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Analysis of Pedagogical Content Knowledge (PCK) Capabilities of Preservice Elementary School Teachers through Science Learning Planning

Analisis Kemampuan Pedagogical Content Knowledge (PCK) Calon Guru SD melalui Perencanaan Pembelajaran IPA

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Abstract
Science material is often abstract, making it difficult for elementary school students to understand. Therefore, teachers need special abilities in designing their learning. So this is a problem for most elementary school teachers. The ability to design science learning in this research is referred to as Pedagogical Content Knowledge (PCK). PCK helps teachers combine in-depth knowledge of subject matter with effective teaching strategies. This allows teachers to deliver material in a way that suits the cognitive development and learning needs of elementary school students. Therefore, this research aims to provide an overview of the PCK abilities of prospective elementary school teachers in designing science lessons. This research is descriptive research which is in line with the research objective, namely to provide an overview of the PCK abilities of prospective elementary school teachers in designing science learning. Participants in this research were 14 students in the fourth semester of the Primary School Teacher Education Study Program (PGSD), Faculty of Teacher Training and Education (FKIP), West Sulawesi University. Data was obtained through a learning design assessment sheet that was oriented towards PCK abilities. Data collection is carried out by asking students to create a learning plan, then the design is assessed using an assessment sheet. The PCK abilities of prospective elementary school teachers are considered varied, where the ability to choose methods is quite good but in terms of mastery and development of teaching materials is still lacking. This is due to the lack of experience of prospective teachers in teaching and the acquisition of science content material only obtained in one course. The implications of this research can be used as a reference for educational curriculum development, especially in elementary school teacher education study programs.
Keywords: Prospective Teachers, Descriptive, Elementary Science, Teacher Competencies, Pedagogical Content Knowledge (PCK)

Abstrak
Materi IPA sering kali bersifat abstrak sehingga sulit dipahami oleh siswa SD. Oleh karena itu, guru memerlukan kemampuan khusus dalam merancang pembelajarannya. Sehingga hal ini menjadi masalah bagi Sebagian besar guru SD. Kemampuan merancang pembelajaran IPA pada penelitian ini disebut sebagai Pedagogical Content Knowledge (PCK). PCK membantu guru menggabungkan pengetahuan mendalam tentang materi pelajaran dengan strategi pengajaran yang efektif. Ini memungkinkan guru untuk menyampaikan materi dengan cara yang sesuai dengan perkembangan kognitif dan kebutuhan belajar siswa SD. Oleh karena itu penelitian ini bertujuan untuk memberikan gambaran bagaimana kemampuan PCK calon guru SD dalam merancang pembelajaran IPA. Penelitian ini merupakan penelitian deskriptif yang sejalan dengan tujuan penelitian yakni memberikan gambaran bagaimana kemampuan PCK calon guru SD dalam merancang pembelajaran IPA. Partisipan pada penelitian ini merupakan mahasiswa semester IV Prodi Pendidikan Guru Sekolah Dasar (PGSD) Fakultas Keguruan dan Ilmu Pendidikan (FKIP) Universitas Sulawesi Barat sejumlah 14 mahasiswa merupakan. Data diperoleh melalui lembar penilaian rancangan pembelajaran yang berorientasi pada kemampuan PCK. Pengambilan data dilakukan dengan meminta mahasiswa untuk membuat sebuah rancangan pembelajaran, kemudian rancangan tersebut dinilai dengan lembar penilaian. Kemampuan PCK calon guru SD dinilai variatif dimana kemampuan memilih metode sudah cukup baik namun dalam hal penguasaan dan pengembangan materi

ajar masih kurang. Hal ini disebabkan karena kurangnya pengalaman calon guru dalam mengajar dan perolehan konten materi IPA hanya didapatkan pada satu mata kuliah. Implikasi dari penelitian ini dapat dijadikan rujukan pengembangan kurikulum Pendidikan khususnya pada program studi pencetak guru SD.
***Kata Kunci**: Calon Guru, Deskriprif, IPA SD, Kompetensi Guru, Pedagogical Content Knowledge (PCK)*

