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The Needs Analysis in the Development of Level of Inquiry with Project Assignments Model to Promote the Creativity of Prospective Physics Teachers

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ABSTRAK

Model pembelajaran berbasis inkuiri dan proyek berperan penting dalam pengembangan keterampilan abad 21, khususnya pengembangan kreativitas bagi mahasiswa calon guru fisika (PPTs). Untuk mengembangkan dan mengintegrasikan kedua model ini dibutuhkan analisis kebutuhan sebagai langkah awal dalam pengembangan. Penelitian ini bertujuan melakukan analisis kebutuhan untuk pengembangan model level inquiry with project assignment. Penelitian ini merupakan penelitian deskriptif. Metode studi penilaian kebutuhan dengan pendekatan analisis konvergen digunakan dalam penelitian ini. Sumber data dalam penelitian ini meliputi dokumen kurikulum berupa rencana pembelajaran semester (RPS) dan modul penuntun praktikum mata kuliah fisika dasar. Data persepsi juga dikumpulkan dari responden 33 PPTs dan dosen pengajar mata kuliah fisika dasar. Teknik pengumpulan data yang digunakan adalah dokumentasi, angket dan wawancara. Hasil penelitian disimpulkan bahwa kurikulum perkuliahan fisika dasar telah memuat kompetensi keterampilan ilmiah dan kreativitas bagi PPTs. Namun, pembelajaran masih didominasi oleh dosen, aktivitas praktikum fisika belum mengarah pada proses pembelajaran inkuiri yang tepat. Pembelajaran proyek jarang digunakan. Kreativitas PPTs belum dioptimalkan dalam belajar fisika. Dosen dan mahasiswa memberikan respon bahwa pengembangan Level of Inquiry with Project Assignments Model (LoI-PA) sangat penting dilakukan untuk meningkatkan kreativitas PPTs. Model hipotetik LoI-PA disajikan dalam pembahasan penelitian ini. Namun masih dibutuhkan penelitian lanjutan untuk mengembangkan langkah pembelajaran yang valid dan mengintegrasikan teknologi informasi dalam langkah model pembelajaran tersebut.

ABSTRACT

This Inquiry and project-based learning models play an essential role in developing 21st-century skills, especially the development of creativity for prospective physics teacher students (PPTs). Developing and integrating these two models requires a needs analysis as the first step of development. Therefore, this study aims to conduct a needs analysis for developing a level inquiry model with project assignments. This research uses a descriptive study. The needs assessment study method with a convergent analysis approach is used in this study. Data sources in this study include curriculum documents in the form of Semester Lesson Plan (SLP) and practicum guidance modules for introductory physics courses. Perception data was also collected from respondents from 33 PPTs and lecturers of introductory physics courses. The data collection techniques used were documentation, questionnaires and interviews. The results of the study concluded that the curriculum for introductory physics lectures contained scientific and creative skill competencies for PPTs. However, lecturers still dominate learning, and physics practicum activities have not yet led to an appropriate inquiry learning process and project learning is rarely implemented. The creativity of PPTs has not been optimized in learning physics. Lecturers and students responded that developing the Level of Inquiry with Project Assignments Model (LoI-PA) is very important to increase the creativity of PPTs. The LoI-PA hypothetical model is presented in the discussion of this study. However, further research is still needed to develop valid learning steps and integrate information technology into the learning model steps.

1. INTRODUCTION

Inquiry is essential in science education since it is the essence of science itself. Inquiry has been a highly advocated approach to teaching and learning in general and science for many years. Inquiry-based learning is a pedagogical approach involving students actively building knowledge through adopting an inquiry mindset in overcoming epistemic problems or in developing and completing projects (S. K. W. Chu et al., 2017; Constantinou et al., 2018). This approach is beautifully compatible with practice because it

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places students as active investigators and thinkers rather than passive recipients of scientific information. Inquiry-based learning objectives vary but generally include some combination of motivation and learning objectives that involve acquiring knowledge, understanding, and skills (Hoisington, 2018; Topalsan, 2020). Apart from offering students opportunities to achieve a better understanding of scientific concepts, principles, and phenomena as well as practical learning outcomes, several previous studies have shown that inquiry-based learning can also develop various 21st Century skills (S. K. W. Chu et al., 2017; Novitra et al., 2021). Inquiry-based learning is relevant in 21st-century environments. The main goal of higher education in the 21st century is to change students' thinking that learning is not just the acquisition of knowledge and skills but human qualities and dispositions to cope with an uncertain world, a complex life, and a changing work environment (Kamp, 2019; Özdo˘gru, 2022). 21st-century science education views learning through inquiry as an effective teaching strategy for constructing meaningful and productive investigations that support new knowledge, develop evidence-handling skills, and encourage student autonomy and exploration. In addition, inquiry in science learning focuses on students' involvement in developing their knowledge related to concepts and scientific reasoning skills (Constantinou et al., 2018; Kelana et al., 2022). Through an inquiry-based approach, students can have the opportunity to design and conduct scientific investigations so that they can study science in a scientist-like way (Connor & Rosicka, 2020; P. S. Dewi et al., 2023).

