Investigation of mathematical methods for physics lecture process at pre-service physics teacher

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Abstract. Mathematical Methods for Physics learning should master study material holistically and collaboratively for meaningfully learning. The aim of this research is to describe the process for Mathematical Methods for Physics course at pre-service physics teacher. Data were collected using a questionnaire, interviews with lectures and student, and observation. The result of this research are students gave respons positive towards learning material (78.1%), learning media (78.73%), opportunities for expressing (80.44%), literature (82.66%), readiness to face challenge in the next years (80.82%), contextual problem in the learning (49.67%), develop skills (56.57%), and the rest rejected this statement. This result revealed that no contextual on teaching and learning process, the learning process of mathematical methods for physics is not applicable and very mathematical dominant, teaching material is not interest, and lectures are not conducted to equip students with 21st-century skills. This is causes students have not understood the concept and have difficulty learning of Mathematical Methods for Physics.

1. Introduction

Learning is an effort to gain knowledge and understanding through a series of activities involving various elements. Students who are learning, actually in the brain there are many concepts, especially the initial concepts of nature and the environment. Through a systematic learning process, the initial concept produces a concept that is true, precise and directed [1], [2]. Learning physics is developing the ability to think critically, creatively, analytically, inductively, deductively, and with the help of mathematics to solve problems related to natural events both qualitatively and quantitatively, and can develop knowledge, skills, and attitudes of confidence [3]. Therefore mathematical tools are needed to study physical phenomena that occur in the surrounding environment.

In addition, several other studies were carried out by Aspaslan et. al to find effective solutions or ways to solve physics problems. Mathematical Methods for Physics studies the application of mathematics to solve physics problems, and develops mathematical methods suitable for this application, and the formulation of theoretical physics [4]. Mathematical Methods for Physics is needed to study advanced physics courses in higher education, because many physical phenomena analysis requires mathematical representation through this course. Mathematical tools are needed in studying physical phenomena. Mathematical Methods for Physics actually makes it easier for us to
analyze natural phenomena or events. Physical phenomena can simplify the analysis with the calculation method being studied.

The effectiveness of learning Mathematical Methods for Physics is related to lecturer knowledge both in content theory and pedagogy. The mid-level NSTA forum recommends that teachers must have a deep understanding of the physical phenomena in a contextual manner and the concept must be built based on scientific practice and engineering, cross-cutting concepts, and core ideas in scientific rules [5]. Even so, the implementation of learning Mathematics Methods for Physics has not been going well. The results are found in many cases, namely prospective Physics teacher students often use solution-oriented problem-solving strategies, rather than developing a strong understanding of the principles and concepts of physics in studying physical phenomena.

Although there is an research have emerged which discuss the main role of mathematics in understanding physical phenomena. Physics has a special relationship with mathematics in guiding someone to understand physical concepts and phenomena [4]. Physics is the subject of a challenging course to solve various problems. Interconnection between Physics and Mathematics in a phenomenon is concrete [6]. This phenomenon can be investigated by asking several questions intensively. Each problem raised is used to broaden one's understanding of the subject of phenomena. Questions encourage someone to look closely, from a different perspective and strengthen the concept.

A competent educator is the one who masters the concept and has the pedagogical ability of the content [7]. Specifically for physics educators, the competence of prospective teachers can be developed through learning that supports physics and pedagogic concepts. The ability to think mathematically is the result of education. It brings benefits in understanding the concepts of physics because mathematical thinking skills can be transferred and used to solve problems faced by students [8], [9]. The most dominant factor for success in learning physics is the ability of mathematical logical thinking [10]. It shows mastery of physics concepts can be achieved with thinking skills. For example, variable interpretation and proportional reasoning in Physics. This is greatly influenced by the ability to think mathematically directly.

Kuo et al concluded that logical thinking greatly influences student performance in science and the ability to solve Physics problems [11]. In this study emphasizes that the fundamental problem is exploring that not only the facts of science but more important is using the language of mathematics to make physical phenomena more meaningful. It is intended to equip students with 21st-century skills, namely critical thinking, creative thinking, collaborative, and communication. Students have the ability to deal with the demands of the era in the disruptive era that change as they become more unpredictable.

