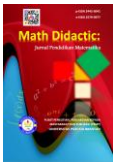

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ANALYSIS OF PEDAGOGICAL CONTENT KNOWLEDGE (PCK) OF UNDERGRADUATE STUDENTS IN MAKING MATHEMATICS TEACHING MODULES USING THE STEAM APPROACH

ANALISIS PEDAGOGICAL CONTENT KNOWLEDGE (PCK) MAHASISWA DALAM PEMBUATAN MODUL AJAR MATEMATIKA MENGGUNAKAN PENDEKATAN STEAM

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Abstract: The purpose of this study is to describe the PCK abilities of undergraduate Mathematics education students who take Micro Teaching courses in the 2023/2024 academic year in the preparation of Mathematics and Science teaching modules using the STEAM approach for junior high school students. The type of research used is descriptive qualitative research. The subjects in this study were 19 undergraduate students at a university in Yogyakarta. The data collection method used was observation of teaching modules made by students. The instrument used is a teaching module assessment sheet. Data analysis techniques used are description or orientation, reduction and selection. The PCK profile obtained in this study is students are able to: (1) curriculum knowledge: design learning in accordance with PBM-STEAM learning syntax, (2) knowledge of learning models: design opening activities and closing activities, (3) knowledge of the material to be taught: design contextual problems that connect Mathematics and Science materials at the junior high school level, and (4) knowledge of students: design guidance questions to help students in solving problems. A novel finding from previous relevant research is that curriculum knowledge is included as an indicator of teaching module completeness.

Keywords: teaching module, PCK, STEAM approach

Abstrak*: Tujuan dari penelitian ini adalah mendeskripsikan kemampuan PCK mahasiswa S1 pendidikan Matematika yang mengikuti mata kuliah Pengajaran Mikro di tahun akademik 2023/2024 dalam penyusunan modul ajar Matematika dan IPA dengan menggunakan pendekatan STEAM untuk siswa SMP. Jenis penelitian yang digunakan adalah penelitian kualitatif deskriptif. Subjek dalam penelitian ini adalah 19 mahasiswa di suatu universitas di Yogyakarta. Metode pengumpulan data yang dipergunakan adalah observasi dari modul ajar yang dibuat mahasiswa. Instrumen yang digunakan berupa lembar penilaian modul ajar. Teknik analisis data yang digunakan yaitu deskripsi atau orientasi, reduksi dan seleksi. Profil PCK yang diperoleh dalam penelitian ini adalah mahasiswa mampu: (1) pengetahuan kurikulum: mendesain pembelajaran sesuai sintak pembelajaran PBM-STEAM, (2) pengetahuan model pembelajaran: mendesain kegiatan pembuka dan kegiatan penutup, (3) pengetahuan materi yang akan diajarkan: mendesain masalah kontekstual yang menghubungkan materi Matematika dan IPA SMP, dan (4) pengetahuan tentang siswa: merancang pertanyaan bimbingan untuk membantu siswa dalam menyelesaikan masalah. Temuan yang menjadi kebaharuan dari penelitian relevan sebelumnya adalah pengetahuan kurikulum dimasukkan sebagai indikator kelengkapan modul ajar.*

Kata Kunci*: modul ajar, PCK, pendekatan STEAM*

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Education is one of the important components in the development of human life. In the education system, one of the components that play an important role in carrying out the education process is the teacher. To carry out their duties as educators and teachers, a teacher must have professional competence. The competencies that must be possessed by a teacher as an educator according to Law No. 14 of 2005 concerning teachers and lecturers, namely: pedagogical competence, personality competence, professional competence and social competence. This is in line with the opinion of Solihin et al. (2021), and Aminah & Wahyuni (2018) who say that a professional teacher must have good pedagogical knowledge and content knowledge. According to Yessi (2020), Maryono (2016) and Wulandari & Iriani (2018), PCK built by teachers has an important role in creating meaningful learning experiences for students taught by the teacher.

