



Improve basic physics learning using the Jupyter Notebook App

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ABSTRACT

Basic Physics learning often faces challenges in improving students' conceptual understanding and analytical skills. The Jupyter Notebook application, which offers a Python-based interactive environment, is an innovative alternative to solve this problem. This study aims to evaluate the effectiveness of the use of Jupyter Notebook in learning Basic Physics in first-year students in college. The research method used is quasi-experimental with a mixed-method approach. The results of the study show that the application of Jupyter Notebook improves students' conceptual understanding, problem-solving skills, and learning motivation.

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INTRODUCTION

Based on the results of the observations made, the students' physics subject scores are much lower when compared to other subjects, this is because there are several problems caused by teachers and students. From interviews with teachers, information was obtained that in the learning process students tend to be passive and unmotivated to follow the physics learning process. It appears that when physics learning in the classroom is taking place only a small number of students are active and the rest are busy with activities outside the context of learning, then, when the teacher asks a question only a small number of students are willing to ask, and when the teacher presents a problem, only certain students can solve it (NURMALIATI, 2017). Students must control various representations and tasks simultaneously, such as remembering formulas, using formulas in calculations, conducting experiments, creating graphs, and offering conceptual justifications (Anugrah, 2022). Although physics is already challenging, students have difficulty changing different representations (Ayudha & Setyarsih, 2021).

Compared to other subjects, most students show worse learning outcomes. One of the factors that contributes to low learning outcomes is the lack of use of teaching materials during the learning process (Alvias Noviantika Arnanda, 2021). Learning media, both virtual and physical, are used intentionally to connect teachers and students, helping them absorb knowledge in a more efficient way (Tri & Yanto, 2019). In the field of education, the media is very important (Musfiqon, 2012).

With the advancement of information technology, there is a great opportunity to improve the quality of learning, especially in science subjects such as physics. Due to its abstract and complex nature, basic physics is often considered a challenging course (Popi et al., 2021). Traditional learning, which tends to be passive, is often less effective in helping students understand important concepts. As a result, a new, more interactive and engaging approach is needed (Pelupessy & Agustin T, 2014)(Anggi Mayasari Lubis et al., 2022).

Jupyter Notebook is one of the Python-based applications that offers a platform for interactive learning through the integration of text, programming code, and visualization (Borovský et al., 2024). In the context of physics learning, Jupyter Notebook allows students to explore physical phenomena directly through simulations, data analysis, and engaging graphical visualizations (Lane et al., 2023)(Kim & Henke, 2021).

Research related to the Integration of Jupyter Notebook in first-year physics laboratory courses can improve students' data analysis skills but requires adequate technological infrastructure, such as computers with certain specifications and stable internet access. (Tufino dkk., 2024)(Piccione et al., 2024). Jupyter Notebook allows for the presentation of interactive learning materials, where students can incorporate different types of information, including access to internet sites and programming language instruction, into a single platform (Pimentel et al., 2021)(Castilla & Peña, 2023). This makes it easier to understand physics concepts through visualizations and simulations that can be accessed directly by students (Laipaka et al., 2021).

Basic Physics learning plays an important role in building a scientific foundation for students in the field of science and technology. However, traditional learning methods are often considered less effective in explaining abstract and complex concepts (Siti Nurhabibah Hutagalung, Anda Yanny, 2020). This encourages educators to look for innovative solutions that integrate modern technology. Jupyter Notebook, as a Python-based, open-source application, provides a platform that enables integration between text, code, and visualization in a single interactive document (Charles & Gwilliam, 2023)(Du et al., 2024)(González-Carrillo et al., 2021). With its capabilities, Jupyter Notebook provides new opportunities to improve the quality of learning (Castilla & Peña, 2023).

RESEARCH METHODOLOGY

Students are the main subject of learning while teachers play the role of learning facilitators. Factors such as students' initial skills (including prior knowledge of physics, mathematical ability, and technological literacy, greatly affect their learning outcomes) and lecturer competencies do need to be controlled. This study uses an experimental method with a pretest-posttest design. The subjects of the study were 30 students who took the Basic Physics course at one of the universities in Indonesia (TOPSAKAL, 2023). The students were divided into two groups: an experimental group that used Jupyter Notebooks in the learning process, and a control group that used conventional learning methods (Shah et al., 2024)(Osorio et al., 2024).

