Strategic placement of optics content reinforcement in the curriculum of the physics education study program

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Abstract. This research is a survey that aims to explore the reinforcement of optics content in the curriculum of physics education study programs (PESP) in Indonesia. This survey is carried out through three stages as follows; a) first stage: focusing on investigations related to the distribution of waves and optics courses in 22 PESP’ curriculum structures, b) second stage; involving 6 PESP which is considered to represent the PESP in the first stage, that focusing on analyzing college courses that contains the reinforcement of optics content, c) third stage; involving 2 PESP which is considered to represent the PESP in the second stage, that focusing on investigations related to lecture orientations and how the reinforcement of optics content is carried out. The results of the descriptive analysis show that the distribution of waves and optics course in the curriculum structure is presented in various ways, both from the course placement and the load of the course. The reinforcement of optics contents is also implemented in various approaches and methods.

1. Introduction
The rapid development of science and technology has affected all aspects of human life, including the aspect of education. The role of the teacher is an important component in the success of education. Professional teachers have become a necessity in this era because of its very important role in educating people to have competence in solving various problems and being able to compete in the era of industrial revolution 4.0.

The role of producing professional teachers is inseparable from the role of the teacher training institutions (Lembaga Pendidikan Tenaga Kependidikan or LPTK). LPTK is a higher education institution that is tasked by the government to organize teacher training programs in formal early childhood education, elementary school, middle school, and or high school, as well as to organize and develop science or knowledge of education and non-education.
One of the factors that determine the quality of LPTK graduates is the curriculum. Conceptually, the curriculum can be seen as; a) substance; namely the plan for learning activities for students at school, or as a device to achieve goals, b) system; which is part of the school system, the education system, and even the system of society, and c) the field of study; namely the field of study of curriculum experts, education experts, and teaching experts [1]. The higher education curriculum is a set of plans and arrangements regarding the content and material of studies and lessons, as well as the ways of delivery and assessment that are used as guidelines for the implementation of teaching and learning activities in universities [2].

The issuance of Presidential Regulation number 8 of 2012 concerning the Indonesian Qualifications Framework (KKNI) requires all study programs to develop a curriculum framework by referencing to the KKNI. The development of PESP’ curriculum needs to be improved in order to increase the competence of pre-service physics teacher (PPTs) in Indonesia, in which the goal is to produce professional physics teachers. The results of previous studies indicate that PPTs’ competencies still needs to be improved [3,4].

In the PESP’ curriculum, optics is one of the material content/ courses that must be studied by PPTs. Optics is a branch of physics that describes the behavior and nature of light and the interaction of light with matter. Optics is divided into three branches, namely; 1) geometric optics; which is treated by the method of light rays, that studies the method of light based on the nature of light propagation, studies the reflection and refraction of light, becomes the basis in making optical instrument applications, and uses geometric and trigonometric approaches to solve problems, 2) physical optics; which is concerned with the nature of light and involves primarily the theory of waves, 3) quantum optics; which deals with the interaction of light with the atomic entities of matter and which for an exact treatment requires the methods of quantum mechanics, studies light based on Planck's theory which views light as a light quanta or packets of energy, and studies the phenomenons associated with light and its changes in accordance with energy and mass [5,6].

The reinforcement of optics content in the PESP’ curriculum structure are carried out on different courses, whether its’ different course name, course load, time, or course placement. Therefore, it is necessary to conduct a research related to the distribution of the course to find out which courses are found to reinforce the optics content, and how the reinforcement is carried out. Knowledge related to the reinforcement of optics content in the PESP’ curriculum will be very useful in designing the strategic placements of the reinforcement for PPTs. This is based on the results of a preliminary study which shows that the PPTs’ concept mastery in the optics contents, both geometric and physical optics, is still weak [3].

2. Methods
This research is a survey consisting of three stages. The first stage of the survey is focused on investigating the distribution of waves and optics course in 22 PESP’ curriculum structures whose curriculum documents can be accessed online. Involving 6 PESP, which are considered to represent the sample in the first stage, carries out the second stage of the survey. The second stage is focused on analyzing which courses are possible for the reinforcement of optics content to be conducted. The third stage of the survey was conducted by analyzing the lesson plan (Rencana Pembelajaran Semester or RPS), which was focused on observing the course orientation, and how the reinforcement of the optics content was carried out in the courses analyzed in the second survey. The optics content observed in this study is limited to geometric and physical optics content. Data analysis was carried out descriptively.