Pedagogical knowledge, which is knowledge about how to teach material, and content knowledge, which is knowledge about the learning material to be taught are two integrated and inseparable knowledge (Ayuningtyas & Apriandi, 2019). The combination of pedagogical knowledge and content knowledge builds a knowledge called pedagogical content knowledge (PCK) (Shulman, 1986). Furthermore, according to Magnusson et al. (1999), PCK is knowledge that integrates a teacher's teaching orientation with the teacher's ability to choose effective strategies to deliver subject matter so that it can be easily understood by students. In line with this, Sari et al. (2021) said that PCK is a combination of understanding of subject matter (content knowledge) and ability to teach (pedagogical knowledge). From the three definitions of PCK that have been described above, it can be concluded that Pedagogical Content Knowledge (PCK) is the knowledge possessed by a teacher who integrates knowledge about the material to be taught (content knowledge) with knowledge about how to teach a learning material (pedagogical knowledge) which is used by the teacher to design a lesson that is enjoyable for students, and the material taught can be understood easily by students.

According to Grossman (1990), PCK has three components, namely: (1) subject matter knowledge, which is in-depth knowledge of the content of the material to be taught; (2) general pedagogical knowledge, which is general knowledge of teaching principles, learning strategies, classroom management, interaction with students, and learning evaluation; and (3) knowledge of context, which is: knowledge of the learning context, including knowledge of student characteristics, the school environment, and various other factors that affect the teaching-learning process. The three components form a wedge consisting of four indicators, namely: curriculum knowledge, knowledge of learning materials to be taught, knowledge of learning models, and knowledge of students. Curriculum knowledge is the teacher's knowledge of the content and structure of the curriculum, and the relationship between one topic and another in the curriculum. Knowledge of the learning materials to be taught is the teacher's knowledge of the material, the fundamental reasons behind teaching the material, the relevance of the material to the different levels of development and abilities of the students. Knowledge of learning models is the teacher's knowledge of various learning models that are suitable for the material to be taught, and various learning strategies that can be used to deliver the material effectively and help students understand the material more easily. Knowledge about students is knowledge about how students understand a subject matter, conceptual errors that may be made by students, and ways that can be used by teachers to overcome these misconceptions.

According to Maulida (2022) and Nesri & Kristanto (2020), teaching modules are curriculum-based learning tools that support teachers in designing learning to achieve competency standards

while training students' innovative thinking skills. Teaching modules play an important role as a guide for teachers in delivering material and helping students to understand the material being taught more easily (Sunantri et al., 2016). The use of teaching modules in the learning process makes the teaching and learning process more planned, efficient, effective, and relevant, so that it can make it easier for students to understand the teaching material more optimally (Awaludin et al., 2017). But in reality, there are still teachers who have difficulty in preparing teaching modules (Agusty et al., 2023). In line with this, based on the research results of Setyoningsih & Hariyatmi (2024) revealed that the teacher's shortcomings in pedagogical competence are the inability of teachers to choose and implement learning approaches that are suitable for the material to be taught.

The problem-based learning model is a learning model that provides opportunities for students to solve problems that can develop new knowledge based on the knowledge that students already have (Syamsidah & Suryani, 2018). According to Royani & Saufi (2016), problem-based learning is a learning method that encourages students to understand how to learn and work together in groups to find solutions to problems that have a real-world context. STEAM stands for Science, Technology, Engineering, Art and Mathematics. The STEAM approach is an approach that integrates science, technology, engineering, art and mathematics in a learning process (Nurhikmayati, 2019). According to Katz-Buonincontro (2018), the STEAM approach is an approach that integrates art into the curriculum and learning process in the fields of science, technology, engineering and mathematics. The steps to teach with the Problem-Based Learning model and the STEAM approach are as follows: orient students to the problem, organize students to learn, guide student investigations, develop and present results and analyze and evaluate the problem-solving process (Arends, 2012).

The formulation of the problems that this study will try to answer is as follows: What is the profile of Pedagogical Content Knowledge (PCK) of undergraduate Mathematics education students who take micro teaching courses in the 2023/2024 academic year in preparing Mathematics and Science teaching modules using the STEAM approach for junior high school students?

Research Methods

The type of research used in this study is qualitative research. Qualitative research is used to understand certain phenomena experienced by research subjects, such as behavior, perceptions, motivations, or actions, which are holistically described in the form of words to describe conditions as they are (Fiantika et al., 2022). The stages of qualitative research that will be used are description or orientation, reduction and selection (Sugiyono, 2017). Researchers used qualitative research because the purpose of this study was to describe the PCK profile of each subject in this study. This research was conducted from March to April 2024 in the 2023/2024 academic year.

