Developing of modified inquiry-based laboratory worksheet on optical topic

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Abstract. The aim of this research is to develop a modified inquiry-based laboratory worksheet on optical topic as teaching material supporting laboratory activity. Modified inquiry-based laboratory worksheet that is developed consists of 6 practicum title that is simple refractometer, mirror, lens, microscope, spectrometer, and polarimeter. Modified inquiry-based laboratory worksheet is arranged based on stages of inquiry learning that is problem formulation, hypothesis composing, collecting data, data analysis, and conclusion. Developing modified inquiry-based laboratory worksheet is conducted in physics laboratory at Universitas Negeri Jakarta. The research method is used research and development using ADDIE models (Analysis, Design, Development, Implement, Evaluation). Validation is done by material expert, media expert and learning expert and tested to 26 physics college students. The result of validation test shows the percentage of average score of material expert 85.78%, media expert 89.08%, learning expert 93.92%, and the average score of the total validation test results of 89.5% with a very good interpretation. The results of field trials show the percentage average score is 82.28% with very good interpretation. Therefore, it can be concluded that modified inquiry-based laboratory worksheet worthy to be used as a teaching material supporting laboratory activity of physics college student.

1. Introduction
The higher education has a big role in anticipating educational change rapidly. One of the ways to do is by adapting the concept of 21st century learning. The concept of 21st century learning requires learners to have the skills, knowledge and skills in technology, media and information, learning and innovation skills and life and career skills [1]. In line with that, Tax Dispute Administration formulates that the learning paradigm of the 21st century emphasizes the ability of learners in finding out from various sources, formulate problems, analytical thinking and cooperation and collaborate in solving problem [2].

Science learning has a strategic role in developing 21st century education. In physics learning, 21st century skills can be developed with discovery-based learning processes and a hands-on learning experience. This can be achieved in laboratory activities. Laboratory activities can make students have the ability, skills and experience using experimental tools to understand basic concepts and be able to shape and develop scientific attitudes [3]. Laboratory activities can also improve students' ability to construct knowledge and strengthen students in understanding physics. [4] In addition, laboratory activities can also stimulate high-level thinking skills [5].
The laboratory activities will run in accordance with the procedures and time allocations if they are equipped with good teaching materials. One of teaching materials that can support laboratory activity is laboratory worksheet. The laboratory worksheet is the guide used to investigate or troubleshoot. This worksheet can be a guide to development of cognitive aspects and a guide to develop all aspects of learning in the form of experimental guides or demonstrations [6]. The laboratory worksheet serves to minimize the role of educators and to educate the role of learners, as teaching materials that enable learners to understand the material, as teaching materials that provide many tasks, and as teaching materials that facilitate the learning process [7].

Needs analysis was conducted to find out about teaching materials that were available in physics laboratory with total of respondents 53 physics college student, 10 laboratory assistants, and physics lecturers. The result of requirement analysis shows that 70% of students stated that the laboratory worksheet that used does not lead the students to be active in the experiment. 58% of students stated that the practical manual books are less interesting. The interview result states that the lack of practicum activities in one meeting, the available of practical manual books are not yet appropriate with the learning approaches that is required in the 2013 curriculum.

Nurussaniah and delinurhayati conducted research on the development of physics worksheet with guided inquiry to improve the critical thinking skills of student. The result of the study stated that the worksheet can support laboratory activity and improve critical thinking skills [8]. Another study was conducted by fathur rohman and ayu lusiana by developing physics worksheet that can be used to improve scientific process skills of student [9].

Based on these problems, it is necessary laboratory worksheet that can activate the learners and help students find the concept independently. One learning approach that guides students to active to do innovation independently is the inquiry approach.

The Inquiry approach is a learning process to get information by making observations or experiments to get the answers as well as solve problems on questions or problem formulations using the ability to think critically and logically [10]. The advantage of this inquiry approach, it emphasizes the development of cognitive, affective and psychomotor aspects in a balanced way, so that learning becomes more meaningful and able to increase students' intellectual potential, giving space for students to learn according to their learning style, this learning is not only shown to learn concepts and principles, but also learning self-direction, responsibility, communication, etc. and learning inquiry can extend the memory process [11].

Therefore, the researcher will develop modified inquiry- based laboratory worksheet as a teaching material supporting laboratory activities of physics college student.

2. Methods
The research method used research and development. Research and development method is a research method used to produce a specific product with a research that have the quality needs analysis, and test the effectiveness of the product in order to function in the community [12]. The research model used is the ADDIE research model consists of 5 stages that are analysis, design, development, implement, evaluate [13].