As the first step of the study, we describe the implementation of Mathematical Methods for Physics lectures for pre-service physics teachers. This process is a manifestation of the quality of learning to support study outcomes study programs. Therefore, it becomes important to get insightful information about the perception of pre-service physics teachers because in addition to understanding pedagogical knowledge, they must understand content knowledge. In this article, we describe the implementation of Mathematical Methods for Physics lectures on learning methods, use of media, opportunities for expressing, use of literature, readiness to face challenges, contextual problems, and student skills.

2. Methods

The method used in the research is qualitative descriptive. Data collection techniques are documentation studies, questionnaires, interviews, and observations. The use of this method is because the researcher wants to go directly to the target object and explore it grand to question so that the researcher can find the problem clearly. There is a guarantee that the data certainty process can be obtained because the data collection technique is done in triangulation. If one of the data collection techniques has not been able to find what is intended, it is replaced by another technique. In addition, this technique is used to describe the process of implementing Mathematics methods for Physics lectures at a university in Malang. Samples were obtained by purposive sampling. Questionnaires were distributed to students who had taken Mathematics Physics courses, namely the 3rd and 4th generation
who had not yet graduated. They numbered 107 students. Students who filled out questionnaires were 94 (87.85%) students. Interviews were conducted for 2 lecturers in Mathematics methods for Physics. The results of this interview are used to count the answers given in the student questionnaire. Data analysis techniques were carried out descriptively related to information from lecturers and students.

3. Result and Discussion

3.1. Process of implementing lectures

Mathematical methods for Physics is a compulsory course consisting of 4 credits and must be taken by semester 3 students. Lectures in Mathematics methods for Physics at State University of Malang consist of 3 classes. This course is taught by two lecturers. Learning is directed towards the achievement of Learning Outcome in Study Program of Physical Education which is translated into Standard Learning Outcomes of Graduates. That is able to solve physics problems by applying mathematical and computational methods. This is derived in the Subject Learning Outcomes, which is mastering the essential concepts of series and Fourier transformation, calculus of variations, special functions, and differential equation solutions in series; and applying to solve mathematical and physical problems that are related appropriately, systematically, independently, responsibly, and utilize the development of science and technology

SL is teach class A and class C, while class B is taught by JU. The implementation of the lecture process is arranged in a continuous, clear and directed manner in accordance with the Semester Learning Plan. They made Semester Learning Plan together. The teaching materials used are also mutually agreed upon. However, improvisation and the course of learning in class depend on each lecturer. At this time the pedagogic abilities and content possessed by lecturers play an important role. The implementation of lectures conducted in parallel does not have to wait for another class.

According to RPS, the method used in teaching is a method of discussion. The flow used is brainstorming, theory, group discussion, presentation, reinforcement, and formative examinations. The lecturer delivered the material in front of the class using Microsoft Powerpoint media. Then, asking for groups in small groups of 3-4 people. Students present the results in front of the class. After delivering the material, class discussions are conducted through questions that are poorly understood or give input to the presenter. On this occasion, questions were limited because there would be a review from the lecturer regarding the task presented.

The purpose of class discussion is to discuss the questions prepared by the lecturer. Each group receives one equal problem and the same level of difficulty. The obstacle faced is that the discussion is dominated by the presenter and lasts short. This is because each meeting has 2-3 presenters. Time causes students to have limited capacity to build knowledge. Besides that, the assessment weight for discussion activities reached 10%, but it was not a highlight in the lecture. Discussion activities are actually very important in the process of building knowledge. The opportunity to build knowledge through discussion activities will have the potential for misconceptions in students who are taught.

