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Research Paper

Developing Virtual Physics Practicum Module of Optic Based on Guided Inquiry to Improve Students' Science Process Skills

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Abstract: Science process skills are one of the competencies that must be possessed by students after attending physics learning. Science process skills can be obtained by practicum activities both in person and virtually. However, the availability of virual physics practicum modules is not widely available in schools, even though there are some materials that cannot be done directly. Therefore, a guided inquiry-based virtual practicum module is needed to improve students' science process skills in learning physics. This development research using 4-D method (Define, Design, Develop, and Disseminate). In the development of this module, the researchers only come to the third stage of the four stages. Validation results from experts get an average score of 86% interpretation which means that the module is included in the criteria worthy of use in learning even with the notes of experts to revise some of the components present in this module so that this module complies with existing standards. The results of the analysis of student responses to the practicum module obtained a total average of 85% with the category is "strong." This shows almost all the students gave a positive response to the virtual practicum module based guided inquiry. The development of virtual practicum modules based guided inquiry can improve science process skills of the students, with the average score of students" science process skills before using a virtual practicum module based guided inquiry of 2.63 and the average score of students" science process skills after using a virtual practicum module based guided inquiry of 3.30

Keywords: Practicum Module; Virtual Practicum; Guided Inquiry; Science Process Skills; Optics

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INTRODUCTION

Physics is one of the branches of natural sciences. The process of learning physics always relates to daily phenomena that occur naturally and that are made in practicum activities. Physics learning in schools must be contextual, so that students can understand the concepts of physics thoroughly (Guntara et al., 2021; Tari & Rosana, 2019). Physics practicum activities can be carried out in two ways, namely real and virtual. Virtual practicum is carried out if the materials or needs of the practicum are quite expensive and not available (Gunawan et al., 2019; Kidd & Murray, 2020). Without compromising the essence of practicum activities, virtual practicum can also improve students' science process skills (Darmaji et al., 2019; Harahap et al., 2019; Yusuf & Widyaningsih, 2020). Therefore, a virtual practicum module is needed that can guide students in carrying out practicum. Based on the results of observations, it is known that the unavailability of virtual practicum modules in schools, the difficulty of teachers in holding practicum

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activities so that practicum activities cannot be carried out. Practicum activities in physics learning are one of the activities that can be an attraction for students in learning physics (Wahyuni & Husein, 2019; Yusuf & Widyaningsih, 2020). Practicum activities have an important role in improving students' understanding of concepts (Arista & Kuswanto, 2018; Mardiana, 2019) as well as science process skills (Bulian & Jambi, 2018; Perignat & Katz-Buonincontro, 2019).

In creating an active and fun physics learning process, the practicum module not only contains material but must also be able to guide students to be active in learning activities (Astuti et al., 2018; Pratono et al., 2018) and practicum so that students' critical thinking skills can be formed (D. A. Sari et al., 2019; Sukarelawan et al., 2021). In addition, in practicum activities, it is hoped that students will be able to improve their science process skills (Sunaryo et al., 2022; Uğur et al., 2020; Yusuf & Widyaningsih, 2020), therefore a practicum module is needed that is able to guide students in carrying out practicum. So, the right model to integrate in this practicum module is guided inquiry. Guided inquiry can encourage students to become independent learners (Hermansyah et al., 2019; Rahayui et al., 2018) and think critically (Margunayasa et al., 2019; Misbah et al., 2018) about physics learning. Guided inquiry can improve students' higher-level thinking skills (Maknun, 2020), problem-solving skills, science process skills (Af'idayani et al., 2018; Stender et al., 2018) as well as students' motivation in physics learning (Afriani & Agustin, 2019; Arafah et al., 2020). Learning that involves activities in guided inquiry results in students not feeling saturated in the learning process (Athanases et al., 2020).

