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The Exploration of Self-Efficacy Beliefs and PCK among Gen Z Pre-Service Physics Teachers in Indonesia: A Sequential Explanatory Study

Ike Lusi Meilina[1]✉, Singgih Bektiarso[1], Sayyidatun Najah[1], Ummi Qonitatin[1], Ernasari Ernasari[1], Rosita Putri Rahmi Haerani[2]

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[1]Universitas Jember, Indonesia
[2]University of Auckland, New Zealand

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Abstract

This study aims to explore the relationship between self-efficacy and Pedagogical Content Knowledge (PCK) of Generation Z preservice physics teachers. Given the unique characteristics of Generation Z, who are tech-savvy but often face challenges in mastering in-depth physics content. The research method used is a mixed method with a sequential explanatory design. Quantitative data were collected from 75 preservice physics teachers using a PCK test instrument adapted from DTAMS and a self-efficacy questionnaire. Qualitative data were obtained from in-depth interviews with 20 preservice teacher participants. The main finding of the quantitative analysis was that there was no significant relationship between self-efficacy and PCK among preservice teachers. Pearson's correlation test confirmed that there was no significant linear relationship between the two ($r<0.2$). Qualitative findings explain that self-efficacy is conditional, built through philosophical beliefs about the importance of learning reform, short-term preparation of physics material before teaching, and validation of the success of teaching methods during field practice. This study concludes that for Generation Z preservice physics teachers, self-efficacy develops independently of the domains of knowledge and pedagogy. The implication of this study is that teaching preparation and teaching practice strategies need to be trained more in the preparation of preservice teachers..

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✉ Correspondence Author:
E-mail: ikelusimeilina.fkip@unej.ac.id

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INTRODUCTION

Generation Z was born between 1995 and 2010 (Yuan et al., 2024), an age group that is currently pursuing undergraduate degrees at universities. Although students come from a wide range of ages, Generation Z is quite well represented in higher education. The physics education program is a program that prepares preservice physics teachers before they become teachers. Similar to other programs, preservice physics teachers currently enrolled college mostly Generation Z.

Generation Z has characteristics that differ significantly from those of Millennials. Millennials are interested in interpersonal learning and working in groups in classroom discussions (Imjai et al., 2024). Generation Z preservice teachers are more attuned to intrapersonal learning (Seemiller & Grace, 2016). The learning process suits Generation Z is video-based learning and applied learning, where preservice teachers can see demonstrations of tasks need to be done either in person or online. Learning related to real-world problems, contextual problems, and problem solving are some of types of learning Generation Z prefers (Seemiller & Clayton, 2019).

Educational reform has brought about changes in physics teaching, not only in teachers' teaching practices but also in teaching philosophy (Höfrová et al., 2024). These changes have occurred in how physics is taught and assessed in schools. Learning changes emphasize student activity in the classroom by using constructivist approaches, problem-based learning, and inquiry-based learning. Teaching that used to emphasize mathematics in physics lessons, memorization, and answering questions now requires students to learn more about problem-solving skills, scientific investigation, asking questions, and formulating hypotheses (Houfková, 2024).

Preservice physics teachers are expected to master Pedagogical Content Knowledge (PCK). The function of PCK possessed by teachers is to integrate Domain Knowledge (DK) in explaining physics concepts to students (Kulgemeyer & Riese, 2018). Several previous studies have proven students' mastery of concepts is influenced by teachers' PCK (Puspitaningtyas & Purwaningsih, 2021). Other studies have found teachers' PCK can positively predict student achievement (Keller et al., 2017). There are many studies on PCK for teachers, including studies on relationship between CK and PCK (Neumann et al., 2019; Yuan et al., 2024), relationship between teacher PCK and student learning (Keller et al., 2017; Melo et al., 2017), and PCK development programs for physics teachers (Melo et al., 2020).

Pedagogical Content Knowledge (PCK) is a combination of pedagogical knowledge (PK) and content knowledge (CK). PCK was first introduced by Shulman in 1987. Many experts have attempted to develop a PCK framework and define its components. PCK is the transformation of several types of knowledge for teaching. PCK can be divided into four components, namely 1) knowledge about curriculum; 2) knowledge about students' understanding of science; 3) knowledge about learning strategies; and 4) knowledge about assessment (Magnusson et al., 1999). These four components are important as a foundation for teachers in learning. Preservice physics teachers must develop PCK, seamlessly integrating physics content with effective instructional strategies. This is distinguishes the knowledge of a teacher from that of a scientist (Wulandari et al., 2024).

The new PCK concept continues to be developed by refining the old PCK concept (Behling et al., 2022). One of the latest models of PCK development is the Refined Consensus Model (RCM). RCM explains the complex layers of knowledge and experience of teachers that impact student learning. PCK in this model can be divided into three parts, namely 1) collective PCK; 2) personal PCK; and 3) enacted PCK. Collective PCK (cPCK) refers to knowledge about learning that is agreed upon by experts. Personal PCK (pPCK) represents the personalization of the knowledge and skills possessed by a teacher. Enacted PCK (ePCK) refers to the form of PCK that teachers apply individually in teaching situations, which includes planning, implementation, and reflection on learning outcomes (Behling et al., 2022; Wang & Zhan, 2023). In this model, PCK is not considered a fixed body of knowledge, but can be developed and refined over time (Sarkar et al., 2024).

