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Analysis of Outcome-Based Education Curriculum Implementation: Focus of Study on Classical Mechanics Course

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ABSTRACT. The adoption of Outcome Based Education (OBE) curriculum in universities in Indonesia has been carried out massively, but in some cases, the implementation of OBE has not been carried out optimally, including in Classical Mechanics courses. The purpose of this study was to analyze (1) the suitability of the RPS document to the demands of Outcome-Based Education, (2) the implementation of lectures, (3) lecture evaluation mechanisms, and (4) the difficulties still experienced by students in the Classical Mechanics course. This research was conducted on 3 lecturers teaching Classical Mechanics courses and 64 undergraduate students of Physics Education at one of the universities in Malang. Data were collected through learning observation, interviews, surveys, and document analysis. Qualitative data analysis techniques using Miles & Huberman analysis techniques. The results showed that in general the implementation of the OBE-based curriculum in the Classical Mechanics course was good but there needed to be some improvements both in the RPS, learning implementation, and learning evaluation. On the other hand, there are still many difficulties experienced by students in understanding topics in Classical Mechanics lectures.

1. Introduction

Universities in Indonesia have Physics Education Study Programs aimed at producing prospective physics teacher graduates. Universities as organizers must prepare students to have quality competencies and skills (Asmawi, 2005; Siregar et al., 2023; Suhaimi, 2016; Triana et al., 2024). One way to achieve this quality is with a good curriculum, which serves as an operational framework for achieving educational goals. A good curriculum design that is adjusted to the times and the demands of the field's needs will be the best effort in producing competent graduates.

Higher education in Indonesia has adopted Outcome Based Education (OBE), which focuses on achieving the desired outcomes of the educational process. OBE is an education system that focuses on learning outcomes (Asim et al., 2021; Clear et al., 2020; Rao, 2020), where the long process of education is centered on the material that must be completed and the outcome. Furthermore, OBE is also an approach that emphasizes innovative, interactive, and effective learning (Muzakir & Susanto, 2023). The use of OBE has an influence on the educational process, curriculum design, formulation and learning outcomes, learning methods, assessment processes, and the educational environment. With the implementation of OBE, it is expected that university graduates will be able to develop new skills so that they are ready to compete globally.

In the curriculum design of the Physics Education Study Program at the undergraduate level at one of the universities in Malang City, the courses are divided into three major groups, namely basic character development courses or *Mata Kuliah Dasar Pengembangan Karakter* (MDPK), scientific and expertise courses or *Mata Kuliah Keilmuan dan Keahlian* (MKK), and specialization and self-development courses or *Mata Kuliah Peminatan Dan Pengembangan Diri* (MPPD). MDPK aims to (i) build and develop students' moral values, ethics, and attitudes to become individuals with strong character and (ii) focus on value education, moral, spiritual, and personal integrity. This MDPK course is compulsory for all students, regardless of study program, and emphasizes the formation of personality in accordance with national, religious, and universal values. On the other hand, MKK aims to (i) provide the basics of knowledge and skills according to the fields of science and profession studied by students and (ii) improve students' academic and professional competence in their fields. MKK is specific to each study program and focuses on theoretical and practical knowledge in scientific fields relevant to the major. Finally, MPPD aims to (i) deepen expertise in a particular field according to the specialization or specialization chosen by students, and (ii) support the development of students' personal and career abilities. The main characteristics of this MKK are optional according to student interests, have an applicative nature that supports the development of specific skills, and students are given the freedom to choose according to their interests and career plans. Both MDPK, MKK, and MPPD have an important role in building knowledge and providing sufficient experience for students to prepare for work challenges.