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INTRODUCTION

Science is a branch of knowledge that explains the phenomena of how the universe works and all the components in it (Kurt 2021). Science describes how phenomena occur and the logical reasons behind them (Taruh, Tatura, dan Yusuf 2019). Based on its study review, science is divided into Physics, Chemistry, Biology and Earth and Space Science, although in reality these sciences are interconnected (Handtke dan Bögeholz 2022). In addition, the development of science provides some convenience for society. Many technologies that can currently be enjoyed are products of science itself, especially in the fields of industrial machinery, health, agriculture and others (Gathong dan Chamrat 2019; Pratama, Abdurrahman, dan Jalmo 2018).

The process of discovering technology that helps human work is certainly not obtained in an instant, but through several processes of testing, analysis to the conclusion that the technology is feasible to use (Shana dan Abulibdeh 2020). These processes are referred to as the scientific method. This method is a standardised framework for testing or solving a problem. This method starts from observation, finding and formulating problems, conducting research, analysing data, and reaching a conclusion (Spernes dan Afdal 2023). These steps are used by scientists in conducting research to create various technological innovations that can be enjoyed today.

The products of technology developed by scientists are felt by many parties including students at the elementary school level thus it is important for these students to know how the process or scientific method is carried out (Héctor G. Riveros 2020; Salminawati dan Ningsih 2020). In addition, it is important to instil the instinct to be a scientist in elementary school students so that they get used to looking at and solving problems using scientific methods (Gelir 2022), It can be said that one of the goals or the

nature of science learning in elementary school is to instil the habit of thinking and acting scientifically using the framework previously described (Aisah 2020).

The nature of science learning in elementary school can be achieved if educators or teachers carry out teaching activities that direct students to acquire these abilities (Handono, Nisa, dan Prohatni 2023). Teachers must be able to design science learning with the aim of making students more physically active in class activities and active in thinking in processing the information obtained (Ibourk dan Mathis 2024). Teaching can start by asking students to observe a phenomenon around the school and then asking students to express the results of their observations. This can make students practice observation, which is the first step in the scientific method (Angelia, Supeno, dan Suparti 2022; Prasetyo, Yufiarti, dan Rasmitadila 2022). Furthermore, it depends on how the teacher's creativity in conducting learning in order for students can master the steps or scientific methods that are also adjusted to the level or cognitive level of elementary school students.

The teacher's ability to design learning activities is the key to the success of the learning objectives that have been set. Planning in this case is used as a reference for teachers in carrying out the learning process so that it is right on target (Rokhmawati, Mahmawati, dan Yuswandari 2024). In its implementation, the learning design is adjusted to the intended abilities (Khairunisa, D, dan Qalbi 2022). If the goal is to instil the character of scientific thinking in elementary school students, then the learning that is designed must also be oriented towards achieving these competencies. The teacher's ability to design lessons is also included in one of the teacher's professional competencies called *Pedagogical Content Knowledge* (PCK) (Nasar dan Daud 2020).

PCK was first introduced by Shulman (1987) to emphasise the fundamental role of subject matter in teacher education (research). Although there are various definitions, researchers have identified three important components: content knowledge (CK), pedagogical knowledge (PK) and knowledge related to student understanding.