A teacher's PCK abilities are closely related to self-efficacy beliefs. Self-efficacy beliefs are beliefs about how well a person can perform tasks necessary to overcome potential problems that arise. Preservice teachers' confidence in their teaching abilities is reflected in teaching strategies, their mastery of subject matter, and positive attitude in classroom (Thomson et al., 2017). A prospective teacher's confidence or self-confidence in teaching physics effectively influences performance of prospective physics teacher. Strong self-efficacy beliefs greatly influence teacher's motivation to teach physics (Wu et al., 2021).

Physics education encourages teachers to engage students in various learning experiences, student-centered learning, and emphasizes conceptual understanding (Scherer & Bertram, 2024; Vilppu et al., 2024). There are still many teachers who have different interpretations and perspectives on learning development. Teachers are still fixated on past ideas about effective learning. Research indicates that teachers' beliefs play an important role in understanding learning. Teachers' beliefs in overcoming challenges in learning are referred to as self-efficacy beliefs.

Using Bandura's theory (1977), efficacy is a person's ability to perform tasks and overcome problems that arise in order to achieve expected results. Strong efficacy greatly influences a teacher's motivation to teach, while weak efficacy can cause a teacher to avoid teaching tasks in classroom. The low efficacy of preservice teachers in teaching physics is caused by low confidence in teaching physics, which contributes to their low understanding of physics and lack of experience in good physics learning (Teng & Wu, 2024).

The need to improve efficacy of preservice physics teachers has been discussed in several studies (Bottomley et al., 2024; Lin & Luo, 2023). Additional factors that have been proven to have an impact on efficacy are teaching practice, experience during physics lectures (Boeve-De Pauw et al., 2024), physics learning experience, and the amount of teaching experience. Research shows teachers' beliefs play important role in how they interpret pedagogical knowledge beliefs, how they conceptualize teaching tasks, and how apply decisions in learning (Getenet et al., 2024; Pozas et al., 2024).Teachers' pedagogical actions, teaching approaches, and influence on student abilities are based on personal beliefs (Barros et al., 2010).

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There have been many studies on teachers' PCK, but not many studies on PCK and self-efficacy beliefs for preservice physics teachers that focus more on the thinking characteristics of Generation Z. The different characteristics of Generation Z compared to previous generations have brought changes to the lecture process in preparing for the teaching profession. There is still a lack of research discussing a systematic review specifically on PCK and self-efficacy beliefs of preservice physics teachers and Generation Z's views on the continuity of their teaching careers. A comprehensive review discussing findings on the next generation of preservice teachers is very important (Suryadi et al., 2023). Based on these reasons, it can be said that PCK and self-efficacy of preservice teachers are important to study.

This study addresses need for more research on exploration of self-efficacy and Pedagogical Content Knowledge (PCK) among preservice physics teachers. The contributions of this study can help improve understanding of thinking of preservice physics teachers in implementing teaching practices in classroom and its relationship with self-efficacy beliefs. This study encompasses three main objectives. First, it aims to examine the relationship between self-efficacy and PCK of Generation Z preservice physics teachers. Second, it seeks to analyze whether PCK can predict self-efficacy of Generation Z preservice physics teachers. This research intends to describe educational experiences and self-efficacy of Generation Z preservice physics teachers.

METHOD

To comprehensively address the research objectives, this study uses a mixed-methods research design. The mixed-methods approach involves the systematic integration of quantitative and qualitative data in a single investigation. This methodology was deliberately chosen because it provides a more nuanced and complete understanding of complex educational phenomena than can be achieved by a single methodological approach. Specifically, it allows for integration of broad statistical trends with an in-depth exploration of underlying reasons behind those trends.

This mixed method study investigates the relationship between self-efficacy and Pedagogical Content Knowledge (PCK) of Generation Z preservice physics teachers. Data were obtained through survey measuring self-efficacy and PCK of Generation Z preservice physics teachers. Interviews conducted to supplement data needed regarding views of preservice physics teachers on teaching preparation and self-efficacy beliefs.

This study collected two types of data: quantitative data (surveys) and qualitative data (interviews). The research method used was a sequential explanatory mixed method design (Creswell, 2018), which consisted of quantitative data followed by qualitative data. Qualitative data was needed to help interpret the quantitative data obtained. In the sequential explanatory design, quantitative data collection and analysis were obtained first, followed by qualitative data collection and analysis (Dawadi et al., 2021), with priority given to quantitative data. Qualitative data helped to explain the quantitative data results and research analysis in greater depth. The research participants were 75 Generation Z prospective physics teacher students at state universities in Indonesia, aged 18-22 years. All participants were prospective teacher students in physics education study program, at least in their 7th semester, with a IPK of 3.00 to 4.00. Participants were selected based on a minimum of 3 years of study and were currently undertaking teaching assistance/teaching practice in schools to ensure that each participant had taken courses related to pedagogy.

