Views and practices of mathematical method for physics lecture at pre-service physics teachers

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Abstract. The aim of study is to investigate the lecture process of Mathematical Method for Physics. The model is to develop the concept and ability of mathematical logical thinking of students of Physics Education Study Program. Mathematical Method for Physics is used to study physics related to how to systematically find out about nature. The research subjects consisted of 2 lecturers, and students who had taken Mathematical Method for Physics Courses, namely levels 3 and 4. The number of students filling out questionnaires was 94 students. Observations were conducted in class. Observations are focused on the learning process in the class. Data was collected using questionnaires to get student responses to the implementation of lectures. The results of the study were as many as 57.82% of students gave positive statements about the implementation of lectures, while the rest gave negative statements. This shows that studying physics is not only mastery of a collection of knowledge in the form of facts, concepts, or principles, but also an inquiry process. Therefore, the challenge in facing the 21st century is to improve the quality of education. Learning innovation is adjusted to the demands of educational change in the era of industrial revolution 4.0 (millennial). Learning must utilize information, communication, and technology (ICT). Innovation requires the support of a learning process that can strengthen creativity through critical thinking skills.

1. Introduction

Physics as a science has developed since the beginning of the 14th century. Physics together with biology, and chemistry are included in the natural sciences group [1]. Physics is a part of Natural Sciences (IPA) related to how to find out about nature systematically. Physics studies natural phenomena that are factual, either in the form of facts (facts) or events and their causal relationships [2]. Physics Education is expected to be a vehicle for students to learn themselves and the natural surroundings, as well as the prospects for further development to apply in everyday life [3]. Besides that, the inquiry strategy as an attitude that encompasses the scientific background of prospective teachers has the same role and has a diverse character. Therefore, pre-service physics teachers must actively build knowledge and develop
experience gained to convey ideas so that it triggers high productivity of knowledge [4]. Inquires contribute to building the knowledge of prospective teachers. Therefore, Physics with the help of mathematics is not only the mastery of a collection of knowledge in the form of facts, concepts, or principles, but also a process of discovery (inquiry).

Mathematics is a tool used in studying physical phenomena. The language of mathematical symbols has been used for a long time and is very useful in expressing scientific ideas [5]. Solving complex problems in physics requires collaboration with mathematics to gather data in order to obtain new ideas. Mathematical tools are used in studying physics to communicate and analyze natural phenomena. Rutherford and Ahlgren Galileo Galilei (1990) suggested that the integration of mathematics and science had occurred long ago in history. They likened mathematics as the veins of natural sciences such as astronomy, physics and chemistry. This view reflects that mathematics and science complement each other, because many concepts in mathematics are indispensable for understanding scientific material [6]. Mathematics and science overlap, for example, the process of observation and data collection in science is incomplete without using mathematics to analyze data quantitatively and explain the relationships between variables in making conclusions [7].

The interconnection between Physics and Mathematics is a concrete phenomenon [6]. Physical phenomena that exist in everyday life can be investigated by asking a number of epistemological questions intensively. The answers are intended to broaden understanding of the subject of phenomena. For example, the phenomenon of the volume of a balloon that develops from the ground state to its final state. Mathematics as a tool for physics to do formal manipulation depends on identifying concepts with symbols, and in the other direction concerns the spatial extension of mathematical structures [8]. Mathematics deals with abstract patterns that are unrelated to the material world. Physics is always related to the material world and physical theory is expressed in complex mathematical notations.

Other research shows that the development of science and technology creates new challenges in the world of education, especially in the 21st century [9]. The purpose of science education in NSTA (2013) refers to two things, namely to teach basic skills and prepare students to adapt to use abilities to solve future problems [10]. Learning has now been a shift in both the characteristics and models of learning. An example of a problem is that in a series of learning trajectories, students initially focus on learning basic skills, eventually learning to use these skills more flexibly [7]. The risk is that problem solving is less adaptive, because according to the assessor, procedural methods are less adaptive than practical procedures. Although students use conceptual steps, but they still have irregularities in solving problems. The advantage gained by students is that they are helped to open up opportunities to act in an adaptive, communicative, and collaborative manner [11]. In addition, the theme of curriculum development is shifted to produce productive, creative, innovative and affective Indonesian people.

This research is the first step in developing a Mathematical Method for Physics lecture program in order to equip students of 21st century abilities. Through this course, students are invited to master four things, namely critical thinking skills, critical thinking abilities and problem solving, creativity and innovation, communication, and collaboration [1]. Therefore, this study wants to get a picture of learning Mathematical Method for Physics in a college. The purpose of this study is to investigate the process of Mathematical Method for Physics lectures to develop transferable skills of high school pre-service physics teachers.