The result of the analysis is that the content presented is in accordance with the curriculum, but only a few applications from the basics of mathematical analysis are presented. The serving technique varies greatly. There are those that start from physics concepts into mathematical analytical concepts and vice versa. There are those after the introduction followed by examples of applications in cases of physics, and some discuss the concepts of physics and the application of mathematical analysis. Question exercises are used to train students about applying concepts to contextual cases.

3.2. The Result of Questionnaire

The results of the questionnaire on the implementation of the Mathematics Methods for Physics lecture are shown in Figure 1. It is show that the explanation of the results of the students questionnaire:

3.2.1. Learning Methods. The use of lecturer learning methods in the lecture process varies and is quite interesting. According to student admission, this causes students not to feel bored. They are motivated in attending classes. Students who are positive about this statement are 78.10% and the rest
reject this statement. The details are as much as 55.8% stated strongly agree, 22.3% said they agreed, 14.9% said they did not agree and the remaining 7% stated strongly disagree.

3.2.2. Media. Lecturers use learning media to facilitate the presentation of Mathematical Physics material. The media used are interesting and generate a passion for learning. The material was also delivered in a continuous, organized and scheduled manner. Students who gave a positive attitude towards this statement amounted to 78.73% and the rest rejected this statement. The details are as many as 22.63% of students stated strongly agree, as many as 56.1% said they agreed, 18.25% stated they did not agree, and the rest stated strongly disagree.

3.2.3. Opportunities for Expressing. The lecturer facilitates students to interpret concepts. This is done by providing free opportunities to bring lecture material. This will make students try more optimally. Students who gave a positive attitude towards this statement amounted to 78.73% and the rest refused. The details of this statement are as many as 12.02% of students stated strongly agree, as much as 68.42% said they agreed, 3.28% stated they did not agree, and the rest stated strongly disagree.

3.2.4. Literature. Students prefer to learn the concepts of Mathematical Physics using literature from outside. Foreign literature is more complex so that it is more understandable than the literature or teaching materials made by lecturers. Teaching materials developed by lecturers are less helpful for students to study independently. Students gave a positive attitude towards this statement as much as 82.66%, and the rest refused. The details of this statement are as many as 31.3% of students stated strongly agree, as many as 51.36% agreed, as many as 4% said they did not agree, and the rest stated strongly disagree.

3.2.5. Readiness to Face Challenge. Physics Problems Mathematics is a challenge for students to complete. This makes students interested in attending lectures in Mathematical Physics. Students gave a positive attitude towards this statement as much as 80.82%, and the rest refused. The details of this statement are as many as 20.2% of students stated strongly agree, as much as 60.62% said they agreed, 17.02% stated they did not agree, and the rest stated strongly disagree.

3.2.6. Contextual Problem. The problems given in the lecture process should be contextual. This requires students to conduct an in-depth analysis of these problems. Students are positive about this statement as much as 49.67%, and the rest refuse. The details of this statement are as many as 12.49% of students stated strongly agree, as much as 37.18% said they agreed, 29.89% said they did not agree, and the rest stated strongly disagree.

3.2.7. Skills. Lectures really help students develop their skills, so students feel motivated to make the best effort. Students are positive about this statement as much as 56.57%, and the rest refuse. The details of this statement are as many as 13.82% of students stated strongly agree, as much as 42.75% said they agreed, 38.34% said they did not agree, and the rest stated strongly disagree.
3.3. The Result of Interviews to Lecturer

Students are very enthusiastic in following the learning process in class and outside the classroom. This they showed with enthusiasm they sought information or looked for other sources related to the material. Debriefing 21st century skills in lectures in Mathematics methods for Physics has been conducted by lecturers especially skilled in critical and creative thinking. The ability to associate material with other material has been given. Not all 21st-century skills are provided to students through this lecture, because there are some difficulties. There are a number of conditions in which the learning objectives delivered have not been maximally achieved due to time constraints.