Data were collected using a survey of all 75 prospective teacher participants and interviews with 20 preservice teacher participants who volunteered to take part in the survey. The survey instrument consisted of three measurements, namely Domain Knowledge (DK), Pedagogical Content Knowledge (PCK), and Self-efficacy of preservice physics teachers. The survey was conducted in one out-of-class activity using a survey instrument developed from the Diagnostic of Teacher Assessment Mathematics and Science (DTAMS) instrument (Tretter et al., 2013). The DK and PCK measurement instruments in this study were adapted from the Physical Science Test (PST) development in the DTAMS questions. The adaptation process was carried out by maintaining the original indicators and item format, which were then translated into Indonesian and adjusted in terms of content and construct to be relevant to the research context. The modified instrument underwent re-validity and reliability testing to ensure its psychometric quality. Based on item testing conducted on 44 prospective teacher education students similar to the research sample, a Cronbach's alpha reliability coefficient score of 0.874 was obtained, thus indicating a high reliability score.

The instrument related to preservice teachers' self-efficacy beliefs uses a development of the Science Teaching Efficacy Beliefs Instrument (STEBI, Enochs and Riggs 1990). The self-efficacy beliefs questionnaire indicators used have been adapted into Indonesian, adjusting the STEBI indicators and the content of the instrument construction in physics learning. The dimension distribution, and sample items are presented in Table 1. In this study, evidence of validity and reliability was established by reviewing the survey items with the researchers and testing the instrument with 44 prospective teacher education students similar to the research sample. Reliability scores were calculated and showed good reliability (Cronbach's Alpha = 0.83).

Table 1. Physics Teaching Efficacy Belief Instrument

Dimension	Description	Item number	Sample Item (Adapted to Physics)
Personal teaching efficacy belief	Evaluate preservice teachers' beliefs in their own ability and competence to teach physics effectively	2, 3, 5, 6, 8, 12, 17, 18, 19, 20, 21, 22, 23	"I will continually find better ways to teach physics." "Even if try very hard, I will not teach physics as well as I will most subjects."
Outcome expectancy	Evaluates the belief that effective physics teaching can positively influence and improve student learning outcomes.	1, 4, 7, 9, 10, 11, 13, 14, 15, 16	"When a student does better than usual in physics, it is often because the teacher exerted a little extra effort." "The low physics achievement of some students cannot generally be blamed on their teachers.

The interviews were semi-structured and lasted 45 to 60 minutes. The interviews were conducted with 20 preservice teachers who volunteered to participate in the survey. The interview questions were designed to measure the prospective teacher students' perceptions of the teacher preparation program in higher education, their beliefs about physics teaching, and the success of physics teaching. The interview transcripts were analyzed using an inductive approach, where overarching themes were derived directly from participants' narratives. In this analysis, open coding was used to find main categories in the interview data. During the analyzing process, this was followed by axial coding to find the relationships between these categories and the initial survey results. The next stage, as part of the interpretation, was to construct themes based on comparisons of patterns obtained and to review the themes to ensure that they covered all categories to comprehensively answer the research objectives.

RESULT AND DISCUSSION

The DTAMS instrument obtained indicators of Domain Knowledge (DK) and PCK. The relationship between knowledge domain, PCK, and self-efficacy belief was tested using correlation analysis. A significant correlation was found in Domain Knowledge and PCK of teachers ($r=.397, p<.05$). The results of study show that preservice teachers' PCK does not have a significant correlation ($r=.143, p<.0,5$). In addition, results of the study also show that participants' self-efficacy towards DK is not correlated ($r=.022, p<.05$). The correlation results of Self-efficacy, DK, and PCK can be seen in Table 2.

Table 2. Descriptive statistics and Pearson Correlation Coefficients for the variables

Variables		**(1)**	**(2)**	**(3)**
Pearson Correlation Coefficients	(1) DK	1		
	(2) PCK	.397**	1	
	(3) Self-efficacy	.022	.143	1
Mean		70.40	60.24	73.91
Median		75.00	60.00	74.00
SD		18.61	25.32	6.40
Skewness		-.95	-.12	.06
Kurtosis		.11	-.85	.62

**Correlation is significant at 0.01 level (2-tailed)

The correlation test shows that DK and PCK have a correlation of .397. The correlation value is in the moderate category. DK significantly affects their perception and understanding of PCK, although not in the strong category. The correlation test shows that self-efficacy and DK have no correlation. The two variables do not have a substantial linear relationship. In other words, DK does not significantly affect preservice teachers' self-efficacy. Another correlation test shows that there is no significant correlation between self-efficacy and PCK. The two variables do not have a substantial linear relationship. In other words, self-efficacy has no relationship with PCK and vice versa. The absence of a linear correlation does not indicate a failure of the instrument, but rather indicates a phenomenon of decoupling, whereby the self-efficacy beliefs of preservice physics teachers develop independently of their actual content mastery.