The subjects in this study were 19 undergraduate students of Mathematics Education at a university in Yogyakarta who attended Micro Teaching class C in the 2023/2024 academic year. The data collection method used is observation of teaching modules that have been made by students. The instrument used in this research is the teaching module assessment observation sheet. Instrument validation in this study used expert validation techniques. In preparing the teaching module observation sheet that will be used to observe the teaching module, the researcher derived and developed the things observed in the teaching module based on the PCK indicators proposed by

Grossman (1990). The observation sheet built by the researcher was used to record the results of the researcher's observations of the teaching module that had been designed by the research subject. The observation sheet used by the researcher consists of: (1) twenty-five indicators were used to observe the teaching module identity section, (2) six indicators were used to observe the learning steps section, and (3) four indicators were used to observe the assessment and reflection section. Details of each indicator can be seen in Table 1.

To analyze the observation data obtained by researchers, researchers will use the stages of qualitative data analysis proposed by Miles & Huberman (1994) which consists of three stages, namely: reducing data, presenting data, and drawing conclusions.

Table 1. Teaching Module Assessment Indicators

No.	Teaching Module Components	Observed Indicators
1.	Teaching module identity	
	Compiler name	The teacher writes the name of the person who compiled the teaching module.
	Agency	The teacher writes down the origin of the compiling agency.
	Year of Compilation	The teacher writes the year the teaching module was prepared.
	School Level	The teacher writes down the school level.
	Subjects	The teacher writes down the subjects.
	Phase/class	The teacher writes down the phase and class taught.
	Semester	The teacher writes odd or even semester.
	Subject matter	The teacher writes down the material to be taught.
	Domain	The teacher writes down the domain of the material to be taught.
	Time Allocation	The teacher writes down the time allocation used in learning in hours.
	Number of Meetings (JP)	The teacher writes down the number of meetings that will be used in learning.
2.	Learning Outcomes	The teacher writes down learning outcomes.
3.	Learning objectives	The teacher writes down the learning objectives that have been formulated according to components A (Audience), B (Behavior), C (Condition) and D (Degree).
4.	Initial competencies	The teacher writes down the initial competencies that students must have.
5.	Starter question	The teacher writes trigger questions that will help students overcome their difficulties in solving the problems given by the teacher.
6.	Pancasila Student Profile	The teacher writes a Pancasila student profile that is appropriate to the learning.
7.	Facilities and infrastructure	
	Learning Resources	The teacher writes down learning resources that will be used as references in learning.
	Instructional Media	The teacher writes the learning media.
	Learning tools and materials	The teacher writes down the tools and materials that will be used in learning.
8.	Learning approaches, models and methods	
	Learning approach	The teacher writes down the approach that will be used in learning.
	Learning model	The teacher writes down the learning model that will be used in learning.
	Learning methods	The teacher writes down the methods that will be used in learning.
9.	Assessment	The teacher writes the assessment that will be used in learning.
10.	Types of assessment	The teacher writes down the types of assessments that will be used in learning.
11.	Target students	The teacher writes down the target students who will be involved in the learning.
12.	Learning steps	
	Introduction	**Orientation:** The teacher writes an opening greeting, asks for news, invites students to pray, checks student attendance, checks the cleanliness of the class and organizes the class so that it is ready to learn.
		Apperception: The teacher relates students' experiences to the material to be learned.