One form of student business that can be observed in the lecture process is that students are able to interact with other groups and convey Mathematics Methods for Physics ideas and concepts. But the problem is, there are some students who have not been able to associate physics and mathematical tools. The lecturer thinks that giving debriefing about critical and creative thinking skills is very important to be provided to students. This is done through the assessment of several problems related to everyday phenomena. To collaborate yet, but students in practice they collaborate either with friends and older siblings. To think inventively, the lecturer considers that he has taught because the student is willing to accept the work of his friend. However, lecturers have not provided students with the Internet Computer Technology literacy skills, because in the view of lecturers, they need preparation including internet networks that require adequate infrastructure. Students still "plug and play" existing equations without understanding the physical meaning of the problem given.

3.4. The Result of Interviews with Students

Students do not understand the benefits of Mathematics Methods for Physics courses when they graduate. This shows that even though they understand mathematical tools, they do not understand the physical meaning of learning mathematics. When students take advanced courses and use mathematical equations, they only realize the benefits obtained. This presents its own challenges in classroom learning. There are interesting findings, namely, students only prove their existence before their friends that they are worthy and right in the physics department. Mathematics Methods for Physics is a difficult subject to learn, but after linking it with physics problems it is easier to learn. Other results also show that students experience misconceptions when reviewing material in Mathematics Methods for Physics.

3.5. Discussion

Mathematics Methods for Physics Lectures are lectures that are quite interesting and challenging. The material in this lecture is a Mathematical material for Physics to implement. Therefore, students who have mastered well on the basis of mathematical analysis have an influence on student achievement in further subjects. In the process of solving problems in Mathematics Methods for Physics, students are expected to have used the available knowledge to solve problems in new contexts. This is in accordance in terms of bridging the fortress between knowledge that traces it [2]. Meanwhile, understanding of mathematical logic in the context of physics empowers mathematical logical thinking skills [12]. Students must optimize and empower the potential of their cognitive skills through integrated learning such as deductive reasoning and analogy thinking in the context of physics.

Literature studies show that some cases of physical phenomena can be approached using mathematics. All cases in physics concepts require solving mathematics using. This further reinforces that the physics phenomenon is a very important concept in mastering the concepts of physics [13]. However, what is also needed is the concept of mathematics. Strong perception is of course very calculated in the realm of cognition of physics education students [1,14]. That is, if it is relevant to mathematical concepts for physics concepts, students will find it difficult to develop existing knowledge.
In addition, the use of varied and quite interesting methods and learning media adds to the enthusiasm and motivation of students in learning [15]. However, in the use of literature, students are more interested in using not what is written by lecturers (outside literature). Outer literature is more complex and easier to understand than literature or teaching materials made by lecturers [16]. Teaching materials developed by lecturers do not help students in independent learning [17].

Explained that mathematics lies in logic, and is a science of patterns and reciprocal relationships between variables so that students' thinking abilities can be empowered through the use of teaching materials. In line with that, Redish and Kuo suggested that scientific disciplines, such as science, could be a forum for developing the ability to think verbally expressed physical problems and to communicate mathematically [12].

This also led to the understanding of new concepts based on previous concepts. Students use concept representation along with the ability to build, interpret, and transform physical systems in playing everyday physical phenomena. This is a challenge for students. They must be able to solve physical problems mathematically and give physical meaning. The contextual problems when attending lectures are given as an exercise. This requires students to conduct in-depth analysis of the problem so that it does not only plug and play mathematical equations without understanding its physical meaning.

4. Conclusion

Based on the analysis of the information obtained, it was concluded that the process of conducting lectures in Mathematics Methods for Physics was good, but there were still several obstacles that caused students to experience difficulties in understanding the material. Learning Physics has a fairly strong association with mathematics. The position of Mathematics Methods for Physics for pre-service physics teachers is to equip mathematics's ability to find information about various kinds of physical phenomena and be able to solve problems systematically so that they realize that physics is not only mastering a collection of knowledge in the form of facts, concepts, or principles but also a process of discovery. However, students realize the importance of the Mathematical Method for Physics after they take further courses. Therefore, students in the Mathematics Method for Physics lecture are asked to learn mathematical tools that are relevant to physical phenomena and develop in the context of physics.

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