2. Methods
This research was conducted in the Physical Education undergraduate program. The research subjects consisted of 2 lecturers supporting Mathematical Method for Physics Courses, and students who had taken Mathematical Method for Physics, namely levels 3 and 4. The number of students who filled out the questionnaire was 94 students from 126. Observation of learning implementation focused on 1) observing the learning process of Mathematical Method for Physics for pre-service physics teachers in class, 2) collecting data through questionnaires to get students’ responses to the implementation of lectures in class, 3) collecting data through documentation regarding assessment instruments and assessment results of Mathematical Method for Physics.
The questionnaire was prepared and distributed to prospective physics teacher students. Observations were made to get an overview of the Mathematics Physics lecture process. The lecture observations were carried out in the even semester of the 2018/2019 academic year. Interviews were conducted with students and lecturers of Mathematical Method for Physics. The interview aims to describe the readiness of students and the difficulties of lecturers in facilitating lectures in Mathematical Method for Physics. Interviews were conducted at students of level 3 and 4. Another purpose of the interview was to synchronize the answers given by students with the results of the questionnaire filled out by students.

Reports and documents related to research analyzed their suitability with the implementation of learning activities. Document analysis is done by analyzing curriculum, RPS, assignments, assessment instruments and test results to lecturers who take Mathematical Method for Physics courses. The purpose of the analysis of this document is to determine the suitability of planning made with classroom learning and related to student readiness.

The steps taken are grouped into three major stages besar [12]. 1) Pre-research stage. The activities carried out determine the students used as subjects and prepare instruments. 2) Implementation phase. The activities carried out were observation of the lecture process in class, and the giving of questionnaires to students, lecturer interviews to find out the readiness of students studying Mathematical Method for Physics, and the difficulty of lecturers facilitating lectures. 3) Data analysis stage. Data from the questionnaire results were analyzed quantitatively the number of frequencies in the Likert scale category of each questionnaire item. Data from interviews and observations were analyzed by descriptive qualitative. The document analysis results are described through tabulating the document analysis findings.

3. Result and Discussion

3.1. result of interview to lecturers
Interviews with Mathematical Method for Physics lecturers 2 relate to student interests and lecturer difficulties in facilitating lectures. Students follow the learning process well. This is reflected in the spirit of seeking information from several sources related to the material. Students are directed to be able to be skilled in critical thinking and creatively associate prior knowledge with information obtained. The difficulty is that there are a number of conditions where the stated learning objectives have not been reached optimally due to time constraints. In the lecture process, students are able to interact with other groups and convey ideas and concepts of Mathematical Method for Physics. But the problem is that there are still some students who have not been able to link physics and math tools.

The ability of the 21st century (transferable skills) is very important to be given to students. This is done by providing problems related to everyday phenomena. In fact, students collaborate with friends and senior level. To think inventively, it has been practiced for students to accept the work of their friends. Lectures on Mathematical Method for Physics have not been started by studying everyday phenomena. During the lecture they are more interested in discussing physical phenomena. Study of daily physical phenomena is carried out when discussing concepts. This makes it difficult for students to learn the development of concepts. Besides that, students solve problems by simply plug and play from mathematical formulas without giving meaning to physical cases.

3.2. result of interview to students
Although students still experience difficulties in learning concepts, but they feel enjoy and are interested in attending Mathematical Method for Physics classes. The benefits that can be obtained by students while attending Mathematics Method for Physics is to understand the mathematical tools used in physics. However, despite learning to use various kinds of literature, they have difficulty giving meaning to concepts and equations obtained in mathematical calculations. Students have tried hard enough to overcome the problems encountered. Mathematical Method for Physics concepts that are studied provoke critical and creative thinking in order to find the right solution. For this reason, there needs to
be an adequate computational laboratory in order to be able to study Mathematical Method for Physics in preparation for further study and further study.

3.3. result of questionnaire to students
The results of the questionnaire given to students in the process of conducting Mathematical Method for Physics courses can be explained in Figure 1. Based on the results of the questionnaire, the respondent gave a positive statement of 57.82%. Respondents gave negative statements of 42.18%.

![Figure 1. Diagram of respondent responses](image)

Information:
A: Mathematical Method for Physics is Difficult
B: Contextual Learning
C: Variations in literature sources
D: The ability to think critically
E: Concept Analysis

