using a web camera designed by the researcher in their learning activities. The results of the students’ responses are displayed in Figure 3. Generally, students suggested making the tool more interesting in appearance and usability.

The general suggestions and criticisms from the responses included:
1) Tool appearance should be made more attractive and portable
2) The tool should be further developed so that it can be used in bright places or rooms.
3.3. The Developed Refractor Telescope

The refractor telescope designed using a web camera (webcam) was presented in Figure 4 while the working principle scheme was displayed in Figure 5.

![Refractor Telescope Using a Web Camera (webcam) (Figure 4)](image)

**Figure 4.** Refractor Telescope Using a Web Camera (webcam).

![Tool working principles (Figure 5)](image)

**Figure 5.** Tool working principles
Observations of refractor telescopes using a web camera (webcam) can be seen in Figure 6.

![Figure 6. Observations of the moon with refractor telescopes using webcams](image)

Since the used of digital images can help students to overcome misconception [19], this tool can be used as a substitute for telescopes in laboratories that are no longer functioning. The students also could follow the stages and working principles of this design and make their own telescope.

4. Conclusion
Based on data analysis and discussion, a refractor telescope has been made using a web camera (webcam). The results of the assessment given by experts and physics education students on the feasibility of the product indicated that the tool has met the criteria of the feasibility of the product to be used as learning media.

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