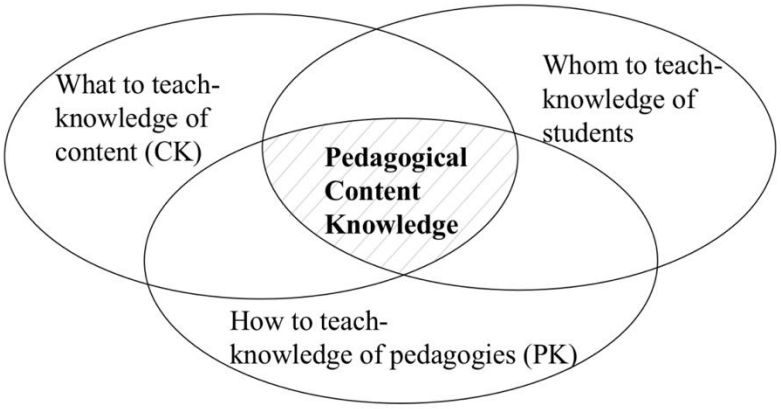

Image 1. Structure of PCK (Zeng, YANG, dan Bautista 2023).

Image 1 illustrates how these three components are interrelated with the construction of PCK. Thus, it can be defined that PCK is a framework for teacher professionalism that combines pedagogical skills and the ability to master the material to be taught (Doyle et al. 2019). In particular, pedagogical skills are the ability of teachers to choose models, methods and approaches to learning that are appropriate to the material and characteristics of the students being taught while still considering the objectives of the learning itself (Yanti, Riandi, dan Suhandi 2020). Meanwhile, the ability to master the material is the teacher's ability to master a topic to be taught. However, the ability to master this material is not absolute that the teacher must master most related to the concept, but rather focus on the teacher's ability to organise the material so that it can be delivered easily. Previous research on PCK was described through an instrument that was filled in by answering various questions. These questions are referred to as *CoRe*, or Content Representation (Akyuz 2018; Mweshi 2019; Yanti dan Rahmadhani 2023). From the series of CoRe questions, it does not show how the teacher's flow in choosing and teaching the material. Based on this, this study used an instrument to assess the lesson plans made by students as research subjects. This was done to obtain an overview of the PCK of prospective elementary school teachers.

Embedding PCK skills for teachers is important to do so that teacher learning is more focused and according to learning objectives. Educational institutions should prepare future teachers to be better prepared to face the challenges of a much more complex educational goal. Therefore, this research aims to provide an overview of how the PCK abilities of prospective elementary school teachers in designing science learning.

RESEARCH METHOD

This research is a descriptive study that is in line with the research objectives to provide an overview of how the PCK abilities of prospective elementary teachers in designing science learning. Descriptive methods do not provide any treatment or manipulation, but describe the conditions as they are (Cresswell dan Clark 2007).

The participants in this study were fourth semester students of the Elementary School Teacher Education Study Programme (PGSD), Faculty of Teacher Training and Education (FKIP), Universitas Sulawesi Barat (University of West Sulawesi), totalling 14 students. The sampling method used was purposive sampling. Purposive sampling is a sampling method with a grid or limit of criteria determined by the researcher. The criteria determined are having programmed the courses 'Basic Concepts of Elementary Science' and 'Elementary Science Education'.

In this study, the materials that were designed were (1) Heat transfer, (2) Introduction to plants, (3) The solar system, and (4) Characteristics of living things. The determination of this topic is done in order for students, as samples in this study, can be compared in their ability to design a science lesson that is appropriate for the elementary level. The results of the design were assessed based on the PCK ability-oriented lesson plan assessment sheet adapted from Nurhidayah (Nurhidayah, Khaidarsyah, dan Prasetyo 2023).

The data in this study were obtained through learning designs that have been made by students. The design was then assessed using an assessment sheet consisting of several aspects as described in table 1.

Table 1. Description of assessed aspects

Assessed Aspects
Create a learning plan
Able to choose effective strategies and effective methods
Able to create concepts that are easier to understand
Able to develop evaluation in learning
Able to master the material
Able to invite students to solve problems in learning

Assessment on each aspect was given a score with a range of 100. To see the percentage of student ability in each aspect in general using the equation:

$$Student\ skill\ percentage = \frac{Total\ score\ in\ one\ aspect}{Total\ of\ students}$$

The discussion in this study surrounded the ability of students in terms of each aspect.

