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PCK Profile of Mathematics Education Students in Practicing the Flipped Classroom Strategy

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Abstract: This research aims to determine the planning and implementation of the flipped classroom strategy in teaching compound probability material and determine the PCK profile of Mathematics Education students in practicing the flipped classroom strategy for teaching material at the high school level. The type of research used in this research is design research and qualitative research. The data analysis technique used in this research consists of three stages, namely: data reduction, data presentation, and drawing conclusions. Based on the results of the analysis carried out, it was found that: HLT for teaching high school level mathematics material using the flipped classroom strategy consists of four phases, namely: pre-phase, namely the researcher provides information related to the activities to be carried out; independent learning phase, namely the researcher provides a learning video regarding material on the probability of multiple events; synchronous learning phase, namely the researcher provides quizzes and practice questions for discussion; and the transfer phase, namely the researcher provides a project in the form of creating teaching modules to carry out learning practices; Undergraduate students' PCK in teaching high school mathematics material uses the flipped classroom strategy, namely 33.3% of students have PCK in the high category because they are able to fulfill some of the PCK categories. Then, the percentage of students who have PCK in the medium category is 53.3% and 13.3% of students have PCK in the low category.

Keywords: PCK, HLT, strategy flipped classroom

Abstrak: Penelitian ini bertujuan untuk mengetahui perencanaan dan pengimplementasian strategi flipped classroom dalam membelajarkan materi peluang kejadian majemuk serta mengetahui profil PCK mahasiswa Pendidikan Matematika dalam mempraktekan strategi flipped classroom untuk membelajarkan suatu materi ditingkat SMA. Jenis penelitian yang digunakan dalam penelitian ini yaitu penelitian desain dan penelitian kualitatif. Teknik analisis data yang digunakan dalam penelitian ini terdiri dari tiga tahap yaitu: reduksi data, penyajian data, dan penarikan kesimpulan. Berdasarkan hasil analisis yang dilakukan diperoleh bahwa: HLT untuk membelajarkan materi matematika tingkat SMA menggunakan strategi flipped classroom terdiri dari empat fase yaitu: pra fase yaitu peneliti memberikan informasi terkait kegiatan yang akan dilakukan; fase belajar mandiri yaitu peneliti memberikan video pembelajaran mengenai materi peluang kejadian majemuk; fase pembelajaran sinkronus yaitu peneliti memberikan kuis dan latihan soal untuk diskusi; dan fase transfer yaitu peneliti memberikan proyek berupa membuat modul ajar untuk melakukan praktik pembelajaran; PCK mahasiswa S1 dalam membelajarkan matematika materi SMA menggunakan strategi flipped classroom yaitu sebanyak 33,3% mahasiswa memiliki PCK dalam kategori tinggi karena mereka mampu memenuhi sebagian kategori dari PCK. Kemudian, persentase mahasiswa yang memiliki PCK dalam kategori sedang sebanyak 53,3% dan 13,3% mahasiswa memiliki PCK dalam kategori rendah.

Kata kunci: PCK, HLT, strategi flipped classroom

▪ INTRODUCTION

Education is very important for the life of every individual, meaning that every individual in Indonesia has the right to get an education. One aspect that affects the role of education today is the quality of educators. The better the quality of educators, the better the quality of education. Therefore, the role of educators is very important in the world of education. This is in line with the opinion of Ariana (2017) who said that teachers as educators are one of the elements that are quite important in the world of education. This is also in line with the opinion of Schleicher (2011) who says that the quality of teachers affects the quality of the education system. Based on the results of research conducted by Peterson et al. (2015) shows that prospective teachers consider their role important as civic educators.

According to a report on global school rankings from the OECD Director of Education, Indonesia is ranked 69th out of 76 countries (Coughlan, 2015). The low ranking of Indonesia's global schools shows that the role of educators is still relatively weak. Therefore, the government still needs to develop an education system that can produce professional educators to improve the quality of education in Indonesia. To become a professional teacher, it is necessary to have certain competencies that can support their performance. This is supported by the opinion of Riswadi (2019) who said that teaching is a profession that must be supported by sufficient competence.

Based on Law No.14 of 2005 concerning teachers and lecturers, it is explained in paragraph 10 that a teacher must have four competencies, namely: pedagogical competence, personality competence, social competence, and professional competence. According to Damawati (2015), the four competencies above are related to the dominant knowledge component of Pedagogical Content Knowledge (PCK). PCK is a combination of content knowledge or teaching material with pedagogical knowledge possessed by an educator when teaching (Setiawan et al., 2018). According to Loughran et al. (2012) PCK is the knowledge possessed by a teacher who presents a learning situation that helps students to understand the content of science. This is in line with the opinion of Shulman (1986) who said that PCK is a special knowledge owned by a teacher related to how to teach certain material/content to students by using strategies that can lead students to understand certain material/content. In PCK there are two core aspects, namely: knowledge related to the conceptions and misconceptions experienced by students towards learning materials; and knowledge related to learning strategies and representations in certain courses (Park & Oliver, 2008; Ball et al., 2008). Thus, PCK is very important for a professional teacher because professional teachers are the main factor in improving the quality of education. In addition, according to Olfos et al. (2014) and Wilson et al. (2002), to be a successful mathematics teacher, one must have a strong foundation in pedagogical content knowledge.