One of the important courses in Physics Education is Classical Mechanics (Safriana & Fatmi, 2018; Taufiq & Kaniawati, 2023), which is included in the scientific and skill courses (MKK). This course is an important course, in addition to its broad scope and many applications in everyday phenomena, Classical Mechanics is a fundamental course that is the basis for many advanced courses. The importance of Classical Mechanics for prospective Physics teachers is not in line with the findings of many researchers. Previous researchers actually found that prospective teacher students have many difficulties in understanding the concepts in Classical Mechanics. Some of the findings include difficulties in understanding basic topics such as Kinematics (Pals et al., 2024; Taqwa & Rivaldo, 2018), Particle Dynamics (Hidayati & Taqwa, 2023), Work and Energy (Gunawan et al., 2021; Lestari et al., 2019), and Rotational Dynamics (Mutsvangwa, 2020). On the topic of Lagrangian and Hamiltonian, difficulties were also found (Leyvraz, 2015).

In this research, we focus more on OBE-based curriculum design and its implementation in learning. The courses that are the focus of this research are limited to Classical Mechanics courses. The analysis of Classical Mechanics lectures from the perspective of an OBE-based curriculum is very important. This is not only to evaluate teaching methods but also to assess the extent to which the curriculum supports the achievement of student competencies and skills and prepares them to face the increasingly complex demands of the world of work. Analysis of the implementation of this OBE-based curriculum is still not widely done, and some research has been done in several courses outside the previous Physics Education study program, for example, in the Electrical Engineering study program (Sardi et al., 2024), Mathematics (Sitepu & Sinaga, 2023), and Science Communication (Mony et al., 2022).

An in-depth analysis of the implementation of OBE-based curricula in Classical Mechanics lectures will provide a comprehensive view of universities' efforts to create graduates who not only have strong theoretical knowledge but are also able to apply it in practical situations. This article will focus on discussing (1) the suitability of the RPS document to the demands of Outcome-Based Education, (2) the implementation of lectures, (3) lecture evaluation mechanisms, and (4) the difficulties still experienced by students in the Classical Mechanics course. This research provides an important contribution to the description of the implementation of the OBE curriculum in higher education in Indonesia.

2. Methods

The method used in this research is a qualitative method. This qualitative research based on field studies was conducted at one of the universities in Malang City. This research was conducted on 3 lecturers teaching Classical Mechanics courses and 64 Physics Education undergraduate students who were taking the course. The samples taken in this study were all lecturers who taught Classical Mechanics courses at the university and some students who were undergoing lectures. The research was conducted during the even semester of the 2023/2024 academic year, from February to June 2024. In this study, there are four main objectives to be achieved, namely analyzing (1) the suitability of the RPS document to the demands of achievement-based education, (2) the implementation of lectures, (3) lecture evaluation mechanisms, and (4) the difficulties still experienced by students in the Classical Mechanics course.

Data were collected through learning observations, interviews, surveys, and document analysis. The documents analyzed were the curriculum process documents of the study program and the Semester Lecture Plan or *Rencana Perkuliahan Semester* (RPS) of the Classical Mechanics course. Learning observations were conducted for six full meetings. Interviews were conducted with lecturers teaching the course, while surveys with open questionnaires were conducted with students to gather information about the difficulties experienced by students. The instruments for assessing the RPS document, learning and evaluation aspects used refer to three official documents, namely, (1) Permendikbud No. 3 of 2020 Part Four regarding Learning Process Standards, (2) Permendikbudristek No. 56 of 2022 regarding Teacher Education Standards, and (3) Permendikbudristek No. 53 of 2023 regarding Higher Education Quality Assurance. Instrument development is carried out with reference to applicable laws, formal documents and policies to ensure suitability, relevance and accountability of the expected results. This foundation not only legitimizes the instruments but also guarantees their compliance with national and international norms. Consulting relevant formal documents, such Ministerial Regulations, National Standards, or other official guidelines, enhances the focus and efficacy of instrument development. This stage guarantees adherence to current policies while enhancing the instrument's credibility in facilitating process improvement, decision-making, or fulfilling organizational requirements. This regulatory and formal document-centric strategy aims to develop instruments that are both pertinent and efficacious, while also facilitating the attainment of overarching strategic goals.