Research Procedure

Preparation Stage: Development of Jupyter Notebook-based learning materials. The training was accompanied by lecturers and accompanying lecturers related to the use of Jupyter Notebook (Hut et al., 2020). **Implementation Stage:** The experimental group studied materials such as kinematics, dynamics, and thermodynamics using the Jupyter Notebook; The control group learned the same material through lectures and textbooks (Hassan et al., 2020). **Measurement:** Pretest before learning and posttest after studying. Additional data collection in the form of questionnaires to measure student learning motivation (Wu et al., 2021)(Pimentel et al., 2021).

The description of the research stages is as follows:

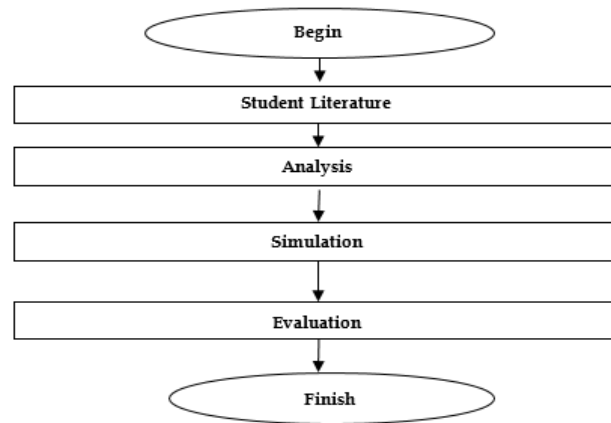


Figure 1. Flow diagram of research implementation method

RESULTS AND DISCUSSIONS

Before you start learning to use the notebook jupyter software. Students are tested to find out their abilities. Based on the results of the research, learning outcome data was obtained as shown in table 1.

Table 1. Student learning outcome data

NO	PRETEST	CYCLE I	CYCLE II
1	40	60	80
2	55	70	85
3	50	50	80
4	60	80	90
5	45	60	80
6	40	60	80
7	80	80	90
8	50	60	80
9	55	80	85
10	40	50	70
11	80	85	90
12	55	60	80
13	50	60	70
14	55	60	85
15	80	80	90
16	50	60	80
17	40	60	70
18	65	80	80
19	70	90	90
20	40	50	70
21	55	60	80
22	45	70	80
23	75	80	90
24	80	80	90
25	55	60	70
26	50	60	80
27	60	80	80
28	80	90	90
29	60	70	80
30	65	80	90
SUM	1725	2065	2455
MIDDLE	57.5	68.83333333	81.83

Based on the table above, it can be seen that student learning outcomes have increased from the pre-test cycle, post-test I to post-test cycle II. This is shown by the average score of students from 57.5 (pre-test) increased to 68.83 (post-test cycle I) and again increased to 81.83 (post-test cycle II). In addition to being seen in the average student. The results of the pre-test showed that 5 out of 30 students who took the test completed their studies and 25 students did not succeed in completing them. With a pass percentage of 16.67%, the results of the final exam of the first cycle, 12 out of 30 students who passed the exam completed the exam and 18 students did not complete the exam with an average of 40%. Increasing again in the results of the second cycle of the Post Test, 25 students completed learning from 30 students who took the test with a pass rate of 81.83%. So that there was an increase in learning outcomes from pre test to post test cycle II by 66.66% As explained above, student involvement in completing activities shows growth in each activity. Positive changes in student performance also affect learning outcomes and learning integrity. It's easier to do so in the table below:

Table 2. Average student learning outcomes

Activities	Number of students who have completed	Percentage (%)	Learning Outcomes	% Increase in Learning Outcomes
Previous tests	5	16,67	57,50	-
Cycle I	12	46,67	68,83	30
Cycle II	25	83,33	81,83	66,66

CONCLUSION

The conclusion of the research on improving Basic Physics Learning Using the Jupyter Notebook Application is that the average student learning outcome increased from 57.50 to 68.83 in the first cycle, from 68.83 in the first cycle to 81.83 in the second cycle, when compared to the pre test with the second cycle, it increased by 66.66%. The improvement in the understanding of the concept of the analysis results showed a significant increase in the post-test scores of the experimental group compared to the control group using the Jupyter Notebook which allowed students to conduct interactive simulations, such as electric field visualization and motion graph analysis, which deepened their understanding of abstract concepts. The problem-solving skills of students who use Jupyter Notebook show an improvement in their ability to solve programming-based problems. This is because they can test hypotheses directly through Python code, thus supporting exploratory learning. Student Motivation and Participation Observations and interviews show that students are more motivated to learn because the Jupyter Notebook environment is considered more interesting and relevant to the world of work.

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