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Changes in the Pedagogical Content Knowledge (PCK) Self-Efficacy of Pre-Service Physics Teachers: Redefining the Role of Influencing Factors

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Abstract: Self-efficacy intervention in curriculum design is an effort to improve the quality of teaching practice for pre-service teachers. This research aims to redefine how pre-service teachers' self-efficacy changes through Physics Learning and Microteaching courses. Interventions are given by designing lectures with mastery of knowledge, guidance, teaching experience, and reflection on teaching experience. The intervention carried out 32 meetings (with a total of 67 hours) in 1 semester. The data collection techniques used a questionnaire consisting of 18 statements and reasons for giving the score through pre-test, mid-test, and post-test. The participants were 51 students in teacher education institutions in Indonesia. The results show that integrating activities such as delivering information about PCK, guidance, and their experience in teaching increased their self-efficacy. Still, their self-efficacy decreased after the teaching experience and reflection on their experience. These results recommend that teaching practice reflection activities should not be the last resort in improving students' self-efficacy. Providing information, guidance, teaching practice, and reflection should become an iterative process, where self-reflection notes as a tool to enhance their performance deficiencies and self-efficacy can be improved.

Keywords: Microteaching; PCK; Pre-service Teachers; Self-efficacy

Introduction

In education, self-efficacy is the most studied related to teacher belief (Gagnier et al., 2022). Self-efficacy is believed to contribute to and predict teacher performance achievement (Larry & Wendt, 2022; Polizzi et al., 2021; Sharp et al., 2022; Yadav et al., 2021). Teacher self-efficacy affects the ability of teachers to implement the curriculum (Bausch et al., 2021) and teaching practice (Bausch et al., 2021; Haron et al., 2021; Navarro et al., 2022), so it will also affect the performance of their students (Mulig-Cruz et al., 2015; Sharma et al., 2021; Sharp et al., 2022). Feelings, thoughts, and actions are influenced by self-efficacy (Hernández-Barco et al., 2021), which contribute to the achievement of one's performance (Hwang et al., 2016). Self-efficacy plays a role in controlling the environment to face various challenges and obstacles (Yulianti et al., 2021) to complete work (Durdukoca & Atalay, 2019; Leonardo & Cha, 2021).

Teachers have the main task of teaching; activities that require the ability to master information and share information become easier to understand (Haryanto et al., 2021). In education, teachers need to have a good mastery of the content of the material to be taught and create innovations by implementing their pedagogical knowledge (Nuangchalerm, 2020). Excellent pedagogic knowledge must be possessed to develop effective learning (Haron et al., 2021). Good content mastery will also help increase the self-efficacy of pre-service teachers (Putra et al., 2021). However, having content knowledge (CK) and pedagogic knowledge (PK) separately is not enough to create quality teaching; it takes integrated knowledge known as Pedagogical Content Knowledge (PCK), first introduced by Shulman (Shulman, 1986).

PCK is one of the professional knowledge that a teacher needs to have (Benegas & Villegas, 2021; Melo et al., 2020) and can be improved, for example, through active involvement in discussion activities (Kim et al., 2020). Self-efficacy in teaching is the belief in

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implementing pedagogical practices in the material being taught to create effective learning for students (Navarro et al., 2022). The implementation of this practice is in line with the PCK framework. Research on teacher education related to PCK has increased (Ladachart, 2020). PCK is essential in developing pre-service teachers' self-efficacy (Thomson et al., 2017). The successful experience of pre-service teachers in teaching affects their self-efficacy and will also impact their expected achievement (Borrachero et al., 2013).

Lecture activities that provide information and provide opportunities for pre-service teachers to gain experience are factors that contribute to the development of PCK (Benegas & Villegas, 2021; Karal & Alev, 2016; Thomson et al., 2017) and their self-efficacy (González-Gómez et al., 2022; Kahraman, 2021; Menon et al., 2020). Several studies recommend that higher education institutions promote PCK (Juhler, 2018; Melo et al., 2020) and self-efficacy (Arcoverde et al., 2022; d'Alessio, 2018; Lee et al., 2019). Lecturers give actions to pre-service teachers, and lecture activities that provide opportunities for them to conduct group learning and hands-on activities also affect their self-efficacy (Gaffney et al., 2013).