The data analysis used in this study used qualitative data analysis techniques with Miles & Huberman analysis techniques (Yusuf, 2016), which consisted of data reduction, data presentation, and conclusion drawing/verification. Data were collected and then reduced and simplified for each data source. Data presentation was carried out, and then coding was carried out to group data according to the similarity of information. Conclusions were drawn to provide an overview of empirical findings in accordance with the research objectives.

3. Results and Discussion

3.1 Semester Course Plan Document Analysis (RPS)

The analysis of the RPS document is emphasized to see the suitability of the SSP that has been designed with the demands of OBE. Based on the results of the document analysis that we have conducted on the three lecturers teaching Classical Mechanics, the three lecturers use the same RPS in lectures. This RPS has been designed jointly by all lecturers teaching the course and has been approved by the head of the Expertise Group (KBK) and the head of the study program. The results of our analysis are presented in Table 1.

Table 1. Semester Course Plan Document Analysis Results

No.	Assessed Aspects	Analysis Result
1.	Completeness of course identity information.	Complete, containing course name, course code, weight (SKS / JS), and teacher.
2.	Clarity and measurability of learning outcomes.	The formulation of SLO, CPMK and Sub-CPMK is clear. However, from 7 SLOs, it is reduced to 55 sub-CLOs, which are considered too many.
3.	The suitability of each lecture for CPMK and Sub-CPMK outcomes.	Each meeting has clearly written CPMK and sub-CPMK that must be achieved. Learning experiences have been designed in detail both offline and online (synchronous and asynchronous).
4.	The learning strategies used are varied.	The learning strategy reflected in the learning experience is always the same in every meeting.
5.	Types of learning strategies used in lectures.	Presentation, and discussion/question and answer.
6.	Assessment methods are clearly explained and in accordance with learning outcomes.	There are individual assignments, group assignments, and active participation in discussions.
7.	A variety of assessment methods was used.	Written exams, assignments/projects, presentations.
8.	Use of up-to-date learning resources.	The main reference book is an old book, but the lecturer also prepares other teaching materials.
9.	Variety of learning resources.	In general, the main learning resources are books and presentation materials from lecturers.
10.	There is information on assessment methods accompanied by clear rubrics.	There is information on assessment methods but no assessment rubric.

Based on the data in Table 1, the designed RPS is generally good. However, there are some findings that make it possible to improve the RPS. Two important factors need to be improved in the RPS. The first is about the CPMK, which amounted to 7 with 55 sub-CPMK. Sub-CLOs are the final abilities that are planned to be achieved by students at each stage of learning (Puspitasari & Sastromiharjo, 2021). With too many sub-CPMKs, measuring their achievement will be difficult. The second is the unavailability of assessment rubrics. In the RPS, assessment is done through written exams, assignments/projects, and presentations, but the rubric used to assess is still missing. From the results of the interviews we conducted, the rubric has not been compiled so far.

3.2 Implementation of OBE-Based Curriculum in Classical Mechanics Course

We explore data on the relevance of OBE-based curriculum demands to the lectures that are run. Based on Permendikbudristek Number 56 of 2022 and Number 53 of 2023, lectures are required to be active, reflective, holistic, contextual, innovative, scientific, collaborative, constructive, interactive, integrative, thematic, and effective. In addition, learning in the lecture process is also required to prioritize the development of creativity, capacity, personality, and student needs. These are the aspects that became the focus of our observations and interviews. The results we obtained related to the lecture process are shown in Table 2.

Table 2. Classical Mechanics Lecture Observation Results

Characteristics	Observation results		
	1st lecturer	**2nd lecturer**	**3th lecturer**
Integrative	Yes	Yes	Yes
Holistic	No	No	No
Active	No	No	No
Reflective	No	No	No
Innovative	No	No	No
Interactive	Yes	Yes	Yes
Scientific	No	No	No
Contextual	Yes	Yes	Yes
Thematic	No	No	No
Effective	Yes	Yes	Yes
Collaborative	No	No	No
Prioritizing the development of creativity, capacity, personality, and student needs	No	No	No