Science process skills abilities are useful for students (Asrial et al., 2019; Astutik & Prahani, 2018; Wiwin & Kustijono, 2018) to be able to integrate the results of his scientific research with the concepts that have been studied. The student must work on solving problems, finding everything for himself and trying with his Ideas so that the student really understands and can apply his knowledge. Students are expected to improve their science process skills, which include ten indicators, observing, interpreting, classifying, asking questions, predicting, hypothesizing, designing investigations, communicating, applying concepts, and inferred skills. The indicator is a benchmark for the extent of the science process skills that students have. Through the increase in students' science process skills, the concepts obtained by students become more meaningful and the ability to think is more developed as well.

Modules are whole and systematically packaged teaching materials (D. A. Sari et al., 2019; Susanti et al., 2021), which contain a series of learning experiences planned and designed for students to master specific learning objectives (Rajabalee & Santally, 2021). Modules are packages of programs arranged in the form of specific units and designed in such a way as to study interest. Modules as one of the teaching materials have one of the characteristics, namely the principle of independent learning (Dewi & Primayana, 2019). Through independent learning, the module is a complement to student learning, both learning modules and lab modules. Modules can be said to be good if they use learning theories that can support the achievement of basic competencies (Sheridan et al., 2019). The characteristics of the module include independence, relying on individual differences, the presence of associations, the use of various media, active participation of students, direct reinforcement, supervision of evaluation strategies (Ambarwati et al., 2020; Song et al., 2021).

Research on developing virtual laboratory modules is important to enhance science process skills because it provides students with a hands-on and immersive learning experience that closely mimics real-life laboratory work. These virtual modules can offer a safe and controlled environment for students to explore scientific concepts and develop their skills in scientific inquiry, experimentation, data analysis, and critical thinking. Virtual laboratory modules also have the potential to reach a wider audience, as they can be accessed remotely by students from any location with an internet connection. This can be particularly beneficial for students who may not have access to physical laboratory equipment or who have limited time to attend traditional laboratory sessions. In addition, research on virtual laboratory modules can help educators better understand how to design and implement effective virtual learning experiences. This includes identifying best practices for integrating technology into the classroom and assessing the effectiveness of virtual modules in improving student learning outcomes. Overall, research on developing virtual laboratory modules is crucial for advancing science education and ensuring that students have the skills and knowledge needed to succeed in the 21st-century workforce.

Based on the background and explanation above, the researcher develops a virtual practicum module that is in accordance with existing needs and is easy to use by the teacher and also students, the modules is based on guided inquiry that aim to improve students' science process skills.

METHOD

This research is a type of development research. This research invites products in the form of a virtual Physics Practicum Module and tests the effectiveness of this module against variables of science process skills. The development model used is a 4-D model consisting of Define, Design, Development and Disseminaton. This research was carried out using a flow diagram as shown in Figure 1.