Based on the results of observations made by researchers through videos of student learning practices in class D micro courses in the 2021/2022 academic year, the PCK skills possessed by students in planning and practicing learning using the flipped classroom strategy still have to be improved because there are several problems faced by students as practitioners, namely: Practitioners have not fully developed 21st century skills in practicing their learning, the questions given by practitioners have mostly not developed high-level skills (HOTS) and the connection between one problem and another in each phase when viewed from low and high level skills has not been well established;

practitioners have not linked the material being discussed during learning with other relevant knowledge; practitioners have not explored the difficulties experienced by students because practitioners tend to immediately give the correct answer; and practitioners have not explored information that students understand after delivering a material.

Based on research conducted by Anindita (2018) in one of the private high schools in Yogyakarta on the topic of derivatives using the Discovery Based Learning strategy, it was found that the PCK skills of teachers still need to be improved because there are still PCK indicators that have not been met. Then the research conducted by Widyastuti (2019) related to the PCK profile of mathematics teachers in one of the private junior high schools in Sukabumi on the topic of quadrilateral using the Problem Based Learning learning model, and the research results obtained that the teacher's PCK ability was quite good because it was able to fulfill almost all PCK indicators. In addition, from research conducted by Sulistyarini (2020) related to the PCK profile of prospective mathematics teachers who conducted PLP-KP in one of the private high schools in Yogyakarta on mathematical induction material using the Discovery Learning learning model, it was found that the PCK skills possessed by prospective teachers needed to be improved again because they had not fulfilled some PCK indicators. From these three studies, it can be concluded that all three examined the PCK profile of mathematics teachers and prospective teachers. However, these three studies have not examined the PCK profile using the flipped classroom strategy.

According to Bishop & Verleger (2013), flipped classroom is a learning strategy that is divided into two parts, namely interactive learning conducted in the classroom and computer-based learning conducted outside the classroom. According to Farida et al. (2019), flipped classroom is a learning strategy in which students study learning modules through a video at home or before coming to class, whereas learning activities in the classroom use more discussion between teachers and students. According to Young et al. (2014) flipped classroom is an exchange of the process of delivering synchronous material/content that is usually done in class with lectures and then giving assignments related to math problems that are done by students at home. This is in line with Herreid & Schiller (2013) who said that the principle in the flipped classroom learning strategy is a learning strategy where things that are usually homework such as problem exercises and problem solving are better done in class, while listening to lectures or watching learning videos that are usually obtained at school are better done by students at home. One of the benefits of the flipped classroom strategy is that it can increase interaction between teachers and students, but it needs careful planning and implementation in order to support effective learning (Moffett, 2015). According to Samarraie et al. (2019) the utilization of flipped classroom can improve student engagement, performance, student understanding, student achievement, and other learning outcomes. The flipped classroom strategy is divided into four phases, namely: pre-phase, self-learning phase, synchronous learning phase, and transfer phase (Tolks et al., 2020).

Based on the problems that the author got through observations and previous research conducted by Anindita (2018), Widyastuti (2019), Sulistyarini (2020), the researcher will conduct research to answer the following questions: how to plan and implement a flipped classroom strategy in teaching compound event probability for Mathematics Education students who take Micro Teaching C class courses in the

2022/2023 academic year, and what is the pedagogical content knowledge (PCK) profile of Mathematics Education students who take Micro Teaching C class courses in the 2022/2023 academic year in designing and practicing flipped classroom learning strategies to teach a material at the high school level.

▪ **METHOD**

Participants

The participants in this study were undergraduate students of Mathematics Education who attended class C Micro Teaching lectures in the 2022/2023 academic year with a total of 15 students, Sanata Dharma University Yogyakarta.

Research Design and Procedures

This type of research is design research and qualitative research. Design research is a research method that aims to develop HLT that occurs between researchers and educators or teachers to improve quality and meaningful learning (Gravemeijer & Eerde, 2009). There are three stages in design research according to Gravemeijer & Paul (2006), namely: preliminary design, design experiment, and retrospective analysis. In addition to using the type of design research, researchers also use qualitative research. Qualitative research is research that has the aim of understanding a phenomenon that is deepened by the subject in the study, for example motivation, behavior, perception, action, etc. holistically which can be done by describing in the form of language/words against a certain natural context and compiled by utilizing various kinds of scientific methods (Moleong, 2007). In