No.	Teaching Module Components	Observed Indicators
		Motivation: The teacher conveys the benefits of learning
		Reference provision: The teacher conveys the objectives of learning. The teacher conveys the learning steps that will be carried out,
	Core	**Problem orientation:** 1. The teacher presents a problem. 2. The teacher gives students the opportunity to understand the problems given by the teacher. 3. The teacher asks students to explain the problem to be solved in their own words.
		Organizing students for learning 1. The teacher provides an explanation regarding the rules for solving problems independently or in groups. 2. The teacher asks students to solve the problems that have been given.
		Guiding student investigations: 1. The teacher identifies any difficulties that students may face. 2. The teacher creates guiding questions and possible student responses to help students solve problems. 3. If students are able to solve the problem in their own way, then the teacher asks the students to clarify their ideas in solving the problem.
		Developing and presenting student work 1. The teacher explains the rules in the presentation process. 2. The teacher asked students to present their work. 3. The teacher asked students who did not make a presentation to respond. 4. The teacher asks students who are presenting to be given the opportunity to respond to students who provide responses to their presentations.
		Analyze and evaluate the problem-solving process 1. The teacher guides students with guiding questions to be able to make conclusions. 2. The teacher confirms the conclusions that have been presented by the students.
	Closing	The teacher will close the lesson by carrying out activities in the form of: 1. The teacher reflects with students on all learning activities. 2. The teacher informs the agenda for the next meeting. 3. The teacher closes the lesson and says closing greetings and provides motivation so that students remain enthusiastic.
13.	Evaluation	The teacher creates an assessment rubric and writes a learning assessment that is in accordance with the GPA.
14.	Enrichment and Remedial	The teacher makes enrichment and remedial questions.
15.	Reflection	Teachers make teacher and student reflections.

Research Results and Discussion

Result

Hypothetical Learning Trajectory (HLT)

The Hypothetical Learning Trajectory (HLT) used to teach junior high school mathematics material is prepared based on the learning steps with the PBM model and STEAM approach. The learning steps carried out in the HLT are as follows: opening learning activities, core activities, and closing learning activities. In the opening activities of learning, the activities carried out are as

follows: opening learning with prayer, preparing the class to be ready to learn, delivering the agenda of activities at this meeting. In the core activities, the activities to be carried out are students compiling teaching modules and discussing the compiled teaching modules. In this activity, there are several things that become the topic of consultation, namely: activities that will be carried out in the learning process, media that will be used in the learning process, and teaching materials that will be built in learning using the STEAM approach and PBM model. In the closing activity, the lesson was closed with greetings and prayers.

Pedagogical Content Knowledge

Based on the teaching module made by subject 1, the PCK profile for subject 1 was obtained as follows: (1) Curriculum knowledge: subject 1 was able to write the learning syntax used, but subject 1 had not completed the module identity and assessment sections; (2) Knowledge of the learning model: subject 1 was able to complete the opening and closing sections, but subject 1 had not been able to complete the learning steps section, namely: guiding student inquiry, and developing and presenting student work; (3) Knowledge of the material to be taught: subject 1 was able to present contextual problems, but had not been able to review the knowledge related to the problem; and (4) Knowledge of students: subject 1 was able to write questions regarding students' understanding of the problem, and guidance questions to solve the problem, but had not been able to write down possible variations of student answers, and difficulties faced by students.

Based on the teaching module created by subject 2, the PCK profile for subject 2 was obtained as follows: (1) Curriculum knowledge: subject 2 was able to write the learning syntax, but subject 2 was not able to complete the module identity and assessment sections; (2) Knowledge of the learning model: subject 2 was able to complete the closing section, but was not able to complete the opening section, namely the apperception activity section and learning steps, especially in the section guiding student investigations, developing and presenting student work, and analyzing and evaluating the problem solving process; (3) Knowledge of the material to be taught: subject 2 was able to present contextual problems, but had not been able to review the prerequisite material, and possible student answers; and (4) Knowledge of students: subject 2 had not written questions to explore students' understanding of the problem, possible variations in student answers, and difficulties faced by students.

Based on the teaching module made by subject 3, the PCK profile for subject 3 was obtained as follows: (1) Curriculum knowledge: able to write learning syntax. However, subject 3 has not completed the module identity and assessment sections; (2) Knowledge of learning models: subject 3 is able to complete the opening and closing sections, but has not been able to complete the learning steps section, namely: (3) Knowledge of the material to be taught: the subject was able to present contextual problems, and make review material and possible student answers; and (4) Knowledge of students: subject 3 was able to write questions regarding students' understanding of the problem, and possible variations in student answers and difficulties faced by students.

Based on the teaching module created by subject 4, the PCK profile for subject 4 was obtained as follows: (1) Curriculum knowledge: subject 4 was able to write the learning and assessment syntax, but subject 4 had not completed the module identity section; (2) Learning model knowledge: subject

4 was able to complete the opening and closing sections, but had not been able to complete the learning steps section, namely: (3) Knowledge of the material to be taught: subject 4 was able to present contextual problems, and make review materials, but was not able to possible student answers; and (4) Knowledge of students: subject 4 was able to write questions regarding students' understanding of the problem, possible variations in student answers, and difficulties faced by students.