FINDINGS AND DISCUSSION

It is important to instil PCK skills in prospective elementary teachers at this time, considering that this ability cannot be obtained instantly, but through a long process or practice until the prospective teacher is accustomed to designing a lesson (Sari, Madhakomala, dan Yatimah 2021). These PCK skills are a key foundation for prospective teachers to create meaningful and successful learning experiences for their students (Suharto, Nurdin, dan Waluya 2022). This not only impacts academic outcomes but also contributes to students' personal and social development, making them more competent individuals who are ready to face future challenges (Siagian dan Artha 2023). Therefore, it is important for every prospective teacher to continuously develop and hone their PCK skills throughout their professional career.

As previously explained, the purpose of this research is to analyse the PCK ability of prospective elementary teachers in science learning through the learning designs they make. As an initial stage, students were given material related to the types of approaches, models and learning methods as a provision for designing a science lesson. Furthermore, students were asked to make a learning design on a predetermined elementary science topic. These topics were (1) Heat transfer, (2) Introduction to plants, (3) The solar system, (4) Characteristics of living things. Prospective teachers only need to choose one of these topics. Below is a table of the percentage of topics chosen by the prospective teachers to create their lesson plans.

Table 2. Percentage of the selected Science topics

No	Topic	Percentage
1	Heat Transfer	15%
2	Introduction to plants	55%
3	The solar system	5%
4	Characteristics of living things	25%

The results of the selection of science topics made by prospective teachers based on Table 2 look quite evenly distributed. There was only one topic that had a large percentage compared to the others which was ‘Introduction to plants’. Introducing plants to elementary school students is an interesting and important topic because it helps students understand the basics of biology and ecosystems. This material provides a simple overview to students related to flowering and non-flowering plants, then the

process of photosynthesis of plants, and confirms the impact and function of plants in human life (Sahronih dan Dahlia 2021). This can raise students' awareness about the importance of preserving the plants around them.

From the table presented, it can be seen that the topic 'Introduction to Plants' was chosen by 55% of prospective teachers because it was considered easier to teach and relevant to students' daily lives. In addition, according to prospective teachers, teaching this material was more flexible because it can be taught inside or outside the classroom. This was confirmed by research conducted by Anggraini et al., (2023) that plant material for elementary school students can be taught in various ways. The results of the study showed that there are 12 variations of learning media to teach this material. It can be said that one of the things that influences the selection of the learning method used is the character of the material itself.

The second highest percentage after introduction to plants was 'the characteristics of living things.' The reason was the same as the first topic, namely because this topic was also considered to be closely related to students. However, this topic was chosen not as much as the first topic because according to the prospective teachers in teaching this topic there are not too many things that can be explored considering that the characteristics of living things, which are (1) moving, (2) breathing, (3) needing food and water, (4) growing and developing, (5) reproducing, (6) sensitive to stimuli, (7) removing residual substances, (8) having cells as a basic unit, (9) adapting, and (10) experiencing metabolism, are general materials and will be explained in detail in separate material chapters.

Next, the materials with a small percentage are heat transfer and the solar system. Heat transfer material is a material that introduces how heat moves from high temperature objects to low temperature objects. Heat transfer is influenced by the constituent substances of the object that moves the heat. This can be classified into three types of heat transfer; conduction, convection and radiation. Based on the character of the material, not many prospective elementary teachers chose it because it is quite complicated for them to make a learning design from abstract material, and according to them, this material requires a simple practicum that they must design that is suitable for elementary students. Lastly, the solar system material which in this study was the material with the least percentage.

The solar system material is material that explains the collection of celestial bodies consisting of the sun, planets, natural satellites, asteroids, comets, and other celestial bodies that revolve around the sun. According to prospective elementary school teachers, this material is very abstract and difficult to visualise. In addition, there are no facilities in the area to make observations where students can make visits as part of a study tour.

