An optical instrument worksheet in physics class

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Abstract. Optical instruments are one of the basic subjects in physics. The use of a very wide range of optical instruments in life creates a demanding environment so that students have adequate skills. This research aims to develop worksheets that can support student skills. The worksheet prepared in the form of a learning tutorial is expected to improve higher-order thinking skills. This study uses a 4D development model (Define, Design, Development, Dissemination) with the stages of implementation to Development. The results showed that there was a significant increase in students’ higher-order thinking skills. The student also stated that the worksheets developed had an attraction with a percentage of 79.6% for the implementation aspect, 74.2% for the language aspect, 82.1% for the design aspect, and 75.3% for the acceptance aspect.

1. Introduction

The development of 21st-century technology is identical to digitization. From the physics point of view, this is closely related to the widespread application of the concepts of electronics, optics, and quantum theory. The three groups are found in so many new technologies. Nevertheless, other fields of physics still have an important role in creating modern equipment.

The modern equipment certainly requires modern human resources. It aims to complement technological advancement and user submissions. One of the user submissions group who needs more skills upgrade is the high school students. The high school students as the next generation require the maturation of mind-set and skills to face of digitization technological era that keeps growing. One of the skills that high school students need to face the 21st century is critical thinking skills [1]. Some research has developed efforts to improve critical thinking skills. Some of them were developed a form of practicing and learning that will improve critical thinking skills [2–4], developed learning instruments [5,6], or developed a worksheet [7-11].

Development of a worksheet as a learning media has specialty because it can be referenced to study matter independently. Because the worksheet has learning content that provide step by steps which students need to learn so the teacher will be helped by the worksheet and will be a systematically learning processed [12].

This research aims to develop worksheets that can increase student critical thinking skills. The worksheet is developed by a tutorial that has the purpose of giving some practical steps to the students in the learning process. This worksheet hopefully gives an example to the teacher about how to improve student's critical thinking skills.
2. Experimental methods
This study uses a 4D development model (Define, Design, Development, Dissemination), but in this paper study will be described to development stage. The step of define done by tracing school needs by observing and literature research. The results of this step show that the optical instrument concept is needed to be complete of the worksheets in a learning process. The step of design held by making a worksheet design that will be used by the students. The worksheets’ design given to the expert to a validating test. After obtaining a suggestion and then repaired, the design of the worksheet continued to the development step and doing a limited scale test of respondents. The limited scale test of respondents done by 30 research subjects that randomly selected. The testing step is done by collecting data of critical thinking skills improvement and students’ worksheets’ responses.

3. Results and discussion

3.1. Define
Define step done by analyzing of four aspects, they are front-end analysis, subject analysis, assignment analysis, and concept analysis. The results from front-end analysis show that the student and the teacher are using the learning sources are not so well, students and teachers just using a textbook. Furthermore, learning media are using rarely or just temporary. This condition needs to be transformed because the students who have easy information accessed. This monotonous learning will instead the student to increase their ability [13].

The subject analysis shows that students have an interest to use the learning media. Some learning theory said that each of the student has different learning style. Furthermore, providing the material in multiple representation will be helping students to understand [14]. Students also need a form of practicing mindset to be adapted with the 21st-century competition. So the students need some specific assignment form that not contained in the general textbook.

The next analyze is about physics concepts. The investigation results from some research and technology products, give a simple conclusion that they are three groups branch of physics that have a big contribution to create modern technology. The three groups branch of physics are electronics, optics, and quantum. Based on the subject position as a technology user, so this analyze has a conclusion that the needed worksheets are on the optics content.

3.2. Design
This step to make a worksheet design and some prototype of worksheets. The worksheet which is developed is a print tutorial worksheet. The worksheet component is developed shown in Figure 1.
The approach test results from an expert about the worksheet which is developed shown in Table 1.

Table 1. Recapitulation of validation assessment by expert.

| No. | Aspect          | Percentage | Category |
|-----|-----------------|------------|----------|
| 1   | Media using effect | 78%        | Good     |
| 2   | Presentation    | 83%        | Very Good|
| 3   | Content         | 75%        | Good     |
| 4   | Language        | 79%        | Good     |

Based on Table 1, the validators give an appropriateness score for the worksheet which is developed in the four aspects. Overall, the worther percentage of the worksheet is 78.75% with the interpretation is good. This result that based on theoretical shows that this tutorial worksheet has a minimum aspect to use in a learning process to improve student critical thinking skills. Based on this approach, tutorial worksheets can be used in the learning process [15].

3.3. Development

The development step is the realization of design of the worksheet. The worksheet which has validated by the expert may produce and adapt in physics class. In this stage, the critical thinking skills data was collected.
Table 2. Recapitulation of $<g>$ score.

| Category | Amount | Percentage |
|----------|--------|------------|
| High     | 0      | 0%         |
| Medium   | 27     | 90%        |
| Low      | 3      | 10%        |

Table 2 shows the result of $<g>$ score that accumulated by a level. Based on data from Table 2 can be concluded that generally the critical thinking skills improvement is in medium level or on numeric score has an average of 0.43. This result is also supported by a $t$-test data that has a counting value of 5.25 greater than 2.045 so it can be concluded that $t_{count} > t_{table}$. This result shows that there are significant differences between the students who use the tutorial worksheet and not [16].

The next data is about student’s responses after using tutorial worksheets. The result of students’ responses shown in Table 3.

Table 3. Scores on every aspect of student responses poll.

| No. | Aspect   | Percentage | Interpretation |
|-----|----------|------------|----------------|
| 1   | Implementation | 79.6%      | Attractive     |
| 2   | Language  | 74.2%      | Attractive     |
| 3   | Design    | 82.1%      | Very Attractive|
| 4   | Acceptable| 75.3%      | Attractive     |

Generally, the students have a good response to tutorial worksheets. It is shown in Table 3 that almost in every aspect have a positive responses of students. The positive responses and significant improvement show that the tutorial worksheet of instrumental optics concept can help teachers to manage the learning process and students in learn the material. The other research results show the same results that said that there are some unique things from the tutorial worksheet that make an interesting learning experience. That unique things are the students have an easier adapted with their learning style [17]–[19], have a systematic learning process [11], improving students’ motivation because of multiple representations [20], and involves the student to act in a learning process [21].

The result of this research can be a first step to the next research. Limitation and the obstacles that found by the researcher are limitations to presentation a physics phenomenon in worksheets and in the learning process implementation. For the next research about this tutorial, the worksheet can adapt experimental research to make students find out more information about them learn material. To find out more information on experimental research can help the student to keep their knowledge longer because their own experience in a learning process will be longer keeping in their mind.

4. Conclusion

The analyzed results show that one of the physics concepts which have to more practice is an optic instrument which has more implementation in daily life. Tutorial worksheet is one of the alternative ways to help students with a learning process. The validations by the experts show that the tutorial worksheets have a complete requirement to use in the physics learning process especially in optic instrument concept. The result of the implementation and statistic test shows that tutorial worksheets can improve students' critical thinking skills significantly on a medium level. The students’ responses show an acceptance that be concluded by positive responses.

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