The Implementation of the PCK-Based Electricity and Magnetism Textbook on Student Learning Outcomes

Boisandi & Sy. Lukman Hakim Alsagaf*
Physics Education Study Program, IKIP PGRI Pontianak, Indonesia
*Corresponding Author: lukman28542@gmail.com

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Abstract *- This study aims to investigate the implementation of electric-magnetic textbooks based on Pedagogical Content Knowledge (PCK) on learning achievement in the physics education IKIP PGRI Pontianak. The problem is that there needs to be more consistency between the mastery of theory and practice of students, especially in practice in the laboratory. Students need help to implement the theory they have learned into practice. The electric magnetic textbook has advantages: the pedagogic structure and content balance theory with practice. It has been adapted to the learning achievement of the magnetic electricity course in the physics education study program of IKIP PGRI Pontianak. The sequential embedded mixed-method design was used in this study to extract information from the research subject. The research was conducted at the Physics Education IKIP PGRI Pontianak. The object of this research is the student of Physics Education IKIP PGRI Pontianak Semester VI Academic Year 2021/2022. The data collection technique used in this study is an indirect communication technique with research instruments such as pretest-posttest questions and response questionnaires and interviews. The first qualitative stage obtained an average response of all aspects of 79% with high criteria. Learning effectivity is obtained based on the average normalized gain <g> of 0.57 with medium criteria. There is an increase in student learning achievement obtained from the response questionnaire after treatment by 81%; the category is very high. The interview showed the consistency of increasing student learning achievement on magnetic electricity.*

Keywords*: PCK; Magnetic Electricity Textbook; Learning Achievement*

INTRODUCTION

Educational institutions must design and implement the learning tools necessary to maintain relevant learning processes, especially at the tertiary level. Implementing learning tools is undoubtedly inseparable from the curriculum used as a reference. Each instructor strives to design an engaging learning process for students so that the learning process aligns with the formulated learning outcomes. Students are also expected to actively participate in implementing the discipline of knowledge in their lives and align with the development of science and technology.

Several instances have revealed a gap between students' theoretical knowledge and practical skills. It can be attributed to students needing to realize the importance of achieving learning targets in their studies, resulting in unachieved learning outcomes. If left unchecked, this could lead to declining students' academic performance and graduates.

The alignment and understanding of learning outcomes with the curriculum and subject matter characteristics will make learning more efficient. The physics education research has reported significant results by applying models and strategies to students' conceptual understanding and practical skills (Ibrahim & Yusuf, 2019). However, a recent challenge is that learning has been influenced by online education, requiring the availability of suitable references that can be accessed openly. This is due to the rapid development of technology in all aspects of Indonesian society, such as the increased use of social media activities and websites (Das et al.,

2016; McKemmish et al., 2017; Poushter et al., 2018).

There is a strong relationship between the quality of textbooks and understanding of the nature of science, such as empirical, methodological, theoretical, creative, social, and cultural dimensions (Ramnarain & Chanetsa, 2016). Teachers' ability to integrate technology determines how technology influences the learning environment (Valtonen et al., 2018; Sulisworo et al., 2019).

Preliminary research has been conducted on developing a PCK-based electricity and magnetism textbook aligned with the learning outcomes of the physics education study program at IKIP PGRI Pontianak. The resulting textbook has met the requirements and is available in an online ISBN version (Boisandi & Alsagaf, S.L., 2021). As a follow-up to previous research, it is essential to examine the influence of the developed textbook, specifically the PCK-based electricity and magnetism textbook, following the learning outcomes stated in the 2019 curriculum document in the physics education study program at IKIP PGRI Pontianak.

Based on the explanations above, the research aims to: (1) investigate the implementation of the PCK-based electricity and magnetism textbook on students' mastery of theory and practice and (2) describe students' learning outcomes in the electricity and magnetism course. Based on the research background, this study's results are expected to contribute, particularly in exploring the factors that influence students' learning outcomes.

RESEARCH METHODS

The research adopts a mixed-method approach. Data collection, both qualitative and quantitative, is conducted through a single study. The sequential embedded mixed-method design is utilized in this study to gather information from research subjects (Creswell, 2007). The first qualitative phase is conducted before the quantitative phase through passive observation using response sheets. The quantitative phase involves data collection and analysis using a quasi-experimental research method to examine the implementation of the electricity and magnetism textbook.

Figure 1. Design of *explanatory sequential* (Creswell, 2007)

The second qualitative phase uses active observation techniques after the quantitative phase. The observation instrument includes response sheets and interviews.

The research subjects are the Physics Education Study Program students at IKIP PGRI Pontianak in their sixth semester of the academic year 2021/2022. The research was conducted at the Physics Education Study Program at IKIP PGRI Pontianak, located at Ampera Street No. 88, Pontianak, West Kalimantan, during the academic year 2021/2022. The data collection technique employed in this research is an indirect communication technique using research instruments such as pretest-posttest questions, observation sheets, and response sheets.

