Need analysis for developing of a light waves module: a three-dimensional learning framework

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Abstract. Some meaningful changes in science learning standards are listed in A Framework for K-12 Science Education and Next Generation Science Standards: For States, By States under a three-dimensional learning framework. Learning modules must be developed with the framework as the most advanced science learning standards. The research focus was to determine student needs for developing light waves module based on a three-dimensional learning framework. This study involved 147 respondents consisting of 22 teachers with different backgrounds and 125 high school students in the Purwakarta Regency. The instrument used was a 3DLQP questionnaire which included initial knowledge of the three-dimensional learning framework, learning modules in the school, criticism, and suggestions. Data obtained from questionnaires, interviews, national curriculum documents, NGSS complementary documents and then analyzed using triangulation of data sources. Based on the results, the teacher and student responses explain the need for the development of learning modules. This learning module is expected to facilitate the development of coherent and interconnected student knowledge, so that it can be used in various situations of everyday life.

1. Introduction

Currently, science and technology are progressing very rapidly, causing changes in qualifications and increasingly competitive workforce competencies. This also affects the standard of science learning which changes significantly. The change in the standard framework for science education was accommodated by the National Research Council (NRC) called the Next Generation Science Standard (NGSS) by developing A Framework for K-12 Science Education [1]. NGSS aims to produce outcomes that have knowledge of practice, crosscutting concepts, and core ideas in the fields of science and engineering and have the skills and mindsets of scientists and engineers to use them in solving problems related to global issues [2]. This standard framework in science education is known as three-dimensional learning. Three-dimensional learning consists of science and engineering practices, disciplinary core ideas, and crosscutting concepts. Each framework in the NGSS represents the goals that must be achieved by students in learning science according to the grade level and characteristics of the material being taught [3].

Creating learning to produce students who achieve the NGSS framework is a challenge for a teacher [4]. One solution to assist teachers in the learning process is to use modules. According to Rahayu, Ertikanto, and Wahyudi (2018) [5], the module in learning is very useful in the learning process because the module is packaged completely and systematically, it contains a set of learning experiences that are planned and designed to help students master specific learning objectives, learning material or substance, and evaluation.
The development of NGSS-oriented modules has begun to be implemented in Indonesia. Based on the research of [6], NGSS-oriented teaching materials help students to improve their skills in investigating and solving problems. The results of [7] state that NGSS-oriented science learning tools are suitable for use as teaching materials in schools, effective in improving skills and defining student problems. Other research reveals that NGSS-oriented science teaching materials can improve mathematical computational thinking, the results are obtained from NGSS validation oriented from teacher explanations and field trials on students. The results of the instrument's feasibility assessment were declared valid, so the results showed that the NGSS-oriented science learning media was suitable for use in the science class [8]. [9] stated that three-dimensional learning can facilitate the research team in implementing education including scientific practice, cross-sectoral concept techniques, and disciplinary core ideas in science learning.

Several studies on three-dimensional learning have been carried out by several experts before. [10] suggest that three-dimensional learning frameworks are a productive way to design curriculum and assessments to help students achieve science education goals. In addition, criteria were also developed to revise assessment items in the Physics learning process. The assessment items developed using these criteria are expected to be used to assess student learning both conceptually and scientifically. Then, [11] developed the criteria for the assessment items into a Three-Dimensional Learning Assessment Protocol which has included validity and reliability tests. Furthermore, [12] examines the relationship between core ideas in a three-dimensional learning framework. The study of [13] developed the Three-Dimensional Learning Assessment Protocol (3D-LAP) to evaluate the success of implementing the three-dimensional learning framework in science learning. Based on the explanation above, there are opportunities for the development of three-dimensional learning-based modules.

Based on the description above, this research was conducted to analyze the needs in developing a module based on a three-dimensional learning framework on light waves material. The material of light waves is still considered difficult by students. This is supported by several previous studies including [14] trying to overcome students' misconceptions in the concept of light. Other studies have shown that learners have misconceptions about light, light sources, vision, and other related concepts from primary to higher education levels [15,16,17]. [18] revealed some common errors about light, light sources, and visual processes that have been determined at all levels.

2. Method
The method used in this research is qualitative. This study involved 147 respondents consisting of 22 teachers and 125 high school students in the Purwakarta Regency. Data were obtained from questionnaires, interviews, national curriculum documents, NGSS complementary documents which were then analyzed using triangulation of data sources. Triangulation is a data analysis approach that synthesizes data from various sources [19]. The instrument used is a 3DLQP questionnaire which consists of three parts. The first part contains prior knowledge about the three-dimensional learning framework. The second part is about school learning modules. The third part contains criticism and suggestions. The collected data is then analyzed in the following stages:

![Figure 1. Data Analysis Stages](#)
a. Data collection stage: to obtain information needed to achieve research objectives
b. Reduction stage: this stage is done by summarizing, choosing the main things, focusing on the things that are important in the research
c. Presentation stage: presenting data in the form of narrative text or tables for easy understanding
d. Conclusion stage: In this stage, conclusions are drawn