Higher education for student science teacher candidates makes scientific inquiry or practice the cornerstone of education or the main goal in science education courses. In America, the term "scientific practice" or "scientific investigation" is an essential objective in the Science Education Framework and Standards for Science Teacher Preparation (Morrell et al., 2020; Otero & Meltzer, 2017; Özer & Sarıbaş, 2022). In studies of analysis of science curriculum texts in China and Finland, it is known that the term "inquiry" as a 21st-century competency ranks first (27.8%) in science curriculum texts in Finland and ranks second (25.7%) in science curriculum texts in China (Wang et al., 2018). Inquiry is one of the main competencies that appear in both the Chinese and Finnish curricula and is the competency most closely related to knowledge and skills in science. In Georgia, one of the requirements of high school physics standards is that students must be interested in studying physics processes. Three main directions are set to make students learn physics appropriately, namely (1) aspects of physical phenomena, understanding the basic concepts of physics, (2) aspects of scientific inquiry, observing and conducting simple experiments carried out by students, and (3) aspects of science & technology, understanding the impact of science and technology on society and the environment; evaluate important scientific discoveries; understanding that scientific views and opinions evolve and may change over time (Güngören, 2021; Kapanadze et al., 2023).

The science curriculum taught in educational institutions is seen as a subject that can help improve the quality of creative thinking among students (Daud et al., 2012; Dupri et al., 2021). Previous study said that the most crucial 21st-century skill to train PPTs is creative thinking skills (Fatmawati et al., 2019). Other study also proposed a model that includes questioning scientific creativity, divergent thinking, and thinking about several other elements in scientific imagination, inquiry, and innovation (Hu & Adey, 2002). Creative thinking is essential because it is the first step for someone to think critically and provide new ideas or breakthroughs. Students with good creative thinking skills will be able to carry out scientific creativity in pedagogical practices related to the process of teaching practice (Serdyukov, 2017; Zhou, 2021). Competent and creative physics teacher candidates will be able to transfer creativity to students when teaching. Creativity in learning physics refers to students' ability to think innovatively, relate physics concepts to real-world situations, and create new solutions to problems or challenges related to physics. This skill involves students thinking outside the boundaries and formulating unique approaches to understanding and applying physics concepts (Ozturk, 2021; Saleh et al., 2021). Several previous studies have analyzed the impact of various learning models in increasing student creativity. Inquiry-based learning is learning with a constructivist paradigm that can not only increase in-depth understanding and inquiry skills, but also interest in science, and creativity (Boğar, 2018; Mitarlis et al., 2020; Rodríguez et al., 2019). For student science teacher candidates to have competence in inquiry skills, inquiry-based learning is undoubtedly the primary model in training conceptual and procedural knowledge for students. However, students and teachers resisted implementing inquiry-based learning. Science teacher candidates do not seem to fully understand the proper procedures for inquiry and other essential aspects, such as the development of creativity in science learning (Özer & Sarıbaş, 2022; Wenning & Vieyra, 2020). The previous study conducted a meta-analysis on 17 research articles (Bi et al., 2020), and a Systematic Review conducted by other study on 30 research articles (Sidek et al., 2020). However, no research has been found on the application of the Level of Inquiry model combined with Project Learning to increase the creativity of PPTs. Project-based learning has much potential for enhancing 21st-century skills and engaging students in real-world tasks (Aristin & Purnomo, 2022;

Haatainen & Aksela, 2021). The main components of Project-Based Learning are (1) asking questions or problems to organize and start activities and (2) obtaining the final result or several products as a series of activities, individual communication, or various task results that answer the problem (W. S. Dewi et al., 2022; Made et al., 2023). Integrating theory and scientific practice by producing products through project learning can also improve learning outcomes more effectively. Project-based learning needs to be implemented in the physics learning process. Developing and integrating these two models is important and exciting because inquiry-based learning can occur well through project implementation (K. W. S. Chu, 2009; Wilhelm et al., 2008). However, one of the critical initial stages in the project is conceptual building and skills, which can be facilitated through the level of inquiry model. Students build knowledge starting from the initial inquiry level, namely discovery learning, then proceed sequentially to the interactive demonstration level, inquiry lessons, and inquiry laboratory. The final stage of the inquiry level, namely real-world application and hypothetical inquiry, can be carried out through project activities. So that inquiry and projects are closely related to science learning activities (Fan & Ye, 2022; Haatainen & Aksela, 2021). Inquiry and project-based learning is constructivism learning that is based on investigation and includes gathering information from various sources so that it can improve inquiry skills and student creativity (Gunawan et al., 2017; Hursen, 2018; Perdana et al., 2023).

It is necessary to carry out a needs analysis in educational institutions for PPTs before developing an inquiry model and projects that are offered to increase the creativity of PPTs. Needs assessment is essential in planning development programs. Essential questions in needs analysis relate to (a) determining whether a problem or need exists and explaining that problem and (b) making recommendations for ways to mitigate the problem. Needs assessment is an effort to estimate deficiencies and consider these deficiencies as unmet needs or problems that were not previously known (Garira, 2020; Royse et al., 2010). Educational interventions such as learning models must be developed based on assessment and need analysis. Therefore, it is necessary to carry out a needs analysis to find out the deficiencies of the physics lecture program and then use this information as a basis for developing educational interventions in the form of inquiry learning models and projects that can promote the creativity of PPTs. The purpose of this preliminary research is to carry out a needs analysis, including describing problems in learning physics and providing recommendations for the design of an inquiry model to promote the creativity of PPTs. Sources of problems in needs analysis are explored through; (1) analysis of curriculum that has been implemented in physics education, (2) analysis of Semester Lesson Plan (SLP) documents, (3) analysis of practicum implementation guidelines, (4) analysis of student responses in implementing physics lectures, and (5) analysis of student creativity, and (6) analysis of student and lecturer responses regarding the development of the model offered. The uniqueness of this study resides in the results of a comprehensive analysis of the curriculum, the practicum process, the student experience, and the lecturer's perspective in order to develop a basic physics teaching model based on level of inquiry and project that encourages student creativity. Investigations rarely utilize the level of inquiry and learning projects to enhance the creativity of prospective physics teachers. This preliminary study is significant to obtain sufficient and helpful information in developing a Level of Inquiry model that is combined with Project Assignment and is oriented towards increasing the creativity of PPTs.