Self-efficacy has a fairly low SD of 6.40. This indicates that the self-efficacy scores of preservice teachers are very homogeneous (uniform). The data is concentrated on the median value, indicating that preservice teachers have similar and consistent perceptions of self-efficacy. This is different when compared to DK and PCK, which have SD values of 18.61 and 25.32. High SD values indicate that there is a significant gap between participants with high and low abilities. The results of the comparison visualization of DK, PCK, and Self-efficacy can be seen in Figure 1.

The random distribution pattern visually shows that there is no clear linear pattern between the DK variable and self-efficacy or between PCK and self-efficacy. The regression line, which is almost horizontal and close to zero, is evidence that the correlation formed is very weak. This shows that as DK and PCK scores increase, preservice teachers' self-efficacy does not increase consistently. This is supported by the existence of participant data points in all four quadrants. There are participants in the upper left quadrant who show low DK/PCK scores but have high self-efficacy scores. Likewise, there are participants in the lower quadrant who show high DK/PCK scores but have low self-efficacy. The results of the analysis using scatter plots that describe the correlation between variables can be seen in Figure 2a and Figure 2b.

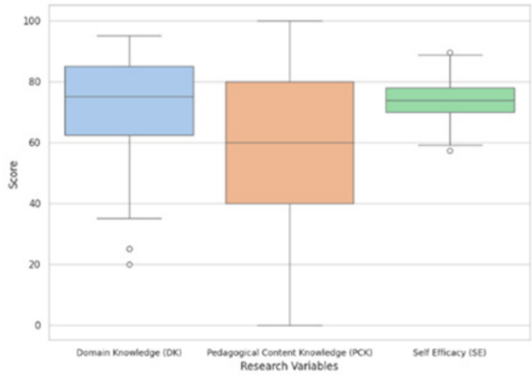

Figure 1. Comparison of Score Distribution (Variance) Across Variables

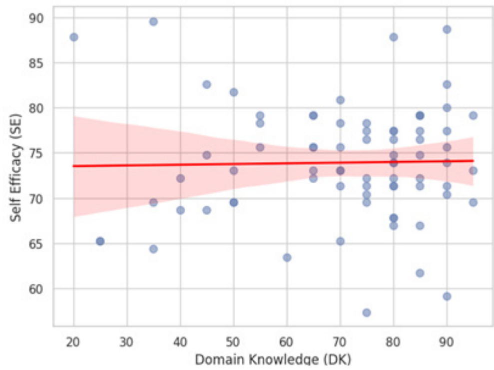

Figure 2a. Relationship between DK and Self Efficacy

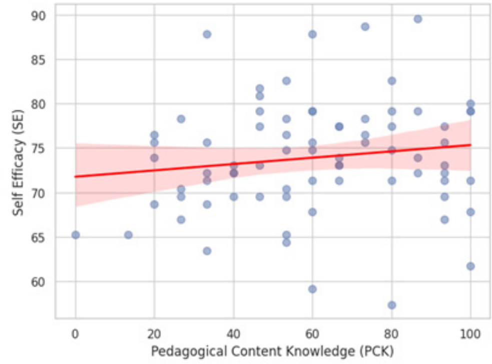

Figure 2b. Relationship between PCK and Self Efficacy

Preservice teachers' views on teacher education and self-efficacy

The interviews revealed five main themes, namely 1) Academic experiences in high school; 2) The self-efficacy paradox; 3) Conditional self-efficacy; 4) Perceptions of teacher professional program preparation; and 5) Emotional transformation. These five themes are described in the Table. To provide a clear description of the preservice teachers' perspectives on each theme, several interview excerpts, the most representative data, were captured in this way to illustrate an ridea or category described in the qualitative results in Table 3.

Table 3. Major themes regarding preservice teachers' views on teacher education and self-efficacy

Theme	Category	Description
Academic experience in high school	a. High School Experience (Negative & Positive)	Preservice teachers use their experiences as students as a starting point. Negative experiences (passive teachers, lectures, infrequent attendance) create insecurity, while positive experiences (engaging, interactive teachers) become role models.
	b. Pedagogical Beliefs	Their current beliefs (e.g., "teaching must use games") were formed as a reaction or resistance to the negative experiences (lecturing teachers) they had in the past.
The Self-Efficacy Paradox	a. Belief in Teaching Methods (High)	Preservice teachers are very confident in their teaching methods. They believe that interactive methods (games, projects, PhET) are definitely better than lectures.
	b. Intellectual/Content Anxiety (High)	At the same time, they are very anxious and lack confidence in their own mastery of the material. They are afraid of misunderstanding concepts, afraid of being questioned by students, or afraid of misconceptions.
Conditional Self-Efficacy	a. Emotions & Feelings (Anxiety)	Anxiety about getting concepts wrong, fear of being questioned by students, or fear of misconceptions are the main triggers.
	b. Material Preparation	Their main solution to overcoming anxiety is to prepare/study the material before teaching. Their confidence is conditional: it only appears if they have mastered the material.