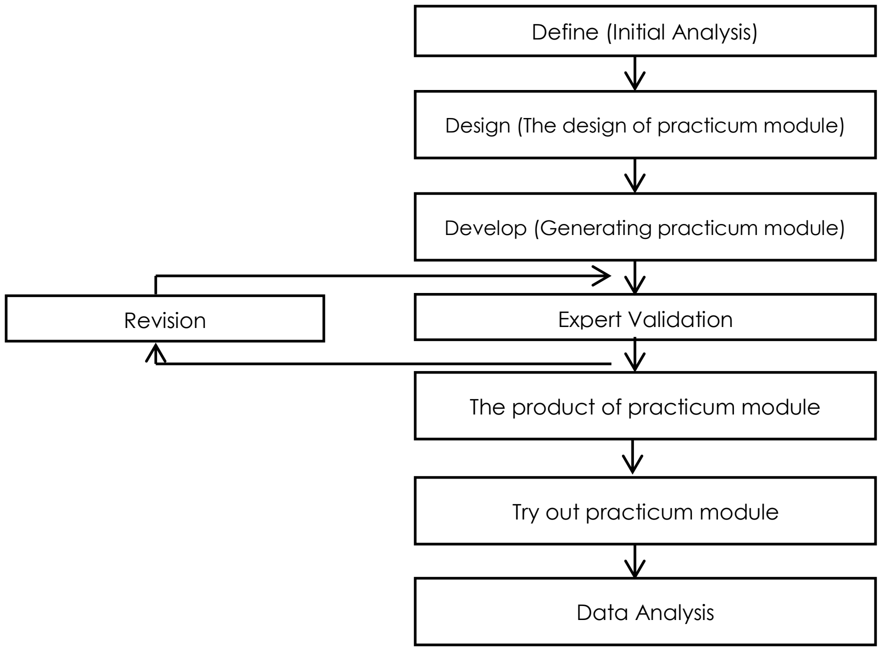

Figure 1. Research Flowchart

To obtain the required data in the form of feasibility tests by experts, the instruments used in the form of questionnaires as in table 1.

Table 1. Questionnaire of Module Eligibility

Indicator	Statements
Content Validation	a. Practicum module supports practicum activities
	b. Practicum modules are based on the needs of the students
	c. This module includes all the material that must be studied by the student.
	d. The basic theory is systematically organized
	e. The concepts relate to daily life
Language Validation	a. The fonts used are easy to read
	b. The formulas are clear and easy to read.
	c. The provisions of such information are clear, relevant and unambiguous
	d. The sentences are based on Indonesia's Enhanced Spelling System.
	e. The sentence is easy to understand
	f. The use of language is effective and efficient.
	g. The choice of language is simple and communicative
Structure Validation	a. The title is clear
	b. The material is presented in a systematic order
	c. This module has interesting illustrations and relevance
	d. The presented numbers and symbols are related to the concept of physics.
	e. The image of the experiment tool is clearly presented
Product Benefits	a. Engaging students" curiosity
	b. Involve students to be active during practicum activities.
	c. Improve students' knowledge, experience, and skills.

Questionnaires are given to several validators who are experts in their fields. Analysis of questionnaire instruments is used to test the feasibility of products. The instrument uses the Likert scale. The categories of answers given are 4 for excellent, 3 for good, 2 for enough, and 1 for very poor. Questionnaire answers were weighted 4, 3, 2, 1 for positive statements and 1, 2, 3 ,4 for negative statements. Individual score results are stated as follows Formula 1:

$$\% \, Score \; Interpretation = \frac{\sum score \; of \; acquisiton}{\sum maximum \; score} \times 100\% \qquad (1)$$

Eligibility criteria for products are presented in Table 2.

Table 2. Data Interpretation of Module Eligibility

Percentage (%)	Notes
80 - 100	Good/Valid
60 - 79.99	Enough/Valid
50 % - 59.99	Less/Valid
0 – 49.99	Bad/Not Valid

To find out the student's response to the practicum module in a small class trial, it can be analyzed using the Equation 2.

$$NRS = \frac{\sum RS}{RS_{maximum}} \times 100\% \qquad (1)$$

Notes:
NRS = The percentage of student responses (%);
RS = student responses for each item;
RS maximum = The total of student responses

After calculating the student response value for each statement item, the next step is to determine the criteria for the percentage of student response value per statement item as Table 3.

Table 3. Criteria category of student responses to practicum modules

Interval Score	Category
0 ≤ NRS < 20	Very Weak
20 ≤ NRS < 40	Weak
40 ≤ NRS < 60	Enough
60 ≤ NRS < 80	Strong
80 ≤ NRS < 100	Very Strong

After testing a small class to find out the student's response, then a large-scale class trial was carried out to determine the effectiveness of the practicum module on the ability of the student's science process before and after treatment. The data techniques used include descriptive analysis, data requirements analysis, and hypothesis testing. Science process skills are assessed by a grid of observation sheets as in the Table 4:

Table 4. The grid of observation sheets for science process skills

No	Indicators
1	Observing teacher"s demonstration
2	Asking the application of optics
3	Identifying tools, materials, and the result of an experiment conducted
4	Adjusting the prediction made with the theory and the materials taught
5	Determining the acceleration of earth gravity accurately
6	Answering, asking, and giving solution or opinion in a group discussion
7	Writing and summarizing the result of the experiment, and writing the answer on the module based on the result of the discussion
8	Presenting the result of the discussion, accurately, and effectively
9	Connecting the data from the experiment to the existing theory
10	Applying theory from any sources and the data from an experiment by looking up to supporting references to strengthen the conclusion
11	Selecting the relevant theories (references)
12	Concluding based on the experiment organized based on the objectives revealed in the practice module

RESULT AND DISCUSSION

The development of this virtual practice module uses a 4-D model of the learning media design model. The 4-D development model was chosen because it is the recommended development model in the development of learning devices. This model consists of four stages of development, namely Define, Design, Develop, and Disseminate. The research flow is as follows:

Define Stage

At this stage, the analysis begins with how the student's initial circumstances, knowledge, skills and attitudes are to achieve the learning objectives listed in the curriculum. From this analysis, it was produced that in learning physics, the ability to think critically in conducting experiments is still very minimal, because teachers have difficulty in doing practicum. The guided inquiry is very commonly used by scientists in the world in conducting research, namely observation, asking questions, asking hypotheses, practicum / experiments, writing experimental results and making conclusions (Husnaini & Chen, 2019; Kang & Keinonen, 2018). This method is considered ideal to teach students to be familiar with practicum. Practical activities are considered important because they can provide students with a hands-on learning experience. They can apply the theories that have been learned and can develop students' science process skills (Af'idayani et al., 2018; U. Sari et al., 2020).

Design Stage

At this stage, researchers will design lab modules that meet the criteria for a good lab module. The writing of the practicum module is carried out with steps, namely 1) Basic formulation competencies that must be mastered come from the content standards of the national curriculum set by the government; 2) Designing from the technical side, such as adjusting to the guided inquiry methods that generally apply in the world, the form and arrangement of practicum modules; 3) Determine the form of assessment; and 4) Compilation of appropriate materials. In the development of the practicum module, material from class XI was selected, namely Optics. In this material, it is necessary to understand the concept of understanding that must be directly practiced by students, because if it is only the theory, students will be confused in understanding in depth about this concept. In addition, the material used is relatively easy to obtain and does not make it difficult for teachers and students. In this concept, there are also many applications to the real world that we can immediately make an example to students of how important this concept is.

Develop Stage

At this stage, the physics practicum module is oriented towards a scientific approach to the concept of optics. The purpose of this stage is to produce a revised module based on input from experts. Among them are the validation of the module by experts followed by revisions, limited trials whose results form the basis of the revision, and further trials in the real class. In further trials to find out the science process skills of students by using a guided inquiry lab module.

The practicum module that has been developed is then consulted with several expert lecturers so that they can get input for development and improvement before being tested. This stage aims to find out one aspect of product quality development, namely the validity aspect. This is done by testing product validity by experts, and getting suggestions and criticisms from the validator on the product being developed. Validation data obtained were then analyzed and revised. The revised product is a development and improvement based on expert validation.

The virtual practicum module based guided inquiry developed has several characteristics including practical steps by scientific steps, namely (observing, asking, gathering information, associating, communicating). The practicum module consists of several experimental steps accompanied by images that function so that students can practice independently without direction from the teacher, so the teacher is only a facilitator. The contents of the module contained a table of observations and data analysis used to write the results of the student practice.

The feasibility test of this scientific-based lab module is validated by three experts who are competent in their fields. The following are the results of the module validation assessment presented in Table 5.

Table 5. The Result of the Module Validation

Indicator	Average
Content Eligibility Aspect	3.47
Language Aspect	3.23
Structure Aspect	3.12
Product Beneficial Aspect	3.33
Average	3.29

Figure 2 and 3 shows cover and feasibility of practicum module. The cover display according to the theme of the material i.e. optical and clear purpose of the module.