2. METHODS

This research is a descriptive study. The needs assessment study methodology with a convergent analysis approach was used in this study (Royse et al., 2010). A needs assessment is carried out to estimate various deficiencies, weaknesses, or problems in introductory physics lecture programs and make this information the basis for developing inquiry-based learning models and projects. Convergent analysis is used because it involves using multiple sources of information or multiple perspectives. Sources of information in this study were obtained from curriculum documents (lesson plans and practicum modules) of introductory physics lectures and the responses of lecturers and students regarding the implementation of introductory physics lecture models and creativity in learning physics. The method for carrying out needs analysis includes eight steps of needs analysis (Royse et al., 2010), but in this study, these steps were reduced to six main steps, as presented in Figure 1.

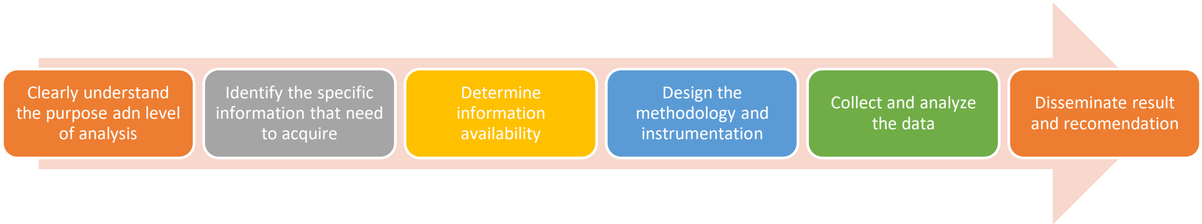

Figure 1. The Needs Analysis Step in the Current Research

Base on Figure 1 the first stage was to set data mining objectives, namely exploring data related to implementing physics lectures and student creativity. This study's analysis level is only at the course program level, which involves lecturers and students. The second phase was carried out by detailing the information needed, namely information related to the implementation and problems in the inquiry project, profiles of student creativity, and the need for developing inquiry models and student creativity. The third stage determines whether the information is available or needs to be disclosed or measured. The fourth stage is to determine the methods and instruments for collecting data. The fifth stage is to collect and analyze data both qualitatively and quantitatively. The sixth or final stage is to dissimilate the results and provide recommendations from related model suggestions that are considered to be able to solve problems or follow development goals.

This research was conducted at the Physics Teacher Prospective Education Program at a major private university in West Kalimantan. In addition to analyzing the primary physics curriculum documents, this study involved two lecturers of introductory physics courses and 33 PPTs, with a percentage of 84.8% female and 15.2% male. Students also represent the level of semester V (27.3%), semester VII (48.5%), and semester IX (24.2%). Need analysis data is collected qualitatively and quantitatively. Data collection techniques used in this study were documentation, questionnaires, and interviews. Documentation techniques are used to gather information and data related to the planning, implementation, and assessment of lectures from physics course curriculum documents such as Semester Lesson Plan (SLP) and practicum guidelines. The questionnaire technique was used to collect data related to physics lecture profiles and student responses about: (a) the implementation of inquiry-based learning and (b) scientific creativity in lectures. The questionnaire used was an online questionnaire containing closed questions and open questions. Closed questions in an online questionnaire use answer options based on an attitude scale which consists of 4 scale with several types of answers according to the questions in the questionnaire is show in Table 1 and Table 2.

Table 1. The Scale of the Online Questionnaire About the Physics Lecture Process and the Application of Project-Based Inquiry Learning

The topic of the questionnaire questions	Questionnaire scale			
	(4)	(3)	(2)	(1)
Physics material difficulty level	Very easy	Moderate	Difficult	Very difficult
Contextual physics lectures	Always	Frequently	Seldom	Never
Application of the level of inquiry in physics lectures	Always	Frequently	Seldom	Never
The benefits of implementing project inquiry and hypothetical inquiry in physics lectures	Very helpful	Helpful	Less helpful	Not helpful
The need for inquiry-projects in physics lectures	Very important	Important	Low important	Not important

Table 2. The Scale in the Student Creativity Questionnaire

The topic of the questionnaire questions	Questionnaire scale			
	(4)	(3)	(2)	(1)
Aspects of student creativity (originality, fluency, flexibility) in learning physics	Always	Frequently	Seldom	Never
The urgency of developing creativity in learning physics	Very necessary	Necessary	Less necessary	Not required

In addition to the answer choice models above in Table 1 and Table 2, the questionnaire also gave open questions to find further student responses in providing experience and assessment while attending physics lectures. The semi-structured interview technique is show in Table 3 in this preliminary study was used to obtain information from lecturers regarding the implementation of physics lectures, especially in applying inquiry learning and creativity in learning.

Table 3. Question Topics in Semi-Structured Interviews

No. Item	Question topics in semi-structured interviews
1	The role of the lecturer in the lecture process and practicum in the laboratory
2	Application of the level of inquiry in physics lectures
3	Aspects of creativity in physics lectures
4	Assessment of aspects of skills, attitudes and creativity of students
5	The urgency of developing inquiry models and creativity in physics lectures

Data were analyzed both qualitatively and quantitatively. The analysis of data was conducted by qualitative techniques, including observations and a review of curriculum papers. This analysis aimed to provide a description of the planning, implementation, and evaluation of basic physics courses. The data obtained from questionnaires was subjected to analysis using descriptive statistics and visualized using graphical representations in MS Excel.