Theme	Category	Description
Perceptions of the Teacher Preparation Program	a. Theory Perception (on Campus)	Preservice teachers feel that the physics material in lectures is very difficult, abstract, and dense, which initially often makes them feel insecure.
	b. Practical Perception (Asjar/PPL)	The practicum (Teaching Assistance) program is the most important moment. It validates their methods and builds their true self-efficacy.
Emotional Transformation	a. Anxiety	Preservice teachers begin their journey with emotions "inherited" from high school, such as hatred, insecurity (feeling stupid), or anxiety about the material.
	b. Enthusiasm	These emotions change through teaching practice. They feel happy and enthusiastic when students respond, and proud when they succeed in making students understand or "change their minds" about physics.

Academic experience in high school

When discussing their academic experiences in high school physics, preservice teachers generally talk about their experiences learning physics at school. Preservice teachers consider their experiences learning physics in high school to be the most memorable and to have had a major influence on their views of physics to this day. Preservice teachers do not enter college with a blank slate but rather bring with them strong knowledge and emotions that were formed in high school. Based on the interview results, the experience of learning physics in high school was predominantly a negative one. Several participants consistently reported that the high school teacher's learning model was still passive, centered on lecture methods, and failed to connect the material to the real world. Several preservice teachers described their physics experience in high school as boring:

"When it came to learning physics in high school... my teacher emphasized learning physics through lectures, which made the material less interesting... so my teacher focused on the textbook and made me and my friends bored with physics..."

Other interview respondents illustrated the same idea when talking about their experience of learning physics in high school. Several preservice teachers described conventional physics learning in the classroom. Some preservice teachers mentioned that students were only passive recipients and were given more assignments. One prospective teacher described their experience of physics as follows:

"For 10th grade, I only remember that the teacher was rarely present, so the physics teacher just told us to summarize the material independently and then do the assignments. I also remember that we never had physics lab classes and only used the lecture method in class. The teaching method was to go straight to the physics formulas and ask us to do the problems."

Some preservice teachers recall learning through lectures, rarely doing practical work, and never using technology. This kind of physics learning experience can reduce students' interest and enthusiasm. One respondent mentioned a physics experience that bored him:

"Well, in my experience studying physics in 10th grade, because I was a new student, I wasn't very interested in physics. Then my interest in physics remained minimal because of the teacher himself. I'm sorry, but personally, I honestly didn't really like the lecture method. So, back then, the teacher used more of a lecture method. So, maybe that's why my interest was minimum."

These experiences had an impact on preservice teachers' feelings toward physics. Participants reported feelings of hatred, dislike, or insecurity toward physics. This was also conveyed by other participants who considered physics to be an unpleasant subject:

"To be honest, I didn't really like physics in high school. I was more into chemistry and biology... [The teacher] was boring. It was more because the teacher was old... Then in 11th and 12th grade, the teacher was easy, but the way he taught was too fast. So I'd be like, 'I don't even understand this yet, but we're already moving on to the next topic...' So I just ended up getting lazy about physics."

Negative feelings about physics will remain in the minds of preservice teachers until they reach university level. Even though preservice teachers consciously choose a career in physics, feelings of insecurity remain until they reach university level. This is reflected in the statement of one participant, as follows:

"I went to a boarding school for high school. I didn't get much experience learning physics at school because the teacher was rarely there. So when I went to college, I felt that all my friends already understood the physics material better than I did. I had no practical experience at all in high school, for example, measurement

practicals. I didn't know what to do in those practicals, while I saw my other friends already skilled at taking measurements using various measuring instruments. I felt a bit insecure at the beginning of the lab when I first started physics college."

A small number of preservice teachers mentioned that they had positive experiences when their high school teachers made learning enjoyable and interactive. These positive experiences led high school physics teachers to become role models in practicing physics education.

The Self-efficacy Paradox

Interview notes on self-efficacy and PCK among preservice physics teachers reveal something interesting. This theme reveals a very strong contradiction expressed by nearly 20 prospective teacher respondents. Preservice teachers have very high pedagogical beliefs (PCK), but on the other hand, they have low confidence in their mastery of physics content. Respondents' descriptions of their self-confidence in implementing teaching methods show that preservice teachers believe that modern, interactive, and student-centered methods of teaching physics are correct and definitely better. Preservice teachers believe that hands-on activities are the key to student success, not just physics theory. One respondent described this by saying:

"I will probably use more project-based learning or hands-on experiments in physics lessons rather than just lectures. I will still explain the material but will also apply other learning models such as PBL and so on".

Preservice teachers are very confident about using technology to teach students in the classroom. Gen Z preservice teachers are very aware of the role of technology in learning. Preservice teachers have no difficulty in applying technology in learning. Several courses have facilitated the understanding and application of technology so that Gen Z preservice teachers feel confident in their ability to use technology in the learning process in the classroom. Some technologies that can be used in learning are the Phet virtual laboratory, quizzes using Quizizz and Wordwall, and games in physics learning.

"For my plan to teach physics in my classroom, I will use interactive media that is student-centered... so it's not just focused on the teacher... I will also use learning methods such as project-based learning or problem-based learning, which I will later relate to local wisdom or the daily lives of students".