Table 2 shows that from the learning characteristics required in the OBE-based curriculum, there are characteristics that were observed and not observed (not implemented) during the observation process. The observed characteristics are integrative, interactive, contextual, and effective learning. The first characteristic is integrative learning, which is learning that integrates various disciplines, skills, and understanding that are coherent and interrelated (Sari & Surana, 2022). The aim is to help students see the linkages between different fields of study and how knowledge from different disciplines can be applied holistically to solve real problems. In Learning, we found several times that lecturers emphasized solving cases by integrating knowledge of math, physics, and engineering. The second characteristic is interactive. We often find this through two-way communication between lecturers and students. However, in lectures, there is still no communication between students in discussion activities. This two-way communication is fundamental to maximizing the effectiveness of lecture activities (Fajriati et al., 2022). The third characteristic is contextual education, which links learning materials with the context of real-life (Siung et al., 2023). The main purpose of this learning is to make the learning process more meaningful and relevant for students so that they can understand and apply the knowledge and skills learned in everyday situations. We found this contextual learning in the material explanation and case examples given by the lecturer. The last characteristic is effective, which we identified based on the suitability of the material that has been delivered as planned. However, further research is needed on the effectiveness of learning by measuring the increase in knowledge, attitudes, and skills expected from the course.

On the other hand, we found many learning characteristics that were not observed in the lectures. The first aspect is holistic learning, which assumes that people are basically able to find their identity, meaning, and purpose in life through their connection with society, the natural environment, and spiritual values (Pare & Sihotang, 2023; Tefbana et al., 2022). Holistic learning aims to develop students' full potential, not just their academic aspects. The second characteristic is active, which requires students to be involved in the process of constructing their knowledge. This is in accordance with the demands of Physics learning, which requires students to be involved in constructing their own knowledge through meaningful learning. In lectures, learning tends to be dominated by lecturer explanations. The third characteristic is reflective, which is learning that provides opportunities for students to interpret their own experiences (Gultom & Daulay, 2024; Prasetyo et al., 2014). Reflection in this context is an intellectual and effective activity for students to explore their experiences in achieving new understanding and appreciation. The fourth characteristic is innovation, which requires lecturers to make learning more interesting so that students are more motivated (Purwanto et al., 2021; Yuliana, 2022). During the observation, we found that lectures tended to be conducted using the lecture method.

Another characteristic, the fifth characteristic that was not observed in the observation, is scientific learning. Physics scientific learning emphasizes concept construction with direct contact with physics phenomena, and this aims to maximize student learning outcomes (Siahaan & Pane, 2021; Syahrial et al., 2022). The sixth characteristic that was not observed was thematic learning, which is learning that emphasizes the provision of a specific theme of choice to teach several curricular concepts (A. R. Setiawan, 2019). Based on the observation, the lecture always begins by explaining the material and then proceeds with problem-solving. Furthermore, the seventh characteristic is collaboration, which directs learning to solve problems in groups. Collaborative learning is important, with the support of empirical data from several studies showing that collaborative learning can improve 21st-century skills (A. Setiawan, 2021). In Classical Mechanics, we did not find any collaborative learning. The last characteristic that is not observed is learning, which prioritizes the development of creativity, capacity, personality, and student needs. In lectures, learning still tends to be carried out conventionally with the lecturer as the center of learning, and the learning needs of each student have not been identified.

3.3 Assessment and Evaluation Mechanism in Classical Mechanics Lecture

In assessment and evaluation in accordance with the demands of OBE, lecturers should be able to carry out complex assessments, not only measuring knowledge achievement through written tests in the midterm and final exams. Based on the results of the interviews we conducted, the three lecturers emphasized the final assessment of the course based on the scores of student exam results. This means that so far, classical mechanics lectures have not fully met the demands of the OBE-based curriculum.