3. RESULT AND DISCUSSION

Results

Results of Curriculum Analysis

The initial stage of analyzing the Semester Lesson Plan of introductory physics courses (SLP-IPC) is carried out quantitatively using SLP review sheets both from the availability and suitability aspects regarding Permendikbud No.3 of 2020 concerning National Higher Education Standards and Guidelines for Developing Higher Education Curriculum. The study results show that the SLP for the introductory physics course meets the criteria for the availability and suitability of nine aspects according to national higher education standards. Then further analysis of curriculum documents on SLP and introductory physics practicum modules was carried out qualitatively with the following review results.

Learning Outcomes Graduates charged to Courses (LOCs) in Introductory Physics Courses.

The learning outcomes of graduates of physics education programs that are charged to introductory physics courses (LOCs) include aspects of attitude (A), knowledge (K), general skills (GS), and special skills (SS). The description of the LOCs and Sub-LOCs for the introductory physics course is shown in Table 4.

Table 4. Aspects of Attitude (S), Knowledge (P), General Skills (KU) and Special Skills (KK) Forming Learning Outcomes in Introductory Physics Courses (LOCs-IPC)

Aspects	Learning Outcomes	LOCs-IPC
Attitude (A)	Demonstrates a responsible attitude towards work in his field of expertise independently	Able to explain and apply basic knowledge of electricity, magnetism, light and optics in solving physics problems logically, critically and innovatively and be able to build physics concepts through independent, responsible and measurable practicum activities.
Knowledge (K)	Mastering the theoretical concepts of classical physics and modern physics based on natural phenomena used in teaching physics at school	
General Skills (GS)	Able to apply logical, critical, systematic and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies humanities values according to their area of expertise. Able to demonstrate independent, quality, and measurable performance	
Specific Skills (SS)	Able to analyze problems, find sources of problems, solve problems in the physics learning process and physics laboratory management problems in accordance with the scientific principles of physics, propose various alternative solutions and conclude them for making the right decisions,	

Aspects	Learning Outcomes	LOCs-IPC
	and become lifelong learners who are more independent and capable adapt to dynamic changing situation.	

Introductory physics course (basic physics II) includes material on electricity, magnetism, light and optics is show in Table 4. This course aims not only to train PPTs' knowledge of introductory physics concepts (basic concepts of optics, electricity, magnetism, and electromagnetic waves) but also to train them in solving physics problems logically, critically, and innovatively. In addition, PPTs are also directed to have competencies related to concept-building skills through practicum activities or scientific practice. This activity shows that the competence of "scientific practice" is also emphasized in the physics education curriculum. However, how "scientific practice" is trained must be seen in the practicum implementation module (discussed next). In addition, on specific skills, PPTs are trained to propose various alternative and innovative solutions to make the right decisions in solving problems. This argument explains the importance of creativity for a prospective physics teacher-student.

Learning Strategies in Introductory Physics Course

The SLP for introductory physics courses (SLP-IPC) shows that the lecture method is online and offline. Online lectures are carried out using the Google Classroom application. The implementation of offline lectures is carried out through discussion and inquiry-based learning as well as practicum, which is part of the assignment. This strategy shows that the implementation of experiments or practicum is carried out after students get theory in lectures in class. The introductory physics lecture strategy has led to inquiry activities. However, introductory physics courses have not implemented the level of inquiry model with project assignments. In LOCs-IPC, there are competency aspects of solving innovative physics problems and building concepts through practicum activities. This competency can be achieved by developing a level of inquiry model with project assignments.

Assessment Techniques in Introductory Physics Courses

Assessment of the introductory physics course known from the SLP-IPC document includes Presence (10%), Assignments (15%), Midterm Examination (25%), Final Semester Examination (30%), and Practicum (20%). Each meeting has assignments in the form of activities to design experiments in the laboratory and complete practice questions. The trial report is part of the assignment assessment. In comparison, practicum assessment includes a pretest and post-test for each experiment, attendance, and practicum exams. Midterm and final semester exams are conducted in writing. Based on a review of midterm and final semester exam questions, it is known that the cognitive level measured in terms of knowledge more often uses questions that are application (Cognitive level 3 in Bloom taxonomy/C3), analysis (C4) and some questions that are evidentiary or evaluation (C5). There were no questions that were in the low-level category, such as knowing (C1), understanding (C2), or the highest level, namely creating (C6). However, the form of questions and scoring rubrics related to assessing student creativity has not yet been found. In addition, no assessment technique was used to assess learning outcomes related to independence and learning responsibility in introductory physics courses.

Results of the Practicum Guidelines Analysis

The introductory physics practicum guideline document is prepared as a guideline for carrying out experiments or practicum in the laboratory consisting of the title and objectives of the practicum shown in **Table 5.**

Table 5. Titles and Practicum Objectives in Introductory Physics Courses

Practicum topic	Experiment objective
Practicum 1: The formation of an image by a lens	(1) Investigate the relationship between object distance (s), image distance (s,) and focal length (f); (2) Determine the nature of the image produced by a convex lens.
Practicum 2: Refraction in parallel plane glass	(1) Determine the refractive index of parallel plan glass; (2) Determine the shift of the refracted ray (t) on the parallel plan glass
Practicum 3: Refraction by a prism	(1) Understanding the properties of refraction in prisms; (2) Determine the deviation angle of the prism refraction.
Practicum 4: Resistors in series circuit	Understand the characteristics of series resistors in a closed circuit.
Practicum 5: Resistors in	Understand the characteristics of parallel resistors in a closed circuit.