In addition to using technology, Gen Z preservice teachers also understand the role of contextual learning in physics lessons. They realize that physics must be related to everyday life so that students can better understand physics concepts. Here is an example from an interview:

"My goal in teaching physics is to make students think that physics is not a difficult subject and can be learned. I try to teach my students using examples from their daily lives or their surroundings so that they can understand. When I ask them about a physics concept, they always relate it to their daily lives. For example, if I ask them about an example of gravitational force, they can answer, but if I ask them about the definition and equation of Earth's gravity, they don't understand".

Although most preservice teachers feel confident about the methods (pedagogy) they have mastered, data from the interviews show that preservice teachers simultaneously experience anxiety about their mastery of physics content. Preservice teachers' confidence collapses when talking about their mastery of physics content. One of the fears experienced by preservice teachers is the fear of misconceptions.

"Honestly, I am anxious, afraid that I will be wrong in explaining physics material and formulas. I feel unsure whether the material I have taught is correct and whether the formulas used in solving physics problems are correct".

Another fear experienced by preservice teachers is anxiety and doubt about their understanding of physics concepts, so that when faced with smart students, teachers feel less confident. Some preservice teachers feel anxious that they will not be able to answer students' questions that are outside the scope of the physics topics they have prepared. Preservice teachers feel unable to master all physics material, so some avoid certain topics they dislike, such as the equilibrium of rigid bodies or moment of inertia. The following is an excerpt from the illustration:

"Usually, at the beginning of a physics lesson with students in class, I feel anxious because I am afraid that the students are smarter than me. I am afraid that I will not be able to answer my students' questions or that my students will ask abstract questions that are far from the material being taught".

In the second theme, there is internal conflict within each prospective teacher. Preservice physics teachers feel that they know how to teach physics in an enjoyable way by involving interactive learning models and technology, but they also feel very afraid of making mistakes in explaining physics concepts to students. Preservice teachers have not fully mastered the physics material during their lectures, so they tend to relearn it before teaching students. Their mastery of concepts is also evident when some students ask questions about topics outside the material being taught. If their mastery of physics concepts is low, preservice teachers will find it difficult to connect several physics concepts simultaneously to answer students' questions.

Conditional self-efficacy

The results of the interview transcripts show that preservice teachers' self-efficacy is not a stable trait. Gen Z preservice teachers' self-efficacy is conditional, meaning that it will be high if they rebuild their understanding of physics concepts and reinforce them before each teaching session. The dominant strategy for managing anxiety is to prepare materials before teaching. The most important preparation for preservice teachers is mastery of the material before entering the classroom. They explicitly associate self-efficacy with the level of material preparation. One participant described this idea by saying:

"To overcome this, I personally had no choice but to be confident from the start, not to worry, and to be absolutely sure that I could do it... so to overcome this, I had to be really prepared by studying physics before teaching. I worked hard to prepare the material thoroughly and boost my confidence. The way to prepare is by understanding the physics material before teaching it; if I don't understand it, I feel less confident... so I gain confidence when I master the material..."

Several participants described self-efficacy as an on/off switch that depends on teaching preparation. Thorough preparation of physics content is key to ensuring that the teaching process runs smoothly, which indirectly reduces preservice teachers' anxiety about teaching. One respondent stated:

"If I am underprepared, I feel anxious. If I feel that I am sufficiently prepared, I enjoy teaching in class".

This strategy even includes specific behaviors, as expressed by one participant, who used the strategy of *"studying at night, I practiced teaching to deliver physics material in front of a mirror first."*

This theme confirms that the core issue for preservice teachers is mastery of physics content. The main solution is not learning how to teach well (PCK) but rather learning about physics concepts better. This statement is in line with the findings of Thomson et al. (2016), which link Personal Efficacy closely to the emotions of preservice teachers. Based on the interviews conducted, it was found that preservice teachers' self-efficacy is very fragile, and strategy they use to manage this anxiety is to improve their mastery of concepts.

Perceptions of Teacher Preparation Program

In interviews, participants expressed varying levels of efficacy in teaching physics. Although all prospective teacher respondents received the same form of instruction, namely physics and education theory and direct teaching practice, their range of self-efficacy differed. When talking about their self-efficacy, more participants reported low self-efficacy than those who reported high self-efficacy. Low self-efficacy is generally associated with a lack of strong mastery of physics concepts. One prospective teacher described this idea by saying:

"During lectures, the lecturers actually taught physics material from the basics, but I didn't understand it very well because the material was difficult during college".

When talking about their learning experiences in college, many preservice physics teachers feel that they lack an understanding of physics because they assume that physics is very difficult, abstract, and involves a lot of material. Participants generally mention in their interviews that they do not enjoy learning complex and in-depth physics content, that they lack mathematical knowledge, and that they have difficulty learning advanced physics. Preservice teachers find it difficult to relearn physics material in college courses because some students did not learn it in high school. In addition, some preservice teachers argue that what they learned in high school is very different from what their lecturers teach in their courses. The following is an illustrative quote:

"When I entered the physics education program, I was a little surprised to find that physics covered such a wide range of material. My experience learning physics in high school was very limited, and some of the material was not taught in school. I also didn't really like mathematics in high school. But when I started college, I tried to understand physics because it was like learning it for the first time. Because it was new, I felt unfamiliar with the physics formulas and some of the equations had to be solved using mathematics. So, while studying in college, I tried to digest all the physics material".