Explanation of Figure 1 are, 1) Mathematical Method for Physics is Difficult to Understand. Respondents to the statement whether Mathematical Method for Physics is a difficult subject. Respondents responded to the statement quite varied. Students who gave positive statements as much as 46.14%, and those who stated agreed as much as 12.3%. Students who disagree there is a variation of learning media as much as 24.90% and students give statements strongly disagree as much as 16.66%. Based on this questionnaire showed students gave positive statements of 58.44% and students gave negative statements of 41.56%. 2) Contextual Learning. The second statement is a concept conveyed by the lecturer taking contextual examples. This statement was responded by students by giving a positive statement of 68.73%, and respondents who gave a negative statement of 31.27%. The details of this statement are 22.63% stated strongly agree, 46.10% stated agreed, 18.25% stated disagreed and the remaining 13.02% stated strongly disagree. 3) Variation in literature sources. Lecturers conduct lectures on Mathematical Method for Physics by studying concepts using literature from various sources. Students who gave positive statements about this problem were 70.44% and students who gave negative statements were 29.56%. The details of the statement are 48.42% of students strongly agree, 22.02 students agree, 13.28 students disagree, and 16.28 strongly disagree. 4) The ability to think critically. The next statement is that lecturers develop students' critical thinking skills. This statement was responded by respondents fairly balanced. Respondents who stated strongly agreed as much as 29.30%. Respondents who stated agreed as much as 21.36%. Respondents who stated disagreed as much as 26.18%. Respondents who stated strongly
disagree as much as 23.16%. Based on the results of the questionnaire, respondents who gave positive statements amounted to 50.66%, and respondents who gave negative statements amounted to 49.34%.

5) Concept Analysis. The last statement was that Mathematical Method for Physics lectures facilitated respondents to analyze physical phenomena based on concepts. Respondents who stated strongly agreed as much as 20.20%. Respondents who stated agreed as much as 20.62%. Respondents who stated disagreed were 37.02. Respondents who stated strongly disagree with 22.16%. Respondents gave positive statements of 40.82%, and respondents gave negative statements of 59.18%.

3.4. discussion
The results of the questionnaire to students indicate that lecturers should use a variety of learning media so that the passion and enthusiasm of students grows in learning Mathematical Method for Physics. Media that present a continuous, well organized and well scheduled material will make it easier to understand the concept. Based on the analysis of the results of the questionnaire, students' responses to the Mathematics Physics lecture process show that students lack motivation to attend Mathematical Method for Physics lectures because of their unpreparedness to learn, reference books and learning resources have not been used, do not use learning media, and have not shown spatial thinking skills. Students do not provide responses or questions during the lecture process. Lecturers are more dominant lectures and some time asking students for discussion. Assignments in the form of diaries and papers.

The results of interviews with lecturers teaching a similar opinion that the enthusiasm of students is high enough to attend Mathematical Method for Physics lectures. This is because they realize that Mathematical Method for Physics courses are the basis for studying courses in the following semester. Concepts mastery of students is still inadequate. The written test results conducted by the lecturer show that scores are still low. The use of media is still minimal and less practical because of the limited number of learning media.

The results of interviews with students showed that students from two different classes obtained information that students liked to take part in Mathematics Physics because it was related to daily life, this course added knowledge, insight and curiosity about celestial phenomena. However, the difficulty of Mathematical Method for Physics material is quite complex, abstract, difficult to observe, the references used are difficult to understand, no learning media is used to explain the material. Positive things conveyed by students that difficulty reading literature can be helped by reading information on the internet from the website of the authorized institution. The concept of Mathematical Method for Physics provokes to want to know more. Based on the results of interviews and questionnaires from students and alumni obtained information that derivative and integral material is the most difficult material in Mathematical Method for Physics.

The results showed that respondents (students and alumni) expressed very low satisfaction with the course of mathematics physics, especially in derivative material. The same research has been carried out by Hongshia Zhang et al., The factors that cause this dissatisfaction are students and alumni, lecture, and educators do not teach concepts contextually [13], [14]. Prospective physics teachers must use various types of inscriptions that wake up and use normatively and pedagogically. They must use it to convey the final form of scientific information, create creative ideas, help students engage in scientific practice, connect multiple concepts, and provide data from natural phenomena. The ability to carry out scientific explanation of a content knowledge helps students achieve a deep understanding. Science and culture influence a person's thoughts, attitudes and actions.

This research also suggests inspirational concepts in the form of subjective reforms, namely the bright spots inherent in the act of learning. Where, students' skills in building evidence-based explanation is seen as a form of involvement in the incubation process. This is because knowledge and ignorance are a structured element even in the small case of physics such as the wave concept problem as an implementation of a derivative concept. A subjective reform requires a change of structure with each other. The use of technology is needed to develop scientific explanation through a computerized, structured argument framework [15], [16]. While structures related to knowledge tend to be closed and independent. Therefore, it is important to teach Mathematical Method for Physics by integrating
multirepresentation through simulation elements, and transitioning different but interconnected simulation elements to improve student learning outcomes.

4. Conclusion
The conclusion that can be drawn is the difficulty still experienced by students related to Mathematical Method for Physics lectures. This has an impact on the implementation of further semester lectures. Physics and mathematics are specific formations and must develop mathematical thinking abilities. That pattern of thinking will affect one's internal patterns. It is important for pre-service physics teachers to connect different levels of representation to understand basic principles, fixation transitions that play a role in establishing meaningful relationships between multiple representations in concepts.

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