Video Based Experiment to Determine Focal Length of a Positive Lens in Physics Learning

Raida, B H Iswanto and I Sugihartono
Department of Physics Education, State University of Jakarta, Jakarta, Indonesia
Jl. Rawamangun Muka, Jakarta 13220, Indonesia
Email: raida_1310819011@mhs.unj.ac.id , bhi@unj.ac.id

Abstract. During the COVID-19 pandemic, conducting experiments in the lab has become constrained due to physical distancing protocols. Experiments activities are important to help students understand the concepts of physics, one of which is the optical learning of image formation on a positive lens. Video based experiment is one of the solutions that can be used as an alternative to do experiments activities in the laboratory due to the COVID-19 pandemic. This study aimed to design and develop a video based experiment to make students to determine focal length of a positive lens. This study used the R&D method with ADDIE development model reference (Analysis, Design, Development, Implementation, and Evaluation). According to the evaluation of material experts and media experts video based experiment covering aspects of content, material, language and presentation of media experts by 81% and material experts obtained by 84%, categorized as very high. Based on the results of the expert test, it can be concluded that the video based experiment is feasible to be used as an optical learning media for students in high school.

1. Introduction
Physics is a science that deals with facts, processes, theories, concepts and generalizations, which is not only about memorizing, but also processes that allow students to relate one concept to another to express meaningful relationships [1]. Therefore, one of the effective methods that can be used in learning physics is experiments. Experiments or practical activities have benefits in learning physics, namely to train students to understand physics concepts and improve skills in conducting scientific experiments [2]. So experiments are a significant activity in learning physics. Currently cases of transmission of the Covid-19 virus are growing very fast. This virus has spread to countries including Indonesia. The spread of Covid-19 covering all fields, such as social, cultural, economic, and educational, those fields perceives its influence in this situation. In the field of education, the Covid-19 pandemic has had a tremendous impact on schools, teachers, and students [3].

Laboratory-based video is one of solutions that can be used as an alternative to do experiments activities in the laboratory. Research conducted by Rodriguez [4] video based experiment allows students to have experiments that show students what happens in the laboratory, according to the appropriate theory [4]. Another study states video based experiment may improve students' understanding of concepts [5]. In addition, implementing a video based experiment can improve students' understanding in learning the study
of acceleration [6]. However, the use of a video based experiment in determining the focal length of the lens has not been found. To determine the focal length can be obtained in the following equation [7]:

\[ \frac{1}{p} + \frac{1}{q} = \frac{1}{f} \]  

(1)

Information:
p is positive if the object is in front of the lens (real object).
p is negative if the object is behind the lens (virtual object).
q is positive if the image is behind the lens (real image).
q is negative if the image is in front of the lens (virtual image).
f is positive if the lens is converging (convex).
f is negative if the lens is diverging (concave).

This equation, which called the lens equation, can be used to relate the image distance and object distance to the lens. Research by Ceuppens [8] states that students have difficulty in determining optical points such as focus points, objects and shadows so that they cannot determine ray diagrams in image analysis of virtual or real image properties. A video based experiment showing a convex lens practice will help students understand the image formation of a positive lens.

The main objective of this research is to design and develop a video based experiment. In this paper, the focus of the video is an analysis of the determination focal length of a positive lens. The research questions for this research are: How to design and develop a video based experiment to determine focal length in a positive lens?

2. Method
The model that will be developed using this R&D method is the ADDIE model. The ADDIE model is one of the approach models used in media development, especially in research and development (R&D). Through the ADDIE model (Analysis, Design, Development, Implementation and Evaluation) [9]. The first phase is the analysis phase, in this phase the researcher conducted a needs analysis to determine students’ understanding of determining the focus distance on the lens by using laboratory-based video as a substitute for experiments at school. At the design and development phase, researchers designed and developed video based experiment include making storyboard, recording, lighting and video editing. The camera used is a Sony A600 with specifications 24.3 MP APS-C Exmor Sensor, full HD 1080p XAVCS S video at 20/0 fps. Video based experiment was developed with scenarios of camera layout and optical room layout are made. The camera layout is used by using video capture techniques with bird eye view, high angle and view level shooting techniques. This technique is used to get different camera angles so that the video does not look monotonous. The camera layout is shown in Figure 1.
After the video was made, then the video was developed through the editing process using Powtoon software to add animation, music and other tools. In the Implementation Phase, the video product developed was implemented in the physics experiments of optical instruments. After that, the evaluation phase was carried out; showing a video based experiment video to the experts. In fact, the evaluation phase was carried out in each phase to produce a video based experiment based on the assessment and input from experts through a questionnaire.