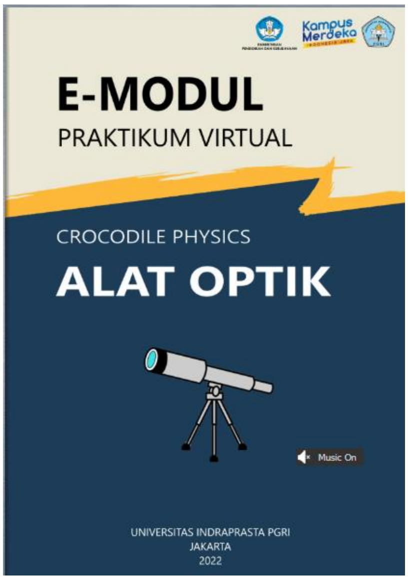

Figure 2. The Displayed cover of the practicum module

The content of the module is systematic and complete according to the steps of the virtual practicum experiment. there is a tutorial video in the module that has been connected to youtube. in addition there is data analysis and comprehension questions aimed at seeing the extent to which students understand practicum and optical theory.

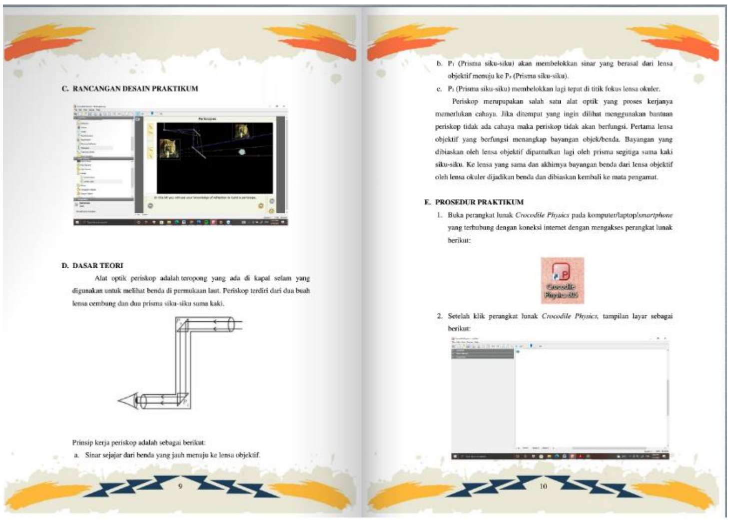

Figure 3. The Content Feasibility of the Practicum Module

Based on the criteria table, the analysis of validation assessment data obtained an average total score of 3.29 or 81% and was included in the criterion "feasible." Improvements are made based on the suggestions or comments of experts, namely 1) Clarifying the concept of guided inquiry methods again, 2) Adding a more interesting introduction before entering the lab material, 3) Providing quotations from the source, 4) In the observation section it is better to add illustrations, 5) Provide descriptions of images and descriptions of tables, and 6) Writing formulas should be clarified again.

After the guided inquiry virtual practicum module was revised, the next stage of the small class trial was for 20 students of class XI of Sma Negeri Bojonegara to find out the student response to the practicum module. From the results of the analysis of student responses to the practicum module, the average total is 4.0 or 80% with the "strong" category. This condition shows that almost all students respond positively to the guided inquiry lab module that has been created.

The Guided Inquiry Virtual practicum module is applied to class XI students of SMA Negeri Bojonegara to find out the skills of the student's science process. Science process skills are the ability to use mind, reason, and action efficiently and effectively to achieve certain results (Rahman, 2019; Hofmann & Hayes, 2019), The average results of students' science process skills are shown in table 6.

Table 6. The average value of student process science skill before and after treatment

No. Indicator	Student Science Process Skills	
	Before	After
1	2	3.7
2	2.5	3.3
3	2.4	3.5
4	3.1	3.1
5	3.7	3.3
6	3.5	3.3
7	2.4	3.6
8	2.1	3.1
9	2.2	2.9
10	3.1	3.0
11	2.5	3.3
12	2.1	3.5
Average	2.63	3.3

Improving students' science process skills using virtual lab modules, with an average score before action of 2.63 and an average score after action of 3.30. This shows that students have good skills in carrying out practicum works with the scientific method. The development of science-based lab modules is very helpful for students to conduct physics experiments so that not only the experimental results that students get but students also better understand physics concepts well.