The experiences of preservice teachers during high school play an important role in learning physics in college. Preservice teachers felt that they had received minimal physics material in high school, so they assumed that physics was difficult, which stuck in their minds and influenced their attitude toward physics in college. Most preservice teachers did not have an enjoyable physics experience in school. There were no practical activities, either in person or virtually. An attitude of dislike toward physics can lead to feelings of insecurity at the beginning of college. One prospective teacher described this idea by saying:

"During college, it turned out that in addition to physics theory, there were also practical activities. I never did any practical work in the school laboratory when I

was in high school. Compared to my friends, it might have been easier for them to understand the practical activities, but I found it quite difficult, for example, the practical work on measurement. I was quite insecure when I first started studying physics at college".

The field practice program is the most important moment for preservice teachers. It validates their methods and builds their true self-efficacy. Preservice teachers consider the teaching practice stage at school to be a proving ground and a test of their pedagogical beliefs in the field. Preservice teachers find that interactive, technology-based, and contextual methods can be used in learning and influence student learning outcomes. The following is an illustrative quote:

"Students there tend to be unmotivated to study physics, but when I use interactive learning models, they start to get interested... [Do you feel capable of making an impact?] Yes, because I use those media, and it definitely has an impact. Initially, they weren't interested, but now they are more interested in learning physics".

Evidence in this learning method has an impact on the psychology of preservice teachers. This success can directly build the self-efficacy of preservice teachers and reduce anxiety. This means that practice is one of the solutions to the problem of student concept mastery and reduces the influence of poor physics learning experiences in high school. One participant described this idea by saying:

"...but after I applied it in one of my high school classes, teaching practice turned out to be not as bad as I thought it would be during college, and I finally felt confident".

From the interview results, many preservice teachers explicitly stated that the courses that were most helpful in building self-efficacy were practical courses such as microteaching and field practice such as Teaching Assistance (Asjar). Teacher preparation programs can be divided into two parts: learning about physics theory, which often causes content anxiety for preservice teachers, and teaching practice in the field, where preservice teachers' pedagogical beliefs are validated and self-efficacy is ultimately built based on evidence of success. Field practice activities test preservice teachers' beliefs, address their anxiety regarding physics content, and ultimately build genuine self-efficacy.

Emotional Transformation

Most preservice teachers do not start physics lectures with enthusiasm. Preservice teachers have negative emotions inherited from their high school experiences. They tend to dislike and express feelings of dislike and dissatisfaction with physics content. Others reveal that this legacy has an impact on their self-doubt, making them feel incapable and incompetent in understanding physics. These negative emotions are carried by preservice teachers before and during the teacher preparation program. Enthusiasm is not an emotion that preservice teachers have at the beginning of the course. This positive emotion arises conditionally after preservice teachers successfully pass field practice activities. Some preservice teachers feel happy when they see that their teaching methods have made students actively involved in class. One prospective teacher described this feeling by explaining:

"My feelings when teaching physics in the beginning were like feeling anxious... but now I feel excited to teach physics... so now I feel happy when I can teach physics to students".

Enthusiasm for the learning outcomes that have been practiced is one of the factors that increase self-efficacy. This is the peak of emotional transformation. This emotion arises when preservice teachers can see the tangible results of student understanding. One prospective teacher described this by saying:

"The students initially thought physics was difficult and boring, but now they understand several physics concepts. This makes me proud to have changed their minds about physics being fun".

This emotional transformation shows that the field practice program serves as proof and emotional change. This field practice program has made preservice teachers who were initially insecure, hated, and anxious about physics content become enthusiastic. This was also helped by the positive responses from students during the teaching practice.

The purpose of this study was to explore the self-efficacy of Generation Z preservice physics teachers in relation to PCK and DK, as well as preservice teachers' views on lectures in physics education programs. The findings of this study indicate that the relationship between the self-efficacy of Generation Z preservice teachers, PCK, and mastery of physics concepts is complex and fragile. Quantitative analysis reveals that PCK and DK are not statistically correlated with the self-efficacy of Generation Z preservice teachers. Other findings from this study also show that DK and PCK have a significant correlation. The correlation coefficient obtained proves that PCK and DK cannot predict the self-efficacy of Generation Z preservice physics teachers. Although the PCK and DK abilities of Generation Z preservice teachers are heterogeneous, their self-efficacy is very uniform. Based on quantitative evidence, students with high PCK and DK scores do not automatically have high self-efficacy as well.

The qualitative results in this study complement the quantitative results and reveal the complexity of Generation Z preservice teachers' thinking about their teaching practices and their effectiveness in teaching quality physics in their future classrooms. Based on the interview results, it was revealed that preservice teachers began their studies with varying understandings of physics. Some came from positive experiences learning physics in high school, while many others came from negative experiences learning physics in high school. This gap in initial experiences was one of the factors contributing to the wide spread of data. The extreme variability in DK scores (SD 18.61) is most likely a statistical manifestation of this disparity in past experiences. There is a considerable gap between highly competent and incompetent preservice teachers.