3. Results and Discussion

3.1 Design and develop Video Based experiment

This research produces a product in the form of video based experiment to determine focal length on positive lenses. There are several didactic advantages in using video based experiment for teaching concepts in physics: (1) the videos can be freely distributed on the web and explored with students within the classroom, or as a homework assignment to improve students’ understanding of specific content, (2) the students can carry out the analysis of the experiments at any time, as many times as they want, and (3) the students apply and associate physical concepts in real situations [10]. The contents of the video are divided into several schemes that show practical activities with stages up to the end, namely (1) introducing tools and materials presented in figure 3. In tool introduction, video-based experiments showed one by one the tools used in the image formation experiment with the object name according to the displayed object. (2) tool assembly process was presented in Figure 4. The process of assembling the tools in the video-based experiment is shown.
systematically starting from the assembly of precision rails, placement of clamping stacks, placement of objects, lenses and screens to the process of turning on a 12 Volt lamp as a light source to produce shadows. (3) the practical process of determining the focus of the lens was presented in Figure 5. The practicum was shown in a video-based experiment by changing the object distance according to the optical space I, II and III of the lens.

Figure 3. Introduction to Tools and Materials.

Figure 4. Toolkit.

Figure 5. Experiments.
The video was made using a +5 cm and +20 cm positive lens focus. The optical rooms used are room I, room II and room III. The video shows the experiments using a positive lens with different object distances according to the optical space so as to produce different image distances as in Table 1.

**Table 1.** Object distance and shadow distance used in video based experiment (accuracy: 0.01 cm)

| Length of object (cm) | Length of shadow (cm) |
|-----------------------|-----------------------|
| 5.00                  | 2.50                  |
| 8.00                  | 13.00                 |
| 15.00                 | 7.50                  |
| 9.00                  | 16.00                 |
| 25.00                 | 32.00                 |
| 42.00                 | 25.00                 |

The video editing process used the powtoon application. Powtoon is a freeware service or online program that can be used by internet users [11] the use of video editing with powtoon can be used to make animated videos, and some image manipulations equipped with visual and audio features that can attract students to always pay attention to the videos made presented in figure 6. The results of the determination of focal length were obtained from the results of the analysis of the focus distance, object distance and image distance as well as the characteristics of the image in each optical space which can be seen from the video based experiment presented in Figure 7.

*Figure 6. Animation with powtoon app.*
Students can analyze videos by linking video based experiment, the results of calculations and analyzes performed by themselves. To support student analysis materials in knowing the results of the image formation, student worksheets were assisted. Students can stop the video to find out the specific distance of the object and the distance of the image, after that students can determine the focal of the positive lens used in accordance with the experiment shown by video based experiment.

3.2 Video rating by experts

Based on the results of media expert validation, suggestions for improvement or revision were obtained, namely: the video based experiment voice over was quite loud so that the narrator's dubbing was not clear and the light background color was replaced with a dark color.

The results of video based experiment eligibility based on media expert assessments are presented in table 2.

| Aspect     | V Average | Category   |
|------------|-----------|------------|
| Contents   | 82%       | Very Good  |
| Language   | 80%       | Very Good  |
| Presentation | 80%       | Very Good  |

Table 2. The results of the eligibility of media experts

Based on the results of the validation of the material, suggestions for improvement or revision were obtained, namely: the contents of part A on the LKPD questions related to optics and give questions about the results of experiments regarding the effect of object distance, focus point and others on the nature of the image formed. The results of the feasibility video based experiment based on the material expert's assessment were presented in table 3.

| Aspect     | V Average | Category   |
|------------|-----------|------------|
| Material   | 92%       | Very Good  |
| Language   | 80%       | Very Good  |
| Presentation | 80%       | Very Good  |

Table 3. The results of the eligibility of media experts
4. Conclusion
Based on the results and discussion, it can be concluded that this research has produced learning media in the form of video based experiment. Video has gone through a series of stages of development. The video series was combined with several camera layout scenarios, optical room scenarios and student analysis results. Based on the results of the video based experiment expert assessment that has been developed, it has a very good feasibility, so the video was worthy of being used as a media of learning optics in high school.

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