Based on the teaching module created by subject 5, the PCK profile for subject 5 was obtained as follows: (1) Curriculum knowledge: subject 5 is able to write the learning syntax, but subject 5 has not been able to complete the module identity and assessment sections; (2) Knowledge of learning models: subject 5 is able to complete the closing section, but has not been able to complete the opening section, namely: the apperception section, and the learning steps, namely: (3) Knowledge of the material to be taught: subject 5 was able to present contextual problems, but had not been able to create review material and possible student answers; and (4) Knowledge of students: subject 5 had not written questions regarding students' understanding of the problem, possible variations in student answers, and difficulties faced by students.

Based on the teaching module made by subject 6, the PCK profile for subject 6 was obtained as follows: (1) Curriculum knowledge: subject 6 is able to write learning syntax and assessments, but subject 6 has not been able to complete the module identity and assessment sections; (2) Knowledge of learning models: subject 6 is able to complete the opening and closing sections, but has not been able to complete the learning steps section, namely in the section guiding student investigations, developing and presenting student work, and analyzing and evaluating the problem solving process; (3) Knowledge of the material to be taught: subject 6 was able to present contextual problems and make review materials, but not yet able to possible student answers; and (4) Knowledge of students: subject 6 had not written questions regarding students' understanding of the problem, possible variations in student answers, and difficulties faced by students.

Based on the teaching module created by subject 7, the PCK profile for subject 7 was obtained as follows: (1) Curriculum knowledge: subject 7 was able to write the learning syntax, and assessment, but subject 7 was not able to complete the module identity section; (2) Learning model knowledge: subject 7 was able to complete the opening and closing sections, but was not able to complete the learning steps section, namely: (3) Knowledge of the material to be taught: subject 7 was able to present contextual problems, and make review material, but was not able to write down possible student answers; and (4) Knowledge of students: subject 7 was able to write down questions regarding students' understanding of the problem, possible variations in student answers, and difficulties faced by students.

Based on the teaching module created by subject 8, the PCK profile for subject 8 was obtained as follows: (1) Curriculum knowledge: subject 8 was able to write the assessment, but subject 8 was not able to complete the module identity section and learning syntax; (2) Knowledge of learning models: subject 8 was able to complete the closing section, but was not able to complete the opening section in the motivation section and learning steps, namely: (3) Knowledge of the material to be taught: subject 8 was able to present contextual problems, and make review materials, but had not been able to write down possible student answers; and (4) Knowledge of students: subject 8 was able

to write down questions regarding students' understanding of the problem, but had not written down possible variations of student answers, and difficulties faced by students.

Based on the teaching module created by subject 9, the PCK profile for subject 9 was obtained as follows: (1) Curriculum knowledge: subject 9 was able to write the assessment, but subject 9 had not completed the module identity section and learning syntax; (2) Knowledge of learning models: subject 9 was able to complete the closing section, but had not been able to complete the opening section in the apperception motivation section and learning steps, namely: (3) Knowledge of the material to be taught: subject 9 was able to present contextual problems, but subject 9 had not been able to write down possible student answers, and make review material; and (4) Knowledge of students: subject 9 was able to write down questions regarding students' understanding of the problem but had not written down possible variations of student answers, and difficulties faced by students.

Based on the teaching module made by subject 10, the PCK profile for subject 10 was obtained as follows: (1) Curriculum knowledge: subject 10 was able to complete the module identity, learning steps, and assessments; (2) Knowledge of learning models: subject 10 was able to complete the closing section, but had not been able to complete the opening section in the apperception motivation section and learning steps, namely: (3) Knowledge of the material to be taught: subject 10 was able to present contextual problems, and make review materials, but was not able to write down possible student answers; and (4) Knowledge of students: subject 10 was not able to write down questions regarding students' understanding of the problem, write down possible variations of student answers, and difficulties faced by students.