The next process in this research was to make a simple learning design conducted by prospective elementary school teachers. They were given a form containing the chosen topic, approach, model, and method along with the learning steps. Then the form was analysed with the PCK observation sheet and the value was determined quantitatively. In general, the results of the PCK ability of prospective elementary teachers are presented in tables 3 and 4.

Table 3. Observation results of science learning design per participant

Participant	Assessed aspects (%)					
	1	2	3	4	5	6
A	90	88	75	40	40	78
B	90	87	75	40	48	77
C	87	87	70	35	50	77
D	78	75	68	35	45	75
E	78	73	89	53	48	60
F	89	75	89	35	48	63
G	90	75	80	50	60	64
H	90	80	78	50	50	65
I	80	80	70	50	38	79
J	89	80	79	40	40	75
K	89	83	79	40	56	75
L	89	86	87	42	40	88
M	89	86	87	42	40	83
N	89	86	87	42	48	85
Average	87	82	80	42	47	75

Table 4. The results of the observation sheet on the learning design of prospective elementary teachers

Assessed Aspects	Percentage
Create a learning plan	87%
Able to choose effective strategies and effective methods	82%
Able to create concepts that are easier to understand	80%
Able to develop evaluation in learning	42%
Able to master the material	47%

Able to invite students to solve problems in learning	70%

Table 4 shows the percentage of the average number of students' abilities in each aspect. The data shows that all prospective teachers who participated in the study have been able to make lesson plans as evidenced by their ability to choose topics and analyse reasons and make steps in teaching these topics which obtained a percentage of 87%. The data obtained also shows that prospective teachers have varied and unique abilities. This was because the PCK ownership of each individual has different tendencies. Science learning often involves complex concepts. By designing interesting and relevant lessons, prospective teachers can trigger students' curiosity and interest in science. Lesson design can also make prospective teachers think about how to apply or relate science material to students' daily lives. This makes learning more meaningful and easily understood by primary school students.

The ability of prospective teachers in choosing learning strategies reached a percentage of 82%, which indicates that they have been able to link the characteristics of the material with appropriate teaching methods. This could be seen from the variety of learning methods used and the reasons for choosing these methods. This ability was implemented when the prospective teachers chose the topic of recognising plants with the consideration to teach it through outdoor learning so that students could experience the experience of observing plants and directly see the varieties of plants around the students. It can be seen that prospective teachers have been able to analyse the characteristics of the material to be adjusted to the method of delivery.

It is also related to how the concept is conveyed for it to be easier to understand. The lesson design sheet made by prospective teachers also contains steps that make it easier for students to understand the material. This step was completed by prospective student teachers by inserting ice breaking in between lessons with the assumption that students would be more relaxed in class so that the material presented would be easier to understand. In addition to providing ice breaking, there are also those who plan this step by organising the selected sub-materials. If the material is organised well, starting from simple to complex, students will understand more easily. Overall, this aspect obtained a percentage of 80%.

The next PCK component is learning evaluation. This component includes how prospective teachers assess whether the material presented can be understood or not by

students. In this aspect, prospective teachers scored 42%. The results in this section show different things from the two indicators discussed earlier. In the evaluation section, teacher candidates obtained a low percentage, namely 42%. After the lesson plan sheets were traced, almost all prospective teachers chose the written test technique in the evaluation section and without any rational reason. This shows that prospective teachers do not have much understanding of evaluation techniques. This condition is due to the fact that prospective teachers are still at the level of semester IV where they have not programmed courses on evaluation in learning. In general, the pedagogical skills of prospective teachers are already in the sufficient category. Prospective teachers have been able to design learning that is adjusted to the characteristics of the material and the character of the students to be faced.

The next discussion is related to the ability to master the material of prospective teachers or what is referred to as content knowledge with an overall score of 47%. In this study, there was no specific test in seeing the extent of prospective teachers' understanding of the material to be taught, especially on the topics for which learning designs were developed. However, it can be seen from the design made, where researchers analyse the depth and breadth of the material designed. If a material can be developed broadly, ranging from simple material, complex material to its relation to other materials (interdisciplinary), it can be concluded that the prospective teacher has good mastery of the material (Yanti dan Rahmadhani 2023). The real conditions that occur in the field do not show this, prospective teachers are not flexible in breaking down the material. They tend to write material descriptions without providing any material that students must master before learning the material.