It is essential to know how the process of changing the self-efficacy of teaching pre-service teachers within the PCK framework can occur. However, there has been no research on this, especially for pre-service physics teachers. Therefore, this study was conducted to redefine how the PCK self-efficacy of pre-service physics teachers changes through lectures integrated with several factors that are believed to affect self-efficacy. These factors include mastery of knowledge (Sharma et al., 2021), training guidance (Barros et al., 2012; Haatainen et al., 2021), experience (Barros et al., 2012; Chen et al., 2022), and reflection on teaching experience (Menon & Azam, 2021; Sharma et al., 2021). These courses are Physics Learning and Microteaching.

To guide this research, several research questions include: (1) How is the PCK self-efficacy of pre-service physics teachers before, in the midst, and after Physics Learning and Microteaching lectures in general? (2) How is the PCK self-efficacy of pre-service physics teachers before, in the midst, and after Physics Learning and Microteaching lectures in the aspects of CK, PK, and PCK? (3) How is the change in PCK self-efficacy of pre-service physics teachers before, in the middle, and after lectures on Physics Learning and Microteaching?

Method

This research is quasi-experimental, conducted at the Physics Education Study Program, one of the universities in Indonesia. The participants in this study were the sixth-semester (VI) students, as many as 51 students. The information regarding the percentage of participants by gender and teaching experience is displayed in Figure 1.

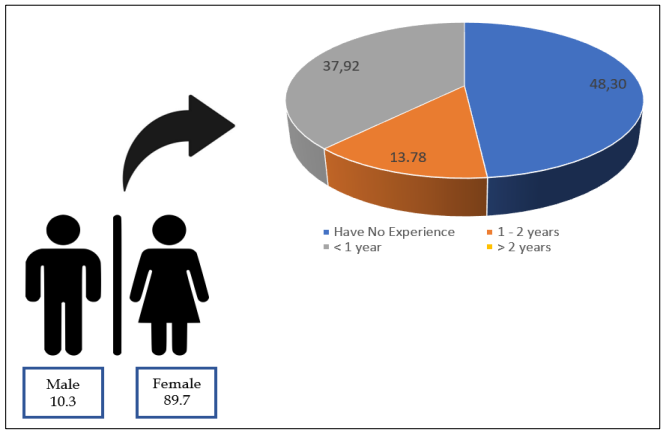

Figure 1. Percentage of participants by gender and teaching experience

This research aims to investigate how the PCK self-efficacy of pre-service physics teachers changes through Physics Learning and Microteaching courses as a treatment. Interventions are given by designing lectures integrating several factors believed to affect self-efficacy. The intervention carried out 32 lecture meetings (with a total of 67 hours) in 1 semester. The treatment given in the study was divided into two types. The first treatment is provided at the 1st to 8th meeting through intervention courses with activities, so pre-service teachers gain mastery of knowledge, training guidance, and teaching practice. The second treatment was given at the 9th to 16th meeting, with intervention courses with the same type of activity added with reflection activities on teaching practices that have been carried out. The research data was taken three times pre-test, mid-test, and post-test. The research design is presented in Table 1.

Table 1. Research Design

Pre-test	1st treatment	Mid-Test	2nd treatment	Post-test
O_1	X_1	O_2	X_2	O_3

O_1: Pre-test score
X_1: Courses activities to gain mastery of knowledge, training guidance, and teaching practice
O_2: Mid-test score
X_2: Courses activities to gain mastery of knowledge, training guidance, teaching practice, and reflection.
O_3: Post-test score.