Need analysis is done to determine the problems in laboratory activities, determine the type of teaching materials to be developed, determine the achievement competence to be expected. Design stage is done to determine the specification of teaching materials that will be developed, the content will be loaded, and determine the assessment strategy. Development stage contains the process of making modified inquiry- based laboratory worksheet, validation test, review and revise modified inquiry- based laboratory worksheet. Validation test is used to see the feasibility of modified inquiry-based laboratory worksheet that has been developed. Validation tests are performed by material experts, media experts and learning experts. Implementation stage is done by testing physics worksheet to 26 physics college students. The evaluate stage is done to evaluation of modified inquiry-based laboratory worksheet development result that have been implemented. The development of modified inquiry- based laboratory worksheet is done in physics laboratory in October 2017 until June.
2018. Data were collected by using assessment sheet and student response questionnaire with score interpretation using likert scale as follows: [14]

| Percentage            | Interpretation          |
|-----------------------|-------------------------|
| 0% - 25%              | Very unfeasible         |
| 26% - 50%             | Not feasible            |
| 51% - 75%             | Feasible                |
| 76% - 100%            | Very worth it           |

3. **Result and Discussion**

Modified inquiry- based laboratory worksheet developed based on literature studies using textbooks, journals, practicum reports, practicum worksheet from several universities, and internet reference information.

3.1. **Research Products**

Modified inquiry- based laboratory worksheet consists of 6 practical titles; (1) Simple Refractometer; (2) Mirror; (3) lens; (4) Microscope; (5) Spectrometer and (6) Polarimeter. Modified inquiry- based laboratory worksheet is arranged consists of five stages: problem orientation, hypothesis formulation, data collection, data analysis, and conclusion. Previous research explains that inquiry-based laboratory activities have a positive impact on improving conceptual understanding and also effectively used in learning [15]. Inquiry-based laboratory activities can also increase the creativity of students 'thinking, creative attitude and creativity of learners' actions [16]. The implementation of the practicum process with the inquiry approach requires a specific strategy. A teacher should focus on thinking skills and conceptual diversity, explain the nature of science, provide information on research topics, should be able to bridge the gap between high-achieving learners and low-achieving learners and then focus on collaborative learning [17]. Here is a picture of Physics Basis II Worksheet of optical material that has been developed.

![Figure 1. Physics worksheet cover](image1)

![Figure 2. Problem orientation content](image2)
3.2. Validation Test Results and Product Testing

The validation expert consists of 7 lecture that is three material expert lecture, two media expert lecture, and 2 learning expert lectures. The result of validation test of the material covering aspect of the content, presentation and language get the average percentage score of 85.78%. The score of each indicator showed by picture 5. Validation test results by media experts covering aspects of the content, presentation and language get an average score of 89.08%. the score of each indicator showed by figure 6. The results of learning validation test that includes aspects of content, presentation and language obtained the average percentage score of 93.92%. The score of each indicator showed by figure 7.

Figure 3. Data colection content
Figure 4. Theory explanation

Figure 5. Validation result of material expert
The average percentage of validation test score by material experts, media experts and learning experts amounted to 89.50% with excellent interpretation which means that modified inquiry-based laboratory worksheet on optical topic has a very good quality based on the aspect of content, presentation, and language. This is in line with previous research which states that practicum worksheet with inquiry approach can improve students' thinking ability [18].

3.3. Field Test
Field trials was conducted to 26 physics college students of Universitas Negeri Jakarta on 2nd semester to explore student’s responses on the use of laboratory worksheet. The students’ responses presented in figure 8.
According to the figure 8, the average percentage of the score of all aspect that is 82.28% with a very good interpretation. It indicates that students reacted positively to use modified inquiry-based laboratory worksheet on optical topic. Based on the previous research result, the comparation between two experimental and control classroom shows that classroom that use inquiry worksheet has significantly number of testable hypotheses, correct hypotheses, and correct evidence-based scientific explanation and higher level of scientific reasoning than the control classroom [19].

4. Conclusion
Developing of modified inquiry-based laboratory worksheet on optical topic done with 5 stages: analysis, design, development, implementation and evaluate. Based on the result and discussion, it can be concluded that modified inquiry-based laboratory worksheet on optical topic done is suitable to be used as teaching material for laboratory activities.

Further suggestions for the next research are; improving physics worksheet from side of appearance, content, and pictures and illustrations to make it easier to understand. And required the development of similar physics worksheet on the others topic.

Acknowledgements
This research is supported by Indonesia Endowment Fund for Education (Lembaga Pengelola Dana Pendidikan/ LPDP), Indonesia. The author would like to thank to experts and physics college students who participated in this research.

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