The teacher's ability to master the material being taught can be influenced by several factors. Firstly, a lack of in-depth understanding of the material itself. At first glance, teaching is an easy job for most people, but actually, being a teacher requires a strong and deep understanding of the subject being taught. In addition, prospective teachers often face various problems stemming from assignments and loads from other courses. This can interfere with their focus on mastering the material thoroughly. The pre-service teachers who participated in this study have not received adequate training or may not have the necessary skills to teach the material effectively.

Based on this, there are several solutions that can be done to improve students' understanding of the material being taught. Students need to get a comprehensive

education about the basic concepts of science. This includes an understanding of science as a way to understand oneself and the environment. With a strong understanding, they will be more confident in teaching the material to students. Another step that can be taken is to provide opportunities for students to engage in teaching practice, either through classroom simulations or direct experience in the field. This will help them apply the theories they have learnt and understand the challenges they may face when teaching. In addition, students' understanding of elementary science materials can also be improved by teaching students to connect various concepts in science and show their relevance in everyday life. This will help them explain to students why the material being taught is important and how it can be applied.

In this study, the PCK of prospective teachers interprets how to package subject matter in such a way that it can be understood by students in the most effective way. Specifically, this knowledge is divided into several parts:

1. Content Knowledge

Prospective teachers must have a deep and thorough understanding of the subject they teach. This includes facts, concepts, theories and knowledge structures in the field. Prospective teachers also need to know how the material is relevant in a broader context and how to relate it to the knowledge students already have (Kim et al. 2018).

2. Pedagogical Knowledge

Prospective teachers must know various teaching strategies and methods that are effective for different types of materials and classroom situations. This knowledge is also accompanied by skills in managing the classroom, creating a conducive learning environment, and maintaining student attention and engagement (Agustina et al. 2020).

3. Knowledge of Students

Prospective teachers must understand the needs, interests and abilities of their students. This includes understanding the various learning styles and ability levels of students by way of understanding students' cognitive developmental levels in order to customise subject matter and teaching methods (Hill dan Chin 2018).

4. Curricular Knowledge

Prospective teachers must understand the learning objectives and standards to be achieved in accordance with the curriculum. As well as understanding the range of resources and learning materials that can be used to support teaching (Bagherzadeh dan Tajeddin 2021).

5. Assessment Knowledge

Prospective teachers must understand how to design and use various assessment methods to measure student understanding, such as tests, quizzes, projects and observations. This evaluation process also has the ability to provide constructive feedback to help students improve their understanding and skills (Yan, Zhang, dan Fan 2018).

Based on the data obtained in Table 3, all prospective teachers who became research participants were able to make lesson plans as evidenced by their ability to choose topics and analyse the reasons and steps in teaching these topics. The data obtained showed that prospective teachers have varied and unique abilities. This was because the PCK ownership of each individual has different tendencies.

Prospective teachers already have a good ability to choose effective strategies and methods. This can be seen from the variety of learning methods used and the reasons for choosing these methods. This ability is implemented when teacher candidates choose the topic of knowing plants with the consideration to teach it in outdoor learning so that students can experience observing plants and seeing directly the varieties of plants around students. It can be seen that prospective teachers have been able to analyse the characteristics of the material to be adjusted to the method of delivery.

Furthermore, it is related to how the concept is conveyed making it easier to understand. The lesson design sheet made by prospective teachers also contains steps that make it easier for students to understand the material. This step was completed by prospective student teachers by inserting ice breaking in between lessons with the assumption that students would be more relaxed in class so that the material presented would be easier to understand. In addition to providing ice breaking, there are also those who plan this step by organising the selected sub-materials. If the material is organised well, from simple to complex, students will find it easier to understand.