Practicum topic	Experiment objective
parallel circuit	
Practicum 6: Ohm's Law	(1) Understanding the relationship between voltage (V) and current (I) in a closed circuit; (2) verify ohm's law.
Practicum 7: The resistivity of a conducting material	Investigating physical quantities to determine the resistivity of a conducting wire
Practicum 8: Capacitor	(1) Determine the capacitive reactance value of a resistor; (2) Understanding the characteristics of capacitors in series and parallel circuits

Based on Table 5, it is known that PPTs in introductory physics courses must carry out eight practicum topics. However, the order of practicum topics is the primary concern. Table 4 shows that scientific practice activities begin with activities to investigate the concept of optics and then proceed with activities to investigate the concept of electricity. The sequential of introductory physics topic is undoubtedly different from the order generally found in introductory physics textbooks (Serway & Jewett, 2018; Young et al., 2020), which places the presentation of a chapter on electricity and magnetism followed by a chapter on light and optics. Practicum activities carried out by students refer to practicum guidelines with a sequence structure, as shown in Figure 2.

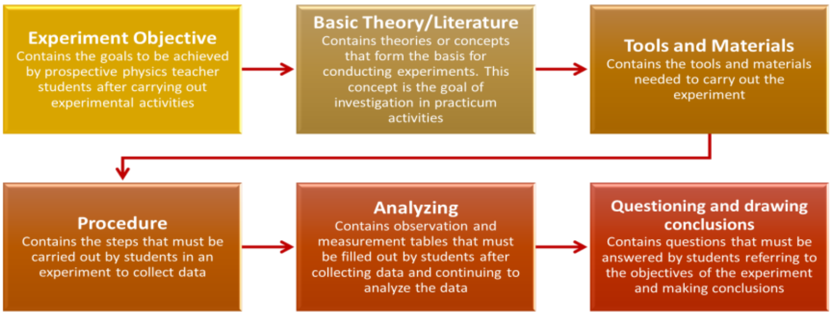

Figure 2. Experimental Procedures in Practicum Guidelines

Based on the structure of the practicum guidelines show in Figure 2, it can be seen that practicum activities still use the "cookbook practicum model," whose purpose is to verify the concepts that PPTs have learned. The structure of the physics practicum guidelines is not following proper inquiry procedures. Although some researchers suggest different steps of inquiry, the inquiry procedure always begins with a guiding question before conducting an investigation (Connor & Rosicka, 2020; Fan & Ye, 2022; Özer & Sarıbaş, 2022). The initial steps of the inquiry have not been seen in the introductory physics practicum guidelines being analyzed.

Student Responses to Introductory Physics Course Topics, Application of Inquiry Learning and Creativity Development

One student's responses to physics lectures are related to difficulties in learning basic physics concepts. The concept of light and optics is used as a case study in this analysis. The results of student responses to light and optics are presented in Table 6.

Table 6. Student Responses to the Difficulty of Introductory Physics Material on the Topic of Light and Optics (The Total Number of Students = 33).

Sub-topics of light and optics	Number of student responses			
	VE	M	D	VD
Snell's law of reflection and refraction of light	0	18	15	0
Formation of an image in a plane mirror	5	26	2	0
Formation of an image in a concave mirror	3	27	3	0
Formation of an image in a convex mirror	4	26	3	0
Refraction on a spherical surface	2	17	14	0
Concave lens	6	18	9	0
Convex lens	6	21	6	0
Light Dispersion	2	20	11	0

Sub-topics of light and optics	Number of student responses			
	VE	M	D	VD
Interference from light	4	15	13	1
Light Diffraction	4	20	8	1
Light Polarization	2	18	13	0
Optical application-based equipment	0	12	20	1

VE: very easy, M: Moderate, D: difficult, VD: Very difficult.

Based on Table 6, it is known that the responses of PPTs regarding the difficulties in learning light and optics material. Overall, from the topic of light and optics, students' difficulty level is in the moderate category. However, there are still some materials considered difficult by PPTs, such as optical application equipment (60.6%), Snell's law (45.5%), refraction on spherical surfaces (42.4%), light interference (33.3%), and light polarization (33.3%). Physics teacher students consider the materials on light interference, light diffraction, and optical application equipment very difficult, but with insignificant percentages.

The causes of difficulties and the importance of understanding the physics topics

The questions in the response questionnaire contain open questions to reveal the reasons why light and optics are difficult to study. The results of the questionnaire answers show some of these reasons, including; (1) Optical material contains formulas that make it quite difficult to learn; (2) some many pictures or diagrams are difficult to understand; (3) Some optical materials have sub-materials that require in-depth understanding, so they need to be studied slowly; (4) Optical materials use many practicums that use tools and materials whose functions are still poorly understood; (5) Often experience confusion in distinguishing the properties between concave and convex mirrors; (6) Difficulty understanding the material because of lack of focus and embarrassment to ask; (7) Lack of interest in learning; and (8) errors often occur in experiments so that they do not produce data or conclusions that are under existing theories.

Another question in the student response questionnaire in lectures is related to the reasons for the importance of studying light and optics. The results of the questionnaire answers show some of these reasons, including; (1) Optical materials are often encountered, and help solve problems in everyday life; (2) Optical material is the basis for making applications or studying optical instruments; (3) related optical materials, especially glass related to technology applications in the RI 4.0 era; (4) Practicum in optics is vital to understand better the theory that has been studied; and (5) Optical materials are often found in other physics materials, so they are essential to study.

The role of the lecturer in learning in the classroom and the laboratory

The questionnaires also asked about the experiences of PPTs regarding the role of lecturers during lectures in class, which is presented in Figure 3.