This practicum module based on the guided inquiry method can be used as a support for teachers in learning in schools. In physics learning, students are trained to correctly understand the process of science that is closely related to everyday life in finding concepts through observational activities or practicum (Hendawati et al., 2019; Hendriana et al., 2019). In addition to science process skills, another thing a student should have is a scientific attitude (Afandi et al., 2019; Wildan et al., 2019). In the practicum module with a guided inquiry method developed, there are steps to observe, ask questions, collect information (practicum), process information, and communicate (reports and practical presentations). This module can show students learning independently (student center) with the scientific method so that students look active when carrying out learning.

The scientific attitude is the attitude shown by scientists when they carry out scientific activities in this scientific activity capable of practicum modules based on this scientific method. Students not only master the concepts of physics in theory, solve problems with mathematical formulas, but are also able to prove the concepts of physics scientifically through the stages of the scientific method. With interaction with scientific approaches in addition to mastery of concepts, students can develop a process of creativity (Bulian & Jambi, 2018). The guided inquiry approach in the learning process has a positive impact on student learning outcomes; This is because in the approach of guided inquiry the student discovers for himself the concepts learned (Aulia et al., 2018; Holubova, 2008).

A good book, which is an interesting book, comes with pictures and descriptions (Asrial et al., 2019; Harjono et al., 2020) . Visually the presentation and research of concepts, symbols, images, tables and illustrations are presented clearly and attractively. In the science-based practicum module, pictures and instructions are presented that mark the scientific method by the 2013 curriculum. So that with this practicum module, students can measure their respective abilities in the practicum. In the presence of LKS or modules, students have the opportunity to develop their thinking skills through a process of specialization, conjecture, justification and generalization (Gutierrez et al., 2022; Sánchez et al., 2021). Learning with modules is an independent learning approach that focuses on mastering the competencies of the study materials learned by students at a certain time according to their potential and conditions (Maulidah & Prima, 2018; Sutarno et al., 2017).

In line with his opinion, students are more active in learning with practicum modules because students have read the modules, thereby minimizing the possibility of students to imitate their peers (Firman et al., 2018; Putra et al., 2019). Students become more active in practicum even though there are still students who are confused. The preparation of competency-based curriculum-based learning modules can increase competence in applying Optics in simple problems and can increase student learning independence (Shofiyah et al., 2021). Another research conducted openended approach can be combined in the form of a practicum module that aims to provide independence to students in overcoming physics learning problems, especially those related to practicum (Siew & Ambo, 2018). Thus the practicum module can support the physics learning process. Practicum performance in the laboratory is a complex process of activity involving many elements (Mann et al., 2021) so that complementary modules are needed. As a reinforcement in applying the scientific method, an experimental or practicum method is needed which is equipped with a practicum module with the aim that students can construct their knowledge in the learning process.

The development of optical practicum modules based on scientific methods equipped with guided inquiry method steps is expected to increase student activity in practicum activities, foster an attitude of independence in learning and students can construct knowledge according to the guided inquiry method so as to get deep learning in physics learning activities.

CONCLUSION

Based on the results and discussion, it can be concluded that the guided inquiry virtual lab module on particle dynamics material is worthy of use as a tool and learning guide for physics practicum based on evaluation by validators. The results of the expert evaluation obtained an average score of 3.29 or 81% and were included in the criteria of "feasible" for use in learning in schools. From the results of the analysis of student responses to the practicum module, the average total is 4.0 or 80% with the "strong" category. This condition shows that almost all students respond positively to the science-based lab modules that have been created. The development of guided inquiry-based lab modules can improve students' science process skills, with an average score of student science process skills before using guided inquiry-based lab modules of 2.63 and an average score of student science process skills after using science-based lab modules of 3.30. The advice that can be obtained for further research is to develop a physics practicum module based on scientifically guided investigation methods for different physical materials. Practicum modules can be equipped with basic competencies that are in accordance with the curriculum used in schools.

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