The instrument used was a Self-Efficacy questionnaire with a Likert scale of 1-9 (1 being very unsure, five being neutral, and nine being very sure). The questionnaire consists of 18 statements, and the

reasons for scoring were adapted from Arsal (Arsal, 2014). The Self-Efficacy Questionnaire is divided into three aspects: Self-Efficacy domains PK, CK, and PCK. Data analysis was conducted to answer research questions 1 and 2 by calculating pre-service teachers' average PCK self-efficacy value and then categorizing it. The criteria used in the categorization of this study are based on the score interval, as shown in Table 2.

Table 2. Categorization of PCK Self-Efficacy

Category	Average Score
Very Low	$1 \leq x \leq 2.6$
Low	$2.6 < x \leq 4.2$
Moderate	$4.2 < x \leq 5.8$
High	$5.8 < x \leq 7.4$
Very High	$7.4 < x \leq 9$

Research question number 3 was answered by conducting the N-gain test. The N-gain test was carried out as part of finding out how the PCK Self-Efficacy changes for pre-service teachers during the pre and mid-tests as well as during the mid and post-tests, using the formula (Hake, 1999):

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad (1)$$

Information:
S_{post}= Post-test score,
S_{pre} = Pre-test score,
S_{max} = Maximum Total Score

This normalized gain is interpreted to express an increase in the PCK self-efficacy of pre-service teachers with the following criteria in Table 3.

Table 3. Categorization of N-Gain

N-Gain Score	Category
N-Gain > 0.7	High
0.7 ≥ N-Gain ≥ 0,.3	Moderate
N-Gain < 0.3	Low

Result and Discussion

In this section, research results are presented, including 1) PCK self-efficacy of pre-service physics teachers in general, 2) Pre-service physics teachers' PCK self-efficacy in the PK, CK, and PCK domains, 3) a Description of changes in PCK self-efficacy of pre-service physics teachers before, in the middle, and after lectures on physics learning and microteaching.

The PCK Self-Efficacy of Pre-Service Teachers in General

After processing the data, the average score of PCK Self-Efficacy is 6.6, 7.1, 6.8 on the pre, mid, and post-test. It indicates that pre-service physics teachers' self-efficacy is in the high category, both during the pre-test, mid-test, and post-tests. The self-efficacy of pre-service physics teachers increased from pre-test to mid-test, where the first treatment was given between the two tests. The figure also shows that the self-efficacy of pre-service physics teachers decreases if the average score during the mid-test is compared to the post-test. The percentage of pre-service physics teachers in each self-efficacy category is presented in Figure 2.

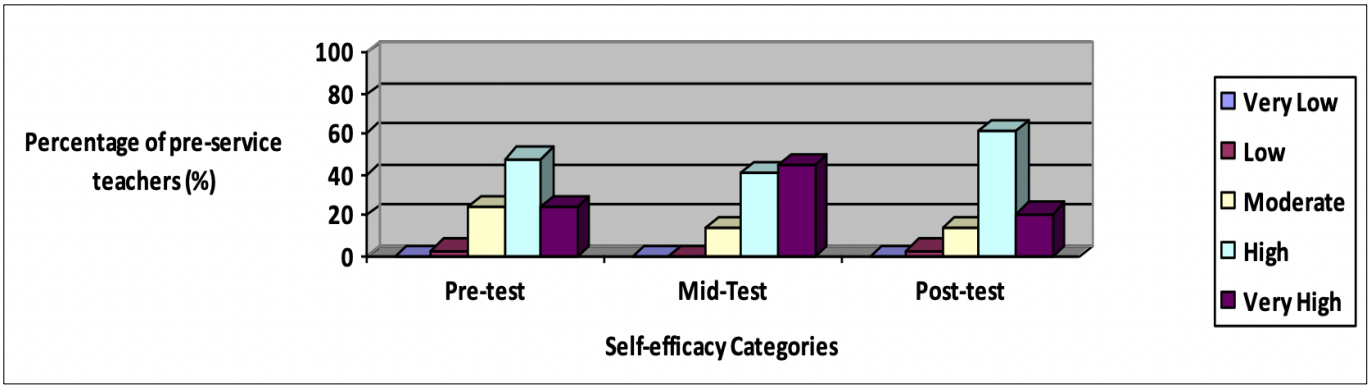

Figure 2. The Percentage of Pre-service Teachers in Each Self-efficacy Category

From Figure 2, it can be seen that no pre-service teacher has very low self-efficacy both in pre, mid, and post-test. The percentage of pre-service physics teachers in the high self-efficacy category has increased (from the mid-test to the post-test). Still, the percentage of pre-service teachers in the very high category decreased.