Table 1. Classification of Normalized Average Gain Calculation

Hake Equation	No	Gain	Category
$\langle g \rangle = \frac{\langle S_{post} \rangle - \langle S_{pre} \rangle}{100 - \langle S_{pre} \rangle}$	1	$\langle g \rangle \geq 0{,}7$	High
	2	$0{,}3 \geq \langle g \rangle > 0{,}7$	Moderate
	3	$\langle g \rangle < 0{,}3$	Low

<Spost> = average score of post-tests; dan
<Spre> = average score of pretests

The pretest and posttest results are calculated based on the normalized average gain (<g>) using the equation developed by Hake (Jumiati, 2011, p. 170).

The effectiveness of learning is obtained from response sheets and interviews. The students' responses after learning can be assessed using Equation 1.

$$\%X_{in} = \frac{\sum S}{S_{max}} x100\% \quad \ldots. (1)$$

$\%X_{in}$ in represents the percentage of responding. $\sum S$ is the total score, and S_{max} is the maximum score. The criteria for the response are presented in Table 2.

Table 2. Responses Criteria

Perentase (%)	Kriteria
80,1 - 100	Sangat tinggi
60,1 – 80	Tinggi
40,1 – 60	Sedang
20,1 – 40	Rendah
0,0 – 20	Sangat rendah

(David and Cholik (as cited in Riduwan, 2014)).

RESULTS AND DISCUSSION

This research continues a previous study on developing a magnetic electricity textbook (Boisandi & Alsagaf, 2021). The magnetic electricity textbook used in this study has advantages regarding its pedagogical structure and content, balancing theory and practice according to the learning outcomes of the magnetic electricity course in the physics education program at IKIP PGRI Pontianak. The learning outcomes represent the minimum achievement expected from students based on the KKNI curriculum of the physics education program at IKIP PGRI Pontianak. The research was conducted on students in the sixth semester of the academic year 2021/2022 who took the magnetic electricity course.

The PCK-based magnetic electricity textbook was implemented with pretest and posttest results presented in Figure 3. The first qualitative phase was conducted before the quantitative phase through passive observation using response sheets, as presented in Figure 2. In this phase, an initial overview of students' learning outcomes in magnetic electricity was obtained, including teaching materials, laboratory work, test questions, the suitability of teaching materials and laboratory work, and motivation. The average response for all aspects was 79%, with a high criterion.

Physics in secondary and higher education institutions are often perceived as uninteresting and less popular, especially regarding magnetic electricity and electronics. However, many technological applications today result from the development and research in physics on these topics (Muhamad & Nurzaman, 2019; Wulansari et al., 2019).