Assessment and evaluation are crucial aspects that measure the success of the learning process, including the learning process based on the OBE-based curriculum perspective. Assessment mechanisms for students must be developed by considering the flexibility of competency demands that continue to change and develop. In order for the results of the assessment carried out in the evaluation process to produce valid information related to the competencies measured, the development of an evaluation system requires a scientific vision. In this case, it is necessary to develop an assessment system that is innovative, creative, flexible, and oriented towards the skills needed in the future. Therefore, assessments conducted only to measure cognitive skills are less relevant today. Varied instruments, not only in the form of tests but also in non-test instruments, are needed to measure multi-competency abilities (Setiono et al., 2023). This non-test instrument can be in the form of performance observation sheets, task assessment sheets, presentation assessments, report assessments, peer assessments, and self-assessments.

3.4 Difficulties Faced by Students in Classical Mechanics Course

We tried to identify the difficulties faced by students in Classical Mechanics. The first data we explored was about difficulties in understanding the material (subject matter) in the course. In this case, students wrote down any material that they felt was still difficult to understand. The analysis results show that almost all students experience difficulties in certain materials in Classical Mechanics, where 61 (95.31%) students have difficulty understanding Lagrangian and Hamiltonian mechanics, 57 (89.06%) students have difficulty understanding the topic of oscillations (simple, harmonic, and damped), 55 (85.94%) students have difficulty understanding the topic of rotational dynamics, 54 (84.38%) students have difficulty understanding the topic of dynamics, and 51 (79.69%) students have difficulty understanding the topic of kinematics in 2 and 3 dimensions. The second data that we explored was about the causes of the difficulties they experienced. Some of the causes of difficulties, according to students' perspectives, include (1) many complex mathematical equations that cannot be understood and are difficult to imagine their physical meaning, (2) learning more explains the derivation of formulas and less illustrates the meaning of formulas or mathematical equations obtained, (3) lack of practice problems, and (4) lack of feedback from the assignments given, including feedback from exams that students carry out. Finally, there is data on students' expectations for future Classical Mechanics lectures to be more interesting. What many students expect is learning that does not only focus on mathematical equations but is accompanied by graphic illustrations to explain the physical meaning of mathematical equations. Students hope that learning can use the help of software technology that can visualize mathematical equations directly so that the mathematical equations they get are not abstract.

These findings show that there are still many students who have difficulty understanding classical mechanics. This topic does tend to have a broad and complex scope because it is related to each other (Safriana & Fatmi, 2018). On the other hand, the materials in Classical Mechanics are advanced materials from Basic Physics I, whereas the materials in Classical Mechanics involve more complex mathematics. Therefore, software is needed to help visualize mathematical equations that tend to be abstract. It would be better if the visualization is done by involving dynamic displays to maximize knowledge construction by students (Ploetzner et al., 2006, 2009).

4. Conclusions

The conclusion of this research shows that the Semester Learning Plan (SSP) document for the Classical Mechanics course has generally met the Outcome-Based Education (OBE) based curriculum standards by including course identity, clear formulation of learning outcomes, and structured learning experiences. However, there are weaknesses in the number of sub-CPMKs, which are too many, and the absence of an assessment rubric that can be used to measure learning achievement effectively. The implementation of OBE-based curriculum in lectures shows positive characteristics, such as integrative, interactive, contextual, and effective learning. However, some important aspects, such as holistic, active, reflective, innovative, scientific, and collaborative learning, have not been well implemented. In addition, assessment still tends to focus on written exams, which do not fully reflect the multi-competency approach as required by OBE. The difficulties faced by students in understanding topics such as Lagrangian, Hamiltonian, oscillation, and dynamics are mainly due to the complexity of mathematical equations that are not accompanied by graphical illustrations or visualizations to explain their physical meaning. Students also feel the lack of practice questions and feedback from assignments and exams. Therefore, an update in learning methods, such as the use of dynamic visualization technology, is needed to maximize students' understanding and ability to master Classical Mechanics material.

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Author's Involvement

MRAT wrote the original manuscript, designed the instruments, analyzed the data, and wrote the revised manuscript. PS reviewed the manuscript and provided guidance on research ideas and instruments. ES reviewed the manuscript and provided guidance on research ideas and instruments. DR guided the research idea, revised the instrument, and reviewed the manuscript. HFR collected and analyzed data.

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