The PCK Self-Efficacy of Pre-Service Physics Teachers in the CK, PK, And PCK Domain

PCK self-efficacy of pre-service physics teachers was also analyzed in each domain, namely PK, CK, and PCK; the results are presented in Figure 3.

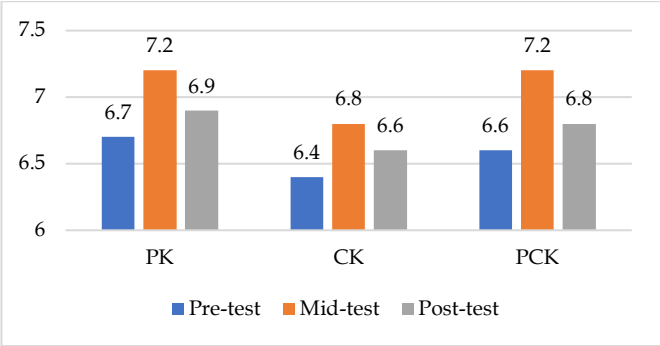

Figure 3. The Average Score of PCK Self-Efficacy in Each Domain and Test

Figure 3 indicates an increase in PK, CK, and PCK domains (between the pre-test and mid-test), but self-efficacy in the three domains decreases from the mid-test to the post-test.

The percentage of Pre-service Teachers in Each Category for every Domain and Test is presented in Table 4. It shows that during the mid-test, none of the pre-service physics teachers had very low self-efficacy in the PK, CK, and PCK domains. The percentage of pre-service teachers in the high category increased from the mid-test to the post-test in each domain. Still, the rate of pre-service teachers in the very high category decreased.

Table 4. The percentage of Pre-service Teachers in Each Category

Category	PK			CK			PCK		
	Pre	Mid	Post	Pre	Mid	Post	Pre	Mid	Post
Very Low	0	0	0	0	0	0	0	0	0
Low	3	0	3	3	0	3	3	0	3
Moderate	17	14	14	28	24	17	17	7	7
High	48	38	38	59	42	59	59	45	66
Very High	31	48	48	10	34	21	21	48	24

Changes In the PCK Self-Efficacy of Pre-Service Physics Teachers

One method to define pre-service teachers' PCK self-efficacy changes is by analyzing their N-Gain self-efficacy. From pre-test to mid-test the N-Gain is 0,21 in low category, from mid-test to post-test the N-Gain is -0.14 also in low category. These results indicate that the self-efficacy of pre-service physics teachers increases after being given the first treatment. The test was then carried out again after providing the second treatment. Still, the self-efficacy of the pre-service teacher decreased.

Further analysis was carried out on the reasons for scoring to observe the changes in the self-efficacy scores given by pre-service physics teachers. The reasons are presented in Table 5.

Table 5. Reasons for Scoring

N-Gain Category	Reasons for Scoring	
	Pre-Mid Test	Mid-Post Test
High	P8	P11
	Pre-test: *I am not sure because I have never taught directly, so I can't measure whether it is effective or not.*	Mid-test: *Because I've never taught, I'm not sure I can do it well.*
	Mid-test: *I learned that before teaching, I need to prepare a teaching method that suits the character of each student, maybe with the help of the latest technology to be more efficient in time so that the possibility of misconceptions will be reduced.*	Post: *Because I have attended microteaching lectures, I have practiced enough to adjust students' character in learning.*
Low	P29	P15
	Pre-test: *I tend to believe that I will be able to plan effective learning activities according to the characteristics of the material. It is because of the theoretical provisions I got during lectures. Still, to adapt them to students' readiness and characteristics, I need to add to my teaching experience.*	Mid-test: *I'm sure but not entirely sure because I've never taught. Therefore, in the future, I will hone my skills.*
	Mid-test: *I'm not too sure because I'm not very experienced in this field*	Post-test: *Based on my experience and observations after taking courses that support my teaching ability, I still need to improve my teaching skills with more activities that support this.*