Based on the teaching module made by subject 11, the PCK profile for subject 11 was obtained as follows: (1) Curriculum knowledge: subject 11 was able to write the learning syntax, but subject 11 was not able to complete the module identity section, and assessment; (2) Knowledge of the learning model: subject 11 was able to complete the opening and closing sections, but was not able to complete the learning steps section, namely: (3) Knowledge of the material to be taught: subject 11 was able to present contextual problems, but was not able to make review material, and possible student answers; and (4) Knowledge of students: subject 11 was able to write questions regarding students' understanding of the problem and guidance questions, but was not able to write possible variations of student answers, and difficulties faced by students.

Based on the teaching module created by subject 12, the PCK profile for subject 12 was obtained as follows: (1) Curriculum knowledge: subject 12 is able to write the learning syntax, but subject 12 has not been able to complete the module identity section, and assessment; (2) Learning model knowledge: subject 12 is able to complete the opening and closing sections but has not been able to complete the learning steps section, namely: (3) Knowledge of the material to be taught: subject 12 was able to present contextual problems, and make review material, but not yet able to possible student answers; and (4) Knowledge of students: subject 12 was able to write guidance questions, but not yet able to write questions regarding students' understanding of the problem, write possible variations of student answers, and difficulties faced by students.

Based on the teaching module created by subject 13, the PCK profile for subject 13 was obtained as follows: (1) Knowledge of the curriculum: subject 13 was able to write the learning syntax, but subject 13 had not been able to complete the module identity section, and assessment; (2) Knowledge of the learning model: subject 13 had not been able to complete the opening, core, and

closing sections as a whole; (3) Knowledge of the material to be taught: subject 13 was able to present contextual problems, and make review materials, but had not been able to possible student answers; and (4) Knowledge of students: subject 13 was able to write guidance questions, but had not been able to write questions regarding students' understanding of the problem, write possible variations of student answers, and difficulties faced by students.

Based on the teaching module created by subject 14, the PCK profile for subject 14 was obtained as follows: (1) Curriculum knowledge: subject 14 was able to write the learning syntax, but subject 14 had not completed the module identity section, and assessment; (2) Learning model knowledge: subject 14 was able to complete the opening and closing sections, but had not been able to complete the learning steps section, namely: problem orientation, guiding student investigation, developing and presenting student work, and analyzing and evaluating the problem-solving process; (3) Knowledge of the material to be taught: subject 14 was able to present contextual problems, but subject 14 had not been able to write possible student answers, and make review material; and (4) Knowledge of students: subject 14 was able to write guidance questions, but subject 14 had not been able to write questions regarding students' understanding of the problem, write possible variations of student answers, and difficulties faced by students.

Based on the teaching module made by subject 15, the PCK profile for subject 15 was obtained as follows: (1) Curriculum knowledge: subject 15 was able to write the learning syntax, and assessment, but subject 15 had not completed the module identity section; (2) Learning model knowledge: subject 15 was able to complete the opening section, but had not been able to complete the learning steps section, namely: in the problem orientation section, developing and presenting student work, and analyzing and evaluating the problem solving process, as well as in the closing section, namely: not reflecting; (3) Knowledge of the material to be taught: subject 15 was able to present contextual problems, and make review materials, but subject 15 was not able to write possible student answers; and (4) Knowledge of students: subject 15 was able to write guidance questions, questions regarding students' understanding of the problem, write possible variations of student answers, but subject 15 was not able to write the difficulties faced by students.

Based on the teaching module made by subject 16, the PCK profile for subject 16 was obtained as follows: (1) Curriculum knowledge: subject 16 was able to write the learning and assessment syntax, but subject 16 had not completed the module identity section; (2) Learning model knowledge: subject 16 was able to complete the closing section, but subject 16 had not been able to complete the opening section, namely: apperception and learning steps, namely: guiding student investigations, developing and presenting student work, and analyzing and evaluating the problem-solving process; (3) Knowledge of the material to be taught: subject 16 was able to present contextual problems, but subject 16 was not able to write down possible student answers, and make review material; and (4) Knowledge of students: subject 16 was able to write guidance questions and questions regarding students' understanding of the problem, but subject 16 was not able to write down possible variations of student answers, and difficulties faced by students.