The research found that Generation Z preservice teachers had consistent levels of self-efficacy. Their self-efficacy results were based on philosophical beliefs about PCK. They consistently believed that the key to teaching was scientific, contextual learning, not just lectures. Some participants mentioned that incorporating technology into learning was the best way to teach physics. This high and consistent pedagogical belief occurs because Gen Z naturally masters technology, so they feel capable of teaching physics using technology such as games, quizzes, videos, and other learning media even though their DK is low.

The self-efficacy of Generation Z preservice teachers is not a stable belief, but rather a momentary belief that needs to be rebuilt every time they teach. Interestingly, this self-efficacy factor only appears if they have mastered the material. Preservice teachers' self-efficacy is high if they are well prepared with the subject matter to be taught. This explains why someone with low PCK can have high self-efficacy because preservice teachers have prepared the material to be taught in advance. The most important sources of self-efficacy in this study are microteaching and teaching practice in schools. These two activities provide moments where their philosophical beliefs about teaching are validated in the real world. Success in teaching practice in the field has a major influence on teacher self-efficacy. This influence is felt not only by preservice teachers who have high PCK and DK, but also by preservice teachers who have low PCK and DK. Participants generally stated in their interviews the importance of obtaining solid preparation in physics and pedagogical material during the teacher education program in order to be able to teach their students at a higher level. This is in line with research (Lendínez Muñoz et al., 2024) which explains that preservice teachers' self-efficacy can be significantly improved through practical experience. Additional findings from other studies state that practical teaching experience in the real world (in the field) is crucial for honing and strengthening teachers' knowledge of pedagogy and how to teach content (Chang et al., 2025). Strengthening scientific reasoning skills also requires improving content understanding among preservice physics teachers (Arfiani, 2025).

Although PCK and DK are not statistically correlated with the self-efficacy of Generation Z preservice teachers, it should be noted that preservice teachers' self-efficacy is a strong predictor of their efforts and persistence in professional and academic domains. A study shows that self-efficacy is an individual's belief or confidence in their ability to teach concepts related to teaching materials (Nousheen et al., 2024). Recent findings indicate that in order to increase the self-efficacy of preservice teachers in complex teaching tasks, teacher education programs cannot only focus on PCK (Ikeda et al., 2025). These findings support the argument that teachers' PCK may not always have a direct impact on self-efficacy and, in some cases, may not guarantee the quality of PCK in teaching physics in the classroom (Jerrim et al., 2025; Saifuddin et al., 2024). DK is largely the main focus of teacher education programs and professional programs for teachers. Developing teachers' pedagogical knowledge is clearly important, but even more important is developing pedagogical knowledge to equip preservice teachers to teach in schools. Preservice teachers feel that physics material in lectures is very difficult, abstract, and makes some preservice teachers insecure. This shows that the DK taught to preservice teachers needs to focus more on teachers' ability to teach in schools. These findings support the argument that DK does not affect self-efficacy, and in some cases, good quality DK does not necessarily guarantee good self-efficacy (Thomson et al., 2017).

The main implication of this study is that PCK and DK of Generation Z preservice teachers are not dominant factors that can increase self-efficacy. Several factors that influence self-efficacy are philosophical beliefs about the importance of learning reform compared to conventional learning. Teaching preparation strategies and practical teaching practices need to be trained more in the preparation of preservice teachers. Teaching practice has a much greater influence on building the self-efficacy of preservice teachers, especially Generation Z, than relying solely on increasing their knowledge of physics content. In addition, the findings of this study can help policymakers consider the types of support teachers need during and after their four years of college preparation in order to be successful in teaching physics after they enter the teaching profession or continue on to the one-year Teacher Professional Program (PPG). Some limitations of this study are related to demographics. Future research should include support from various regions and disciplines, as well as methods for evaluating teacher preparation programs and the impact of program preparation on teachers' classroom teaching practices.

CONCLUSION

This study found decoupling between self-efficacy beliefs and Pedagogical Content Knowledge (PCK) among Gen Z preservice physics teachers. Quantitative analysis results show that the self-efficacy of Gen Z preservice teachers tends to be homogeneous (highly uniform), while their pedagogical competence is heterogeneous (highly varied). Correlation tests explain that there is no linear and significant relationship between two variables. These findings indicate that self-efficacy of Generation Z preservice physics teachers is not built on a strong mastery of physics and pedagogy. PCK is not a significant predictor of the self-efficacy of Gen Z preservice physics teachers. This can be seen from the low correlation value ($r<0.2$), which shows that the high self-efficacy of preservice teachers cannot be predicted from their high PCK scores. The self-efficacy of Gen Z preservice physics teachers is independent of their DK and PCK. Qualitatively, self-efficacy of Gen Z preservice physics teachers is formed through a process of emotional transformation from their experiences. This study indicates that self-efficacy is a dynamic and conditional construct, which depends on philosophical beliefs about the importance of learning reform, short-term preparation of physics materials before teaching, and validation of the success of technology-based interactive methods during teaching practice at school. The results of study explain why they still have high self-efficacy even though their mastery of physics content and pedagogy varies.

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