Good knowledge in integrating theory and practical activities is part of PCK (Juhler, 2018). A good PCK describes a teacher's good quality in teaching (Shawer, 2013) to create meaningful learning (Haron et al., 2021). However, research by Efwinda & Mannan (2021) shows that the PCK self-perception of prospective physics teachers is only in the sufficient category. Further analysis, as shown in Table 3, showed that after the reflection activity, the pre-service physics teachers realized that the teaching skills according to the PCK

Framework they had were still lacking. They still need to learn a lot to carry out quality teaching practices, which causes their self-efficacy to decline.

In the first treatment, physics learning and microteaching lectures were intervened with activities in presenting and discussing PCK information, guidance, and teaching practice activities. This intervention aims to redefine the change in PCK self-efficacy of pre-service teachers. The results shown in Figures 2, 3, and Table 4 show things that are by the statement of Sharma et al. (Sharma et al., 2021), which states that mastery of knowledge and experience can be the key to developing self-efficacy.

Figures 3 show that the self-efficacy of pre-service physics teachers in the mid-test against the post-test decreased. Between these two tests, a second treatment was given as a lecture activity intervention with the same factors in the first treatment but was added with teaching practice reflection activities. This is according to Shawer et al. (2013), which state that self-efficacy can increase if a person has successful experience in completing a task. Conversely, self-efficacy will be lower if someone has failed expertise in completing a task. The answers given by several respondents, as presented in Table 5. correspond to Chen et al. (2022). They state that their mastery of teaching experience is the most influential factor in self-efficacy.

Although there was a decrease in self-efficacy from the mid-test to the post-test, this decrease did not mean that the confidence of the pre-service teacher was very high or high to be very low or low. Still, in Figures 2 and Table 4, we can see that most of the decrease in self-efficacy occurred in the very high category to the high category. Follow-up interviews were also conducted with several pre-service physics teachers with decreased self-efficacy, one example of a pre-service teacher's answer from participant number 7 (P7): "*After the reflection stage, I came to know that in teaching there are many important details that must also be considered, but my teaching practice has not paid attention to these details, for example, clear intonation of voice when explaining. This lowers my confidence that I can teach well. After reflection, I think that I still need to learn a lot, guidance, teaching practice, and reflection to continue improving the quality of my teaching*."

These results recommend that teaching practice reflection activities should not be the final effort in increasing student self-efficacy but as an iterative process before the activities of presenting information, guidance, and enriching teaching experience are repeated. Reflection on the teaching experience is expected to be used as a record of previous learning and performance improvements to improve PCK self-efficacy of pre-service physics teachers, accompanied by an increase in their mastery of knowledge and the quality of their teaching. This follows the statement (Menon & Azam, 2021) that teaching reflection activities are a challenge for pre-service physics teachers based on their previous beliefs in teaching

Conclusion

Based on the data and results of the study, it can be concluded that the PCK self-efficacy of pre-service physics teachers before, in the midst, and after Physics Learning and Microteaching lectures is in the high category. There has been a change in the PCK self-efficacy of pre-service physics teachers through physics learning courses and microteaching. Integrating activities such as delivering information about PCK, training guidance, and their experience in teaching practice increased their self-efficacy. After reflection activity, their self-efficacy decreased. These results recommend that teaching practice reflection activities should not be the final effort in increasing student self-efficacy but as an iterative process before the activities of presenting information, guidance, and enriching teaching experience are repeated. Reflection on the teaching experience is expected to be used as a record of previous learning and performance improvements to improve PCK self-efficacy of pre-service physics teachers, accompanied by an increase in their mastery of knowledge and the quality of their teaching.

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