The next component of PCK is learning evaluation. This component involves how prospective teachers assess whether the material presented has been understood by students. The findings in this section differ from the two indicators discussed previously. In the evaluation component, prospective teachers achieved a low percentage. Upon examining their lesson plans, it was found that nearly all prospective teachers opted for written test techniques in the evaluation section without providing rational justification. This indicates that their understanding of evaluation techniques remains limited. This

condition is attributed to the fact that the prospective teachers are still in their fourth semester, where they have not yet undertaken courses on evaluation in learning. Overall, the pedagogical abilities of the prospective teachers are categorized as sufficient. They have demonstrated the ability to design lessons that align with the characteristics of the material and the students they will encounter.

The next discussion focuses on prospective teachers' mastery of subject matter, also referred to as content knowledge. In this study, there was no specific test to assess the extent of their understanding of the material to be taught, particularly on topics addressed in their lesson plans. However, this understanding can be inferred from the lesson plans they created. The researcher analyzed the depth and breadth of the material presented in these plans. If a topic is developed comprehensively, ranging from simple to complex material and including its interdisciplinary connections, this indicates that the prospective teacher has a strong mastery of the subject matter (Yanti dan Rahmadhani 2023). The reality observed in the field suggests a different situation. Prospective teachers are not yet adept at breaking down the subject matter effectively. They tend to write material descriptions without clearly identifying the prerequisite knowledge students need to master before engaging with the new material.

Research on prospective teachers' PCK has been extensively conducted, and the results generally indicate that few prospective teachers possess an ideal level of PCK. As stated by Padila et al., (2017), indicates that prospective teachers' PCK falls into the pre-PCK category, which is equivalent to a sufficient level. Other than that, Saifudin & Sukma, (2019) suggest that prospective teachers with limited classroom teaching experience tend to have lower PCK abilities. This is because PCK development fundamentally progresses in tandem with teaching experience.

The practical implications of this study include its potential contribution as a reference for higher education institutions responsible for preparing prospective elementary school teachers. It emphasizes the need to develop a curriculum that prioritizes the enhancement of prospective teachers' PCK. The findings align with previous research, which consistently shows that the PCK abilities of prospective elementary school teachers remain at a sufficient level.

However, this study has certain limitations. Notably, there was no specific written test conducted on the four science topics discussed, preventing the researchers from assessing the prospective teachers' foundational knowledge of these topics. Additionally,

relying solely on observation sheets without incorporating further steps, such as direct evaluations of teaching practice, weakens the evidence supporting the conclusion that the PCK abilities of prospective elementary school teachers, particularly in science content, are at a sufficient level.

CONCLUSION

Based on the analysis and interpretation of the findings, it can be concluded that the PCK abilities of prospective elementary school teachers fall into the sufficient category. Their PCK abilities vary, with their proficiency in selecting teaching methods being relatively strong, while their mastery and development of instructional materials remain inadequate. This is attributed to the limited teaching experience of prospective teachers and the fact that science content knowledge is acquired through only a single course. The implications of this study serve as a reference for curriculum development, particularly in elementary teacher education programs, emphasizing the importance of incorporating courses that support the enhancement of prospective teachers' PCK.

However, this study has limitations, as the data were derived solely from observation sheets on the science lesson plans of prospective teachers. Future researchers are encouraged to use more representative data, such as comparing lesson plans with actual teaching practices. Subsequent studies could confirm the PCK abilities of prospective teachers not only through lesson plan analysis but also through direct teaching practices supported by complete instructional tools. This approach would provide a comprehensive understanding of their PCK abilities. Further research could also explore the PCK of prospective teachers by comparing the use of specific teaching approaches with alternative approaches to identify more effective methods for teaching elementary science. Additionally, integrating technology is crucial in this digital era and should be considered in future studies to incorporate technological elements into the science lesson planning of prospective elementary school teachers.

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