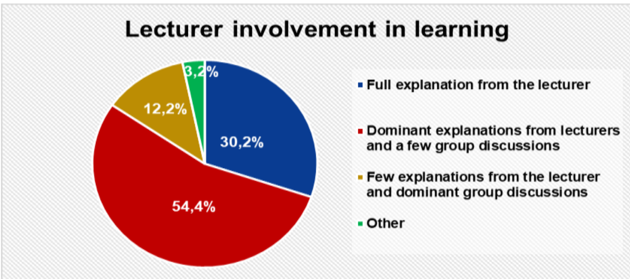

Figure 3. Student Responses to the Lecturer's Role in Basic Physics Class

Figure 3 shows that lectures in class are more dominated by explanations from lecturers and a few group discussions (54.4%). Even 30.2% of students answered that in-class lectures, the lecturer fully explained the material or more, indicating that lectures in class were one-way direction learning. In addition, the questionnaire questions also revealed the experience of PPTs in carrying out practicum in the laboratory. Questionnaire questions reveal the role of lecturers or practicum assistants in carrying out practicum in the laboratory. The results of the questionnaire answers are shown in Table 7.

Table 7. Role or Involvement of Lecturers in Practicum in the Laboratory

Lecturer involvement activities in practicum	Response percentage (%)
Experimental activities are carried out under the full guidance of the lecturer with experimental guides/modules	15.2
Experimental activities were dominated by lecturer guidance with experimental guides/modules	69.7
Experimental activities are slightly guided by lecturers and dominated by student initiatives with guides/experimental modules	15.2
Experimental activities are carried out freely (open-ended) by students based on the objectives of the experiment	0.0

Base on Table 7 regarding the role of the lecturer or practicum assistant in the laboratory during the experiment, most students (69.7%) answered that the guidance of the lecturer or practicum assistant with the module guide provided dominated the experimental activities. There is no answer that the experimental process is carried out freely (open-ended) by students based on the experiment's objectives. Data from student responses to the application of two high-level inquiries in introductory physics courses is show in Figure 4.

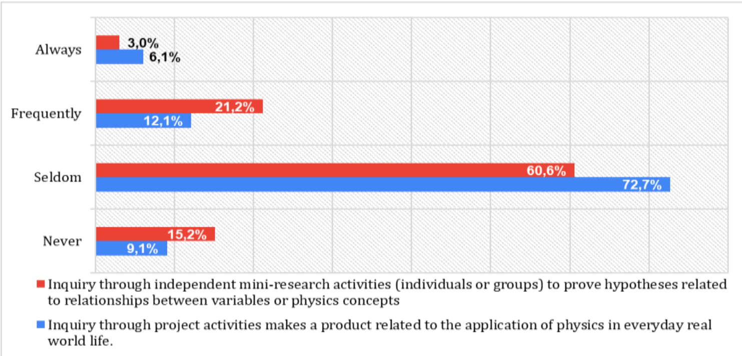

Figure 4. Data from Student Responses to the Application of two High-Level Inquiries In Introductory Physics Courses

Responses about the urgency of applying the level of project inquiry and hypothetical inquiry in introductory physics lectures

The two final levels of inquiry, namely project inquiry (real-world application) and hypothetical inquiry, are models that emphasize science skills and attitudes, creative problem solving, design and construction of technology to solve problems, and can encourage student teacher candidates to communicate and work in teams. Therefore, the urgency of this inquiry model is also necessary to ask PPTs before developing a project inquiry model. The results of the responses of PPTs regarding the urgency of implementing project inquiry and hypothetical inquiry are presented in Figure 5.

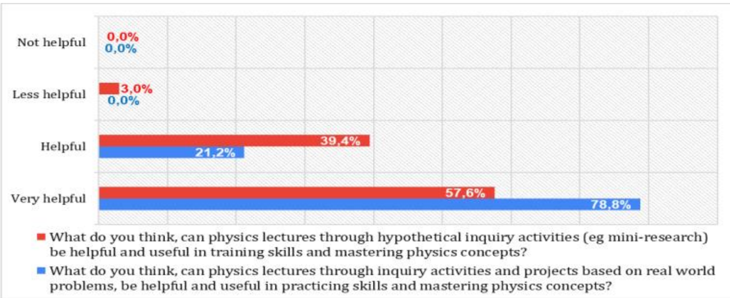

Figure 5. Responses of PPTs about the Benefits of Implementing Project Inquiry and Hypothetical Inquiry in Physics Learning

Base on Figure 5, Questions about the benefits of inquiry-based learning in the form of project activities to solve real-world problems were assessed by students as very helpful (78.8%) and helpful (21.2%), and no answers were found in categories that were less useful and not useful. Concerning the development of physics lectures through mini-research activities (individuals or groups) to prove hypothetical inquiry, the response was also very helpful (57.6%) and helpful (34.4%) for students in physics lectures. Even though there were 3.0% of the answers less helpful, it was not significant. Responses of PPTs about the importance of implementing project inquiry and hypothetical inquiry in physics learning is show in Figure 6.

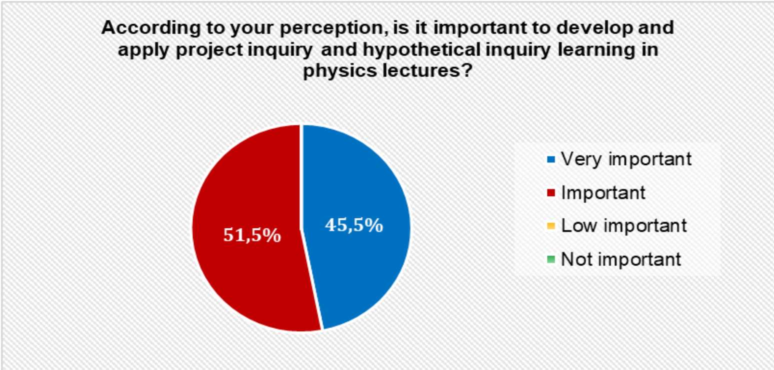

Figure 6. Responses of PPTs about the Importance of Implementing Project Inquiry and Hypothetical Inquiry in Physics Learning

Based on Figure 6, it is known that students think it is very important (45.5%) and important (51.5%) that inquiry-based lectures develop real-world application projects and hypothetical inquiry through simple research to practice skills and mastery of physics concepts. Questionnaires about student perception scale using aspects of creativity in learning were also carried out to determine students' experiences using creativity in learning introductory physics. Questionnaire results related to student creativity in learning physics are shown in Figure 7.