Based on the teaching module made by subject 17, the PCK profile for subject 17 was obtained as follows: (1) Curriculum knowledge: subject 17 was able to write the learning syntax, and assessment, but subject 17 had not completed the module identity section; (2) Learning model knowledge: subject 17 was able to complete the closing and opening sections, but subject 17 had not

been able to complete the learning steps, namely: (3) Knowledge of the material to be taught: subject 17 was able to present contextual problems, write down one of the possible student answers, and make review material; and (4) Knowledge of students: subject 17 was able to write down guidance questions, and questions regarding students' understanding of the problem and possible variations in student answers, but was not able to write down the difficulties faced by students.

Based on the teaching module created by subject 18, the PCK profile for subject 18 was obtained as follows: (1) Curriculum knowledge: subject 18 was able to write the learning syntax, and assessment, but subject 18 had not completed the module identity section; (2) Knowledge of learning models: subject 18 was able to complete the closing section, but had not been able to complete the opening section, namely: apperception and learning steps, namely: in the problem orientation section, developing and presenting student work, and analyzing and evaluating the problem solving process; (3) Knowledge of the material to be taught: subject 18 was able to present contextual problems, but subject 18 had not been able to write down possible student answers, and make review material; and (4) Knowledge of students: subject 18 was able to write guidance questions, but subject 18 had not been able to write questions regarding students' understanding of the problem, possible variations in student answers, and difficulties faced by students.

Based on the teaching module made by subject 19, the PCK profile for subject 19 was obtained as follows: (1) Curriculum knowledge: subject 19 was able to write the learning syntax, but subject 19 had not completed the module identity section, and assessment; (2) Learning model knowledge: subject 19 was able to complete the opening and closing sections, but subject 19 had not been able to complete the learning steps section, namely: (3) Knowledge of the material to be taught: subject 19 is able to present contextual problems, and make review material, but subject 19 has not been able to write down possible student answers; and (4) Knowledge of students: subject 19 is able to write guidance questions, and questions regarding student understanding of the problem, but the subject has not been able to write down possible variations in student answers and difficulties faced by students.

Based on the results of observations of teaching modules from 19 subjects, it can be concluded that (1) for curriculum knowledge, students have been able to write learning syntax well, but have not been able to complete the module identity and assessment completely; (2) for knowledge of learning models, 12 students have been able to complete the opening section, and 17 students have been able to complete the closing section, but all students have not been able to complete the learning steps at the stage of guiding student investigations, presenting and developing work results, and analyzing and evaluating the problem solving process; (3) For knowledge of the material to be taught, all students have been able to design contextual problems that integrate Mathematics and Science knowledge, but students have not been able to compile review material related to prerequisite knowledge, and write down possible student answers in solving the problem; (4) For knowledge of the learning model, 12 students have been able to complete the opening section, and 17 students have been able to complete the closing section.

Discussion

This study aims to describe the Pedagogical Content Knowledge (PCK) profile of mathematics education students in preparing teaching modules based on the STEAM approach. This approach is considered effective to prepare students with the abilities needed to live in the 21st century, namely critical thinking, creativity, and problem-solving skills. STEAM integrates science, technology, engineering, art, and mathematics in one learning unit, so that students can connect theory with real-world applications (Mu'minah, 2021; Rarastika et al., 2025; Rilianti et al., 2023).

Based on the research results for curriculum knowledge, all subjects were able to compile learning syntax according to curriculum standards, but some had not completed the module identity and assessment. In the teaching module identity, several parts that have not been able to be written completely, namely: overview of the teaching module, learning objectives, and learning outcomes. Furthermore, in the assessment section, the parts that have not been able to be written completely, namely: the type of the assessment was used in their lesson, the rubric of their assessment, and reflection questions. This indicates that students' understanding of curriculum implementation still needs to be improved. According to Rahayu et al. (2023), understanding the curriculum is important because the curriculum is designed with various elements that support the learning process to take place optimally and effectively. One important part that teachers must be able to write in the teaching module is learning outcomes. This is because Learning Outcomes (CP) are competencies that students must achieve at each stage of development, with the teacher acting as a translator of material in accordance with the CP in the Merdeka Curriculum (Tusyanah et al., 2024). Furthermore, assessment in learning has the main role or function of evaluating the extent to which students achieve predetermined learning objectives (Arta, 2024). From this, it can be seen the importance of choosing the right assessment in learning.