3. Result and Discussion
3.1. Distribution of Waves and Optics Courses in the PESP’ Curriculum Structure
In general, the distribution of waves and optics courses on PESP’ curriculum structure are categorized into two categories as follows: 1) presented in a single unit under the name of waves and optics
course, 2) presented separately in different courses, namely waves course and optics course. In several PESP’ curriculum, wave and optics courses are placed in odd semesters, while some are placed in even semesters. The status of the courses is compulsory for all PPTs. Generally, to take this course, PPTs are required to have passed basic physics course and mathematical physics courses. The results of the survey related to the distribution of waves and optics courses on the PESP’ curriculum structure is shown in Table 1.

| No | PESP’ Code | Course                        | Credits | Semester | Status  |
|----|------------|-------------------------------|---------|----------|---------|
| 1  | PESP-01    | Wave Optics                   | 4       | Even (IV)| Compulsory |
| 2  | PESP-02    | Wave Optics                   | 3       | Odd (V)  | Compulsory |
| 3  | PESP-03    | Waves and Optics              | 4       | Even (IV)| Compulsory |
| 4  | PESP-04    | Optics                        | 2       | Odd (III)| Compulsory |
|    | Waves      |                               | 2       | Even (IV)| Compulsory |
| 5  | PESP-05    | Waves                         | 2       | Odd (V)  | Compulsory |
|    | Optics     |                               | 2       | Odd (V)  | Compulsory |
| 6  | PESP-06    | Vibrations and Waves          | 3       | Odd      | Compulsory |
|    | Geometrical and Physical Optics |                         | 3       | Even     | Compulsory |
| 7  | PESP-07    | Waves, Sound, and Optics      | 3       | Odd (III)| Compulsory |
|    | Waves and Physical Optics     |                               | 3       | Even (V) | Compulsory |
| 8  | PESP-08    | Waves                         | 3       | Even (IV)| Compulsory |
|    | Optics     |                               | 2       | Odd (V)  | Elective |
| 9  | PESP-09    | Waves and Vibrations          | 2       | Even (IV)| Compulsory |
|    | Optics     |                               | 3       | Even (IV)| Compulsory |
|    | Waves and Optics Practicum    |                               | 1       | Even (IV)| Compulsory |
| 10 | PESP-10    | Waves and Optics              | 4       | Odd (V)  | Compulsory |
| 11 | PESP-11    | Waves                         | 3       | Odd (III)| Compulsory |
|    | Optics     |                               | 2       | Even (IV)| Compulsory |
|    | Optoelectronics            |                               | 2       | Odd (V)  | Elective |
| 12 | PESP-12    | Basic Waves and Electrodynamics| 4      | Even (II)| Compulsory |
|    | Waves      |                               | 3       | Even (IV)| Compulsory |
|    | Optics     |                               | 3       | Odd (V)  | Compulsory |
| 13 | PESP-13    | Waves                         | 2       | Odd (III)| Compulsory |
|    | Optics     |                               | 2       | Even (IV)| Compulsory |
| 14 | PESP-14    | Waves                         | 3       | Odd (III)| Compulsory |
|    | Optics     |                               | 2       | Even (VI)| Compulsory |
| 15 | PESP-15    | Waves                         | 2       | Even (IV)| Compulsory |
|    | Optics     |                               | 2       | Odd (V)  | Compulsory |
| 16 | PESP-16    | Mechanical Waves              | 3       | Odd (III)| Compulsory |
|    | Mechanical Waves Experiment  |                               | 1       | Odd (III)| Compulsory |
|    | Electromagnetic Waves        |                               | 2       | Even (IV)| Compulsory |
|    | Optics     |                               | 3       | Even (IV)| Compulsory |
|    | Optics Experiment            |                               | 1       | Even (IV)| Compulsory |
| 17 | PESP-17    | Vibrations and Waves          | 2       | Even (IV)| Compulsory |
|    | Optics     |                               | 2       | Odd (VII)| Compulsory |
| 18 | PESP-18    | Waves and Optics              | 4       | Odd (V)  | Compulsory |
| 19 | PESP-19    | Waves and Optics              | 3       | Even (IV)| Compulsory |
| 20 | PESP-20    | Waves                         | 3       | Odd (V)  | Compulsory |
| 21 | PESP-21    | Waves                         | 3       | Even (IV)| Compulsory |
|    | Optics     |                               | 3       | Odd (V)  | Compulsory |
| 22 | PESP-22    | Waves                         | 3       | Odd (III)| Compulsory |
|    | Optics     |                               | 3       | Odd (V)  | Compulsory |

3.2. Identification of Optics Content Reinforcement in the Various Courses

Description analysis of the content in the 6 PESP’ curriculum documents were carried out to discover which courses reinforces its’ optics content. These 6 PESP are considered to be able to represent the curriculum structure of the PESP that chosen as the sample in the first phase of the survey. PESP that presents wave and optical courses is integrated into one course are represented by PESP-01, PESP-02,
and PESP-18. Whereas the PESP that presents waves and optics courses separately into different courses are represented by PESP-04, PESP-14, and PESP-19, as can be seen in Table 2.

| Course Distribution Classification | Sample | Optics Contents Reinforcement |
|-----------------------------------|--------|-----------------------------|
| Integrated into one course         | PESP-01| General Physics, Basic Physics I, Schools Physics I, Wave Optics, Schools Physics Laboratory II, History of Physics, Biophysics |
|                                   | PESP-02| Basic Physics II, Wave Optics, History of Physics |
|                                   | PESP-18| Basic Physics II, Basic Physics Laboratory II, Biophysics, Waves and Optics, Physics Laboratory, Schools Physics Laboratory Management, Physics Theory Introduction to Measurement Tools and its’ Methods, Basic Physics II, Basic Physics Laboratory II, Physics in Islam, Optics |
| Separately into different courses | PESP-04| Basic Physics II, Waves, Schools Physics, Optics, Physics Laboratory |
|                                   | PESP-14| Basic Physics II, Waves, Schools Physics, Optics, Physics Laboratory |
|                                   | PESP-11| Basic Physics, Basic Physics Laboratory, Optics, Optoelectronics |

3.3. Orientation and Optics Content Reinforcement of Courses at PESP-01

To analyze the orientation and how the optics content reinforcement are carried out in the courses at PESP-01, researchers conducted an analysis of the RPS (lesson plan) of the courses that had been identified in the second stage of the survey previously. In the curriculum document of PESP-01, optics content reinforcement was found in the courses of General Physics, Basic Physics I, Schools Physics I, Wave Optics, Schools Physics Laboratory II, History of Physics and Biophysics.

After participating in general physics course, PPTs are expected to be able to master general physics knowledge comprehensively, and be able to develop and apply the knowledge to study the clusters of mathematics and science knowledge. The reinforcement of optics content that includes geometry optics, physical optics, and quantum optics are contents related to the nature of light, color, reflection and refraction, light waves, light emission, and light quanta. The lecture is delivered through an inquiry approach, lecturing, question and answer, and discussion methods.

In the basic physics I course, PPTs are expected to be able to master the basic knowledge of mechanics, waves, sounds, optics, and heat, and able to develop and apply it to seek more advanced physics knowledge. The reinforcement of optics content that includes geometric optics and physical optics are presented through lecturing, demonstrations, question and answer, and discussion methods.

After taking schools physics I course, PPTs are expected to be able to develop learning materials for physics in schools based on Competency Standards (Standar Kompetensi or SK) and Basic Competencies (Kompetensi Dasar or KD) that are relevant on the demands of Content Standards for Primary and Secondary Education, as well as being able to conduct self evaluations in diagnosing and correcting misconception. It is not stated that the optics content reinforcement is focused solely on geometric or physical optics. PPTs are given the task to make a paper related to the analysis and description of physics learning materials in school. Optics is one of the topics that became the subject of the paper.

In the wave optics course, PPTs are expected to have the ability to express wave descriptions in various mediums, the general properties of waves, and the application to waves on water surface, sound waves, electromagnetic waves, and light waves. The optics content reinforcement focused on physical optics. The lectures are conducted through the inquiry approach using lecturing and discussion methods. In addition, assignments are given individually and in the form of a simple experiment project.

After attending the school’s physics laboratory II course, PPTs are expected to have skills related to the working principle of basic measuring instruments, the ability to make manuals of various tools
for demonstration and experiments of physics learning materials. Optics is one of the topics that can be chosen for the course. The lectures are conducted through lecturing, discussion, question and answer, demonstration, and experiment methods.

In the history of physics course, PPTs are expected to have knowledge and insights of the development of physics as a scientific discipline, its' problems, and thoughts behind it. The optics content reinforcement is focused on the studies related to the development of optics in each period. PPTs are given the task to make a paper and present them.