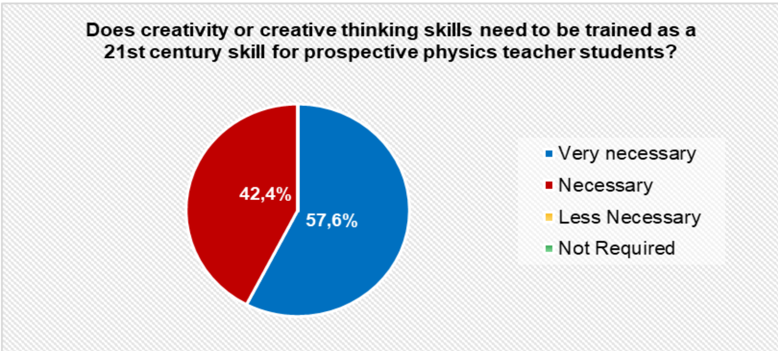

Figure 7. Responses of PPTs about the Urgency of Developing Creativity as One of the 21st Century Skills

The results of the questionnaire as show in Figure 7 show that in learning introductory physics, students still tend to be unskilled in originality, fluency, and flexibility in creative thinking skills. The originality aspect is the aspect that is rarely used (51.5%). Even 9.1% of students state that they have never used answers or steps in learning that have never been used before. The survey results related to students' responses to the urgency of developing creativity (Figure 9) also show that 57.6% of students state that creative thinking skills need to be developed as 21st-century skills for PPTs.

Lecturer Interview Results about Inquiry Learning and Student Creativity

There are five open questions given to the lecturer during the interview. These questions relate to the lecture process conducted in the classroom and laboratory, the application of the level of inquiry in physics lectures, student creativity in learning, student creativity assessment techniques, and perceptions of the development of inquiry models to develop creativity. Results of lecturer interviews about inquiry learning and student creativity is show in Table 8.

Table 8. Results of Lecturer Interviews about Inquiry Learning and Student Creativity

Questions	Summary of answers
1. How is the learning process that you do both in class and practicum in the laboratory?	Lectures are carried out through the delivery of theory and practicum in the laboratory. After the initial material was delivered, students were asked to form groups for presentation and discussion assignments at the next meeting. Students are also directed to carry out experiments or practicums, usually after the theory is presented in class. When carrying out practicums, students are guided by practicum assistants based on the practicum guideline module for each experiment.
2. How often do you conduct lectures through inquiry activities according to the level of inquiry (discovery learning, interactive demonstrations, laboratory inquiry, real-world application inquiry, hypothetical inquiry)?	Lectures are conducted through animated demonstrations using applications such as PhET simulations or the Physics at School application. In addition, students also carry out practicum in the lab with practicum guidelines that have been prepared based on problem orientation at the beginning of each experiment. Learning through projects and mini-research has never been done.
3. How are students' actions (creativity) in giving answers to assignments/questions or working on experimental steps related to fluency, flexibility and originality?	Student creativity is more likely to answer according to the textbook when viewed from the answers to assignments. While in practicum, students follow practicum guidelines even though several groups are active and have high initiative in conducting experiments. Some students also decided to change the experimental steps when a step could not be implemented. However, students tend to use standard steps in practicum guidelines.
4. How do you evaluate the skills and attitude aspects? Has student scientific creativity ever been assessed?	Skills are measured and integrated into practicum assessments even though no specific assessment rubric is related to skills. Assessment is carried out normatively according to the weight of the attendance assessment, assignments, midterm exams and final semester exams. There has never been a special assessment of student scientific creativity in studying physics material.
5. Is inquiry learning (real world and hypothetical applications) and student scientific creativity essential and needs to be developed for students?	To support 21st-century skills such as student creativity, developing inquiry learning through real-world problem-solving projects is essential, not only through class discussion and practicum. Likewise, mini-research to prove hypotheses can also strengthen students' research skills according to the MBKM higher education curriculum, which is oriented towards 21st-century skills.

Discussion

Prospective teacher students need to have scientific creativity because scientific creativity in pedagogical practice is related to the practical process of teaching. Based on the results of the questionnaire, it is known that students use more aspects of flexibility in lectures or practicum. Meanwhile, originality and fluency are not yet visible to students. Scientific creativity has also never been measured and developed in introductory physics courses. Lecturers and students respond similarly: scientific creativity is advantageous and essential for students as a 21st-century skill. Developing scientific creativity is also vital in developing introductory physics courses. Physics teacher candidate students still experience difficulties in understanding fundamental physics lecture material, especially some material related to the concept of light and optics. Students' difficulty can be caused by low interest in introductory physics courses. The concepts of light and optics must be mastered by PPTs (Nurlina et al., 2022; Wahyudi et al., 2020; Zhou, 2021). Apart from being able to master the concepts of light and optics well, students also need to be equipped with inquiry skills and creative thinking skills through lecture development. Optical material is an essential material and is closely related to everyday life. Even though students consider the concept of light and optics essential to master, students still fail to understand the basic principles of optics. This difficulty is also caused by students tending to give reasons about light and optical phenomena by relying on phenomenological primitives and physical intuition (Mešić et al., 2019; Ozdemir et al., 2020). Several misconceptions were also found about optics, which even impact work related to optics. For this reason, PPTs must be given learning experiences by observing real-world phenomena related to light and optics through inquiry activities (Kaltakci-Gurel et al., 2016, 2017;

Wahyudi et al., 2023). It is necessary to develop the creativity of PPTs in studying introductory physics material, especially in the concepts of light and optics. One way to do this is to change the practicum method, which still seems like a "cookbook" to an inquiry-based practicum (Imaduddin & Hidayah, 2019; Wahyudi & Lestari, 2019). The cookbook model practicum makes students not creative because the tools, materials, and procedures are already available by default in the module. Cookbook activities may somewhat indicate the possibility of "hands-on" activities but are rarely related to "mind-on" activities. The recipe book experiment did not facilitate PPTs to build and strengthen deep and meaningful understanding. The application of a cookbook practicum will eliminate the main aspects of inquiry, such as questioning, predicting, planning experiments, drawing conclusions based on evidence based on one's observations, arguing with peers, and forming coherent arguments (Bertsch et al., 2014; Yusiran et al., 2019). This inquiry activity will undoubtedly encourage the development of scientific skills and student motivation in studying physics. The level of student self-actualization motivation will affect student creativity. The development of student creativity through inquiry learning received a positive response from lecturers and students.

Inquiry-based learning is a method that emphasizes scientific skills and attitudes and encourages students to communicate and work as a team to solve problems creatively (Anas & Harum, 2023; Ng & Adnan, 2018). However, the reality of the course still shows a dominance of lecturers both in class and in the laboratory. This poor makes various student skills cannot be optimized in learning. The solution considered appropriate for optimizing students' skills and increasing knowledge, and following the characteristics of science-physics learning is to apply inquiry and project learning. Developing this model is important and exciting because inquiry-based learning can occur well through project implementation (K. W. S. Chu, 2009; Wilhelm et al., 2008). Inquiry and project-based learning are meaningful constructivism-based learning that can develop a variety of higher-order thinking skills (Hugerat & Kortam, 2014; Lu et al., 2021; Mubarok et al., 2019; Tindangen, 2018), and is based on investigation and includes gathering information from various sources, to improve inquiry skills and student creativity (Gunawan et al., 2017; Perdana et al., 2023). It can increase creativity, but project inquiry learning is also effective and fun for students to learn 21st-century disciplinary content and skills (Haatainen & Aksela, 2021; Hursen, 2018; Wenning & Vieyra, 2020). The level of inquiry (LoI) model of instructions put forward by previous study is a spectrum of levels of inquiry. When students become more intellectually sophisticated, the teacher's inquiry level can become more sophisticated.

The final stage of the inquiry level, namely real-world application and hypothetical inquiry, can be carried out through project activities. After building knowledge and skills has passed through the inquiry level (inquiry lab stage), PPTs carry out the project. The project learning steps continue from the project launching stage, developing ideas and products, and presenting product results. The Level of Inquiry with Project Assignment (LoI-PA) model is expected to promote the development of student creativity. Prospective teacher students need to have scientific creativity because scientific creativity in pedagogical practice is related to the practical process of teaching (Spronken‐Smith & Walker, 2010; Zhou, 2021). Through the Level of Inquiry with the Project Assignment (LoI-PA) model, students' creative thinking skills in fluency, flexibility, and originality as creativity aspects can be improved. When solving problems through projects, according to previous study students can find many ideas (fluency) so that they can succeed in changing perspectives (flexibility), and as the number of solution ideas increases, so does the possibility of solving problems that are unorthodox and thus the originality of the solution gets closer (Haim & Wahlster, 2022; Riddell, 2015). Developing project inquiry and hypothetical inquiry learning models to develop student creativity is necessary in introductory physics lectures. Based on the needs analysis, both lecturers and students consider the development of this model very important. However, further research is still needed to develop more concrete learning steps by combining the level of inquiry and the project steps in the last level of inquiry. Weaknesses of the level of inquiry model and project learning need to be addressed, such as the relatively more prolonged learning time consumption (Putri, 2021; Wenning & Vieyra, 2020). On the other hand, resistance to inquiry curriculum can occur for students because of the complexities and frustrations encountered when practicing through inquiry. So, it is necessary to integrate information technology in inquiry-based learning and projects, such as using web learning, animated simulations, videos or electronic modules (Ayu, 2022; Rahmawati et al., 2021; Rusmanto & Rukun, 2020). The use of information technology not only makes physics lectures interesting, and students become independent in learning physics but is expected to make the learning process more effective and efficient.

4. CONCLUSION

A needs analysis has been carried out for the development of the Level of Inquiry with Project Assignments (LoI-PA) model, which will increase the creativity of PPTs. The study results concluded that the introductory physics lecture curriculum complies with the Indonesian National Qualifications Framework (KKNI), which includes attitudes, knowledge, general skills and special skills competencies for PPTs. The results of the analysis of curriculum documents also show that there are competency standards for PPTs related to the mastery of scientific skills and creativity. However, PPTs still struggle to understand some introductory physics material. Introductory physics learning is still dominated by lecturers, physics practicum activities have not led to the right inquiry learning process and project learning is rarely carried out. The creativity of PPTs has not been optimized in learning physics. The development of the Level of Inquiry with Project Assignments (LoI-PA) model is deemed necessary., and student creativity is very important to develop. The LoI-PA hypothetical model has been formulated to increase students' knowledge, scientific skills and creativity. Further research is needed to develop valid learning steps and integrate information technology into the learning model steps.

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