For learning model knowledge, 11 subjects were able to design opening activities, and 17 students were able to design learning closing activities. In the activities in the opening section, students were able to write orientation activities, apperception, providing benefits and learning references. For activities in the closing section, students are able to write things that are done to close the learning, such as reflection, prayer and closing greetings. However, students have not been able to complete the PBM-STEAM learning steps. PBM-STEAM learning steps that have not been able to be completed by students are in steps (1) guiding student investigations, students have not been able to write guidance questions to help students during the discussion process; (2) developing and presenting student work, students have not been able to write how to select presentation groups and strategies used if there are groups that have different answers; and (3) analyzing and evaluating the problem solving process, students have not written guidance questions used to draw conclusions with students. In the process of guiding student investigations and drawing conclusions, it is important to have guidance questions which are usually in the form of sparking questions because sparking questions can be used to stimulate students in developing logical thinking skills (Lestari et al., 2024).

For the knowledge part of the material to be taught, all students were able to present relevant contextual problems. All students can present contextual problems that connect Mathematics and Science materials, but students have not been able to compile review materials, and write down possible student answers. In the review material, students have not completed the review material to be used in learning, such as: students have not written review material for one of the lessons, do not write review questions, and how the material review process will be carried out. In the learning

process, providing review material is one of the activities in the apperception stage. Apperception in learning has an important role to determine the extent of students' readiness to receive lessons (Saidah et al., 2021). In line with this, according to Mushawwir & Umar (2014), in general, the function of apperception in learning is to connect the experience or knowledge that students already have with the new material to be learned, making it easier for them to understand new lessons by making previous lessons a basis or stepping stone. Furthermore, in the possibility of student answers, students have not been able to write possible answers that can be made by students in the teaching module. In the process of preparing teaching modules, teachers also need to predict student answers as well as errors and difficulties that students may face in working on practice questions in order to more easily overcome obstacles that arise during the learning process (Selvianiresa, 2017).

In the aspect of knowledge about students, the subject has been able to compile relevant guidance questions. Students have been able to write guidance questions during the step of guiding investigation and understanding of the problem, but students have not been able to write down the variations of students' answers and difficulties. In the variation of student answers, the subject has not written down the answers that students are able to make during learning, especially in the steps of guiding student investigations and analyzing and evaluating the problem-solving process. This also happens in the student difficulties section; the subject has not been able to write down the difficulties that students can experience when learning. Understanding student characteristics is very important in creating meaningful and effective learning (Sutomo & Aini, 2024). In addition, a teacher needs to understand the problems experienced by students, because learning difficulties can hinder students in receiving the subject matter presented (Husein, 2020).

Conclusions and Suggestions

Conclusions

This study reveals that Mathematics Education students have varying PCK profiles in preparing teaching modules based on the STEAM approach, and PBM learning models. In general, for curriculum knowledge, subjects have been able to write learning syntax, but students have not been able to complete the identity of teaching modules and assessments. This is because the subject has not been able to write the module overview section, learning objectives, and learning outcomes completely. In the knowledge part of the learning model, in general, the subject is able to write the closing and opening parts of learning, but has not been able to in the learning steps section, because students have not been able to complete the steps of guiding student investigations, developing and presenting student work, and analyzing and evaluating the problem-solving process. In the knowledge of the material to be taught, in general, students are able to present contextual problems but students have not been able to compile review material, and write possible student answers because students have not been able to write completely review material, review questions, and do not write possible answers that can be made by students. In knowledge about students, in general, students are able to write down student understanding questions, but have not been able to write down the variety of answers and difficulties that students may face, because students have not written down the variety

of answers that students can make, and have not written down the possible difficulties faced by students.

Suggestions

Based on the above explanation, the researcher provides the following suggestions to researchers who will conduct further research: (1) students are invited in advance to explore and understand the structure of the teaching module in accordance with the applicable curriculum, (2) students are given sufficient experience in formulating learning objectives that are in accordance with the learning outcomes to be achieved in the learning process they design, (3) students need to be asked to read mathematics reference books that are in accordance with the material to be designed by students, and (4) students need to be trained in writing possible answers or variations of answers to problems given by the teacher, and writing possible difficulties experienced by students when solving these problems, and writing guidance questions that are able to overcome these students' difficulties.

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