3. Result and Discussion

3.1. Three-dimensional Physics Learning Questionnaire (3DLQP)
The Three-Dimensional Physics Learning Questionnaire (3DLQP) was distributed to 22 teachers and 125 high school students in Purwakarta Regency. 3DLQP was used to analyze the need to develop a light wave module based on three-dimensional learning.

a. Initial knowledge of three-dimensional learning framework
Based on the results of 3DLQP as many as 74% of teachers do not know about three-dimensional learning. Likewise, the results of 3DLQP given to students, as many as 53% did not know about three-dimensional learning. In the section on initial knowledge about the three-dimensional learning framework, 43% of teachers thought that three-dimensional learning was learning using three-dimensional visual media, while 52% of teachers answered they did not know. In the section on initial knowledge about the three-dimensional learning framework, as much as 44% of students think that three-dimensional learning is a three-dimensional medium that has dimensions of length, width, and height. As many as 9% of students think that three-dimensional learning is related to vectors and spaces and as many as 44% say they don't know. Furthermore, what is important in today's Physics learning is that 100% of teachers answer scientific practice, 68% cross-disciplinary concepts, 41% core ideas of scientific disciplines, and 59% cognitive abilities. While the important thing in learning Physics today is 45% of students answer scientific practice, 63% cross-disciplinary concepts, 47% core ideas of scientific disciplines, and 52% cognitive abilities.

b. Characteristics of Physics learning modules in schools
Based on the results of 3DLQP, 37.5% of teaching materials commonly used help engage students in scientific practice, 50% of teaching materials help students apply cross-disciplinary concepts and 58.3% of teaching materials help students understand the core ideas of disciplines. However, the teaching materials provided by the teacher have not helped students gain coherent knowledge because there are still few that involve scientific practice, even though students have applied cross-disciplinary concepts and understand the core ideas of one field of science. In the 3DLQP results, 41.7% of teachers still use textbooks as their teaching materials in physics learning, 25% use PowerPoint slides, 20.8% use articles or videos from the internet, and 12.5% use modules. From this 12.5% percentage, as many as 87.5% of teachers have made their modules, but the majority of the modules that have been made are not based on three-dimensional learning. This can be seen in the percentage of 3DLQP results, which is 79.2%.

c. Criticism and suggestions
Based on the results of 3DLQP, during the pandemic, teachers are still looking for interesting teaching strategies so that students can better understand and understand the material being taught. The teacher gives feedback so that every material in Physics learning is represented by an application because not all Physics material can be studied in real life so that students can learn Physics material as a whole. In addition, in learning Physics sometimes not all of the same learning models can be applied because, in practice, students often find it difficult to adapt to certain learning models, especially schools located on the outskirts of the city. Furthermore, mobile-based modules can be an alternative solution in implementing Physics learning, because they can add videos and virtual simulations to develop students' knowledge. The teacher also gives criticism and suggestions that it is better for learning Physics in schools not to refer to cognitive knowledge alone but to be correlated with skills in the form of practicum so that students do not only understand the theory. Students' responses about learning physics, namely learning physics tend to be boring because the teacher is more dominant in explaining physics formulas so that innovation in learning physics is needed.
3.2. Interview
Based on the results of interviews, the teaching materials that are often used are textbooks. Teachers do not make their teaching materials such as modules because they are already available in various sources so that teachers simply access them according to the learning strategies to be taught and usually the learning modules provided by MGMP are representative. However, the existing learning modules are not yet oriented to three-dimensional learning.

3.3. Document Analysis
Based on the results of document analysis that the NGSS describes student competencies based on performance expectations by integrating three-dimensional learning (three-dimensional learning). NGSS has similarities with the Indonesian Education Curriculum (K-13) in the use of a scientific approach. The application of NGSS in the learning process can be started from the development of NGSS-oriented teaching materials. The teaching materials are then applied in the learning process scenario [21]. In this study, the teaching materials developed were modules.

A three-dimensional learning-based module will be developed through the following stages. The first begins with performance expectations, which serve to help educators gauge what students should know at the end of a particular topic. Each science learning standard comes with performance expectations and can be found on the NGSS website. With the performance expectations, a series of learning and activities that are developed are expected to bridge the knowledge and skills that students have at the beginning of learning. This is important because the NGSS standard covers secondary schools as a single class group so that it adapts to their level of knowledge.

![Figure 2. Performance expectations](image)

After having performance expectations, learn the disciplinary core ideas that are in line with performance expectations. Disciplinary core ideas are used as a means of exchanging ideas for phenomena, objects, or events studied by scientists in the world. Ideally, the phenomenon should be something interesting to be studied by students and related to their daily lives. After identifying some phenomena, examine how students investigate and explore these phenomena. This section deals with science and engineering practices. The last stage is to determine the seven aspects of crosscutting concepts that are most relevant to performance expectations [22].
4. Conclusion
The need for the development of modules in Physics learning that can facilitate the development of student knowledge that is coherent and interconnected so that it can be used in various situations of everyday life.

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