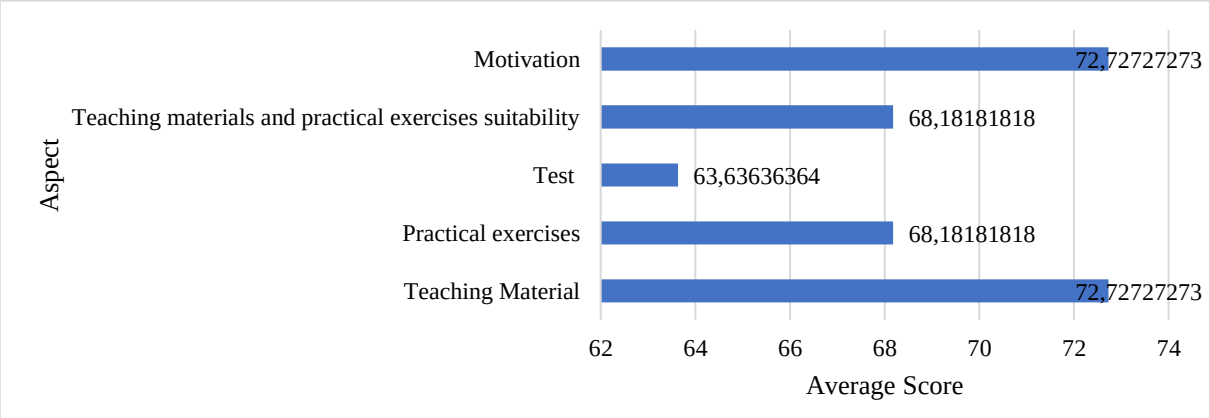

Figure 2. Percentage of Student's Responses

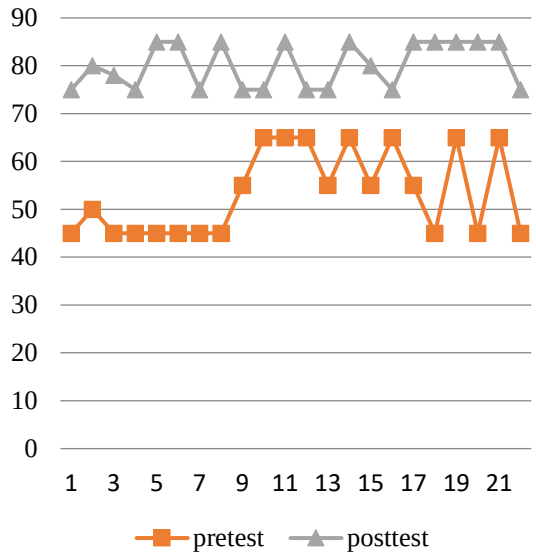

Figure 3. Results of pretest dan post-test

The textbook covers Coulomb's law, Gauss's law, electric potential, capacitors, and magnetism. Students learn the theory and design experiments based on the instructions in the textbook. The research was conducted over one semester. Before the intervention, students were given a pretest, and after the intervention, they were given a posttest, as shown in Figure 3. From the pretest and posttest results, an N-gain of 0.57 was obtained, indicating moderate improvement. It indicates a balance between students' mastery of theory and practical skills in operating laboratory equipment.

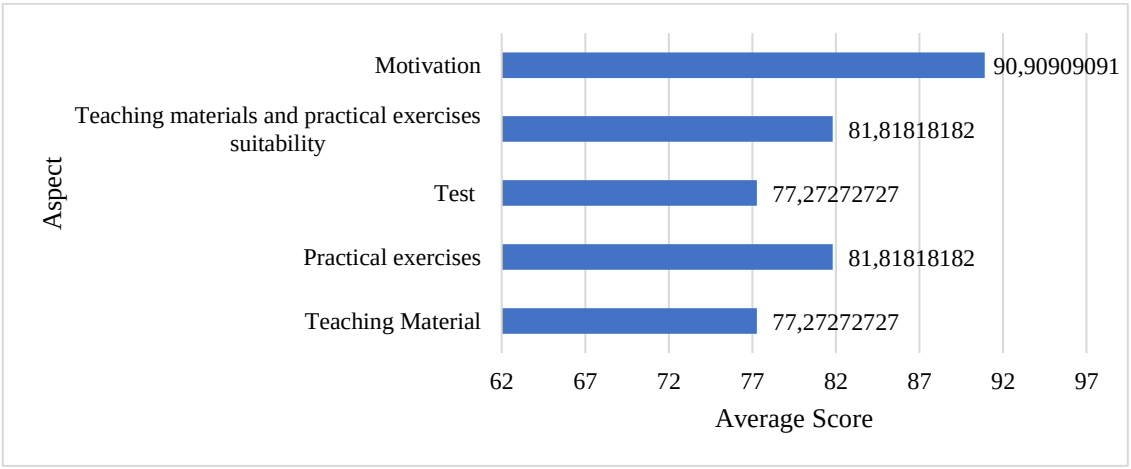

Figure 4. The percentage of student learning achievement responses on the topic of electromagnetism

The questionnaire was given to 22 respondents to assess students' learning outcomes after the intervention. The responses are presented in Figure 3. Based on Figure 3, the average response for all aspects is 81%, indicating a very high level. The specific results for each aspect are as follows: interest in the teaching materials (77% with a high rating), conducting practical work (81% with a very high rating), completing independent exercises (77% with a high rating), suitability of teaching materials and practical work (81% with a very high rating), and 90% of students responded that they were highly motivated in their learning.

The results of the responses show the expected outcomes, particularly regarding the suitability of teaching materials and practical work, as well as high levels of motivation. According to the respondents' feedback, the magnetism topic in the study was enjoyable and aligned with the learning outcomes. It is attributed to the textbook's presentation, which balances the pedagogical structure and content between theory and practice in line with the learning outcomes of the magnetism course in the Physics Education program at IKIP PGRI Pontianak.

The effectiveness of the intervention in the study is described descriptively

through interviews. The interview indicators include interest in the teaching materials, conducting practical work, completing independent exercises, suitability of teaching materials and practical work, and motivation. The interviews were conducted with two randomly selected students to explore their perspectives on the learning intervention further.

The general findings from the interviews are as follows:

1) "I feel more confident in expressing my opinions and asking questions about the magnetism topic, especially regarding magnetism and capacitors, which I initially felt unsure about learning well."

2) "I received guidance and instructions for experiments and independent exercises that I found easy to follow."

3) "I started paying attention to the importance of learning outcomes as learning targets when they were presented in the course contract, as I did not pay much attention to that part before."

4) "At the beginning of the learning process, I imagined dealing with complicated mathematical equations in studying magnetism, but through this learning experience, I became enthusiastic and motivated, especially when conducting practical work."

The findings of this research, using a mixed-method approach, are presented in the quantitative phase, which reveals the alignment between students' mastery of theory and practical skills in operating laboratory equipment. There is a close relationship between the quantitative and qualitative phases, which impacts the exploration of consistency between students' responses and learning outcomes when using the textbook in the research.

CONCLUSION

The implementation of the electromagnetism textbook based on Pedagogical Content Knowledge (PCK) has resulted in moderate mastery of theory and practical skills among students. The implementation of the electromagnetism textbook has successfully enhanced student learning achievement in the electromagnetism course overall, with a very high level of achievement.

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