After participating in the biophysics courses, PPTs are expected to have insight and knowledge related to the application of physics concepts in biology. The optics content reinforcement is focused on studies related to the analysis of the application of the concepts of light and optics in biology. Lectures are conducted through lecturing, problem solving, and discussion methods.

3.4. Orientation and Optics Content Reinforcement of Courses at PESP-14

By analyzing the RPS (lesson plan) on the courses that have been identified in the second stage of the survey, particularly on the PESP-14, researchers can identify which courses reinforce the optics content and how the reinforcement is carried out. From the results of the RPS analysis in the curriculum documents at PESP-14, it was found that the reinforcement of optics content was found in the courses of Basic Physics II, Waves, Schools Physics, Optics, Physics Laboratory and History of Physics.

In the course of basic physics II, PPTs are expected to be able to; 1) master the materials, structures, and basic physical concepts, and their application in technology, 2) use basic physical concepts and appropriate mathematical methods to find solutions to quantitative problems of physics, 3) use measuring instruments and laboratory equipments to improve the precision and accuracy of measuring physical phenomena and conduct experiments in order to find/ prove basic concepts, principles, and laws of physics, 4) collect and analyze experimental data and compile coherent reports on their findings; 5) responsible for the findings obtained, by communicating them in the forum of the class. The reinforcement of optics content that includes geometric optics and physical optics are presented through active learning with a combination of discussion, question and answer, and laboratory activities.

After participating in the waves course, PPTs are expected to be able to; 1) has the ability to use the concepts of waves, and the right mathematical/ computational methods to get solutions to quantitative problems of waves, 2) master the material, structure, and concept of waves, and the application in technology, 3) apply the principles, concepts, and laws of waves in the form of prototypes of science and technology products that are relevant to the needs of the society, 4) implement higher order thinking processes in learning processes and characteristics of Waves both inductively and deductively. The reinforcement of optics content focused on physical optics are presented through discussion and laboratory activities.

In the school’s physics course, PPTs are expected to have an understanding of the essential concepts that becomes the scope of physics subjects in junior high school, high school, and vocational schools. In addition, in this course, studies were carried out regarding misconceptions related to essential concepts that often appeared in physics subjects. Optics is one of the topics that can be chosen by students to be studied in this course. The lecture is presented through the method of lecturing, discussion, and giving assignments. In addition, students are tasked with compiling and presenting portfolio documents related to essential concepts and a study of misconceptions on a given topic.

After taking the optics course, PPTs are expected to; 1) have critical thinking and use the right concepts to analyze qualitatively physics problems, 2) master the material, structure, and concepts of physics, and the application in technology, 3) apply implement higher order thinking processes in learning processes and phenomena of physics both inductively and deductively, 4) designing and carrying out experimental research, analyzing data, and making a conclusion. The reinforcement of
optics content focused on geometric optics and physical optics are presented through material presentations, discussions, laboratory activities, problem solving, and giving assignment.

In the physics laboratory course, PPTs are expected to be able to: 1) master the knowledge of physics laboratory management, 2) understand the use of equipments in high school laboratory and 3) maintain the high school physical laboratory equipments. In this course, it is not stated whether the reinforcement of optics content is only focused on geometric optics and physical optics. This lecture is presented by applying conceptual and contextual approaches with the project-based learning (PjBL) model and survey to high school laboratory, demonstrations, practicum, discussions, question and answer, and lecturing with the use of LCDs and models.

The results of the analysis show that the reinforcement of optics content is done in various ways. In general, the distribution of waves and optics courses on the PESP’ curriculum structure is presented as a single unit, while some are presented separately into different courses. Interference and diffraction is a slice of the topic between the content in the wave and optical courses which are presented in an integrated and separate manner. Optics is one of the essential materials both in physics learning in middle school and high school. Therefore, it is very important to provide an established reinforcement for PPTs. In addition to concept mastery, physics courses are expected to be a means to develop skills of critical thinking [7], creative thinking [8-11], decision making [12] and problem solving [13].

4. Conclusion
The distribution of waves and optics courses on the PESP’ curriculum structure is presented in various ways. In general, the distribution can be categorized into two categories, which are: 1) presented in an integrated manner in one course, 2) presented separately in different courses. The reinforcement of optical content has been done in several subjects by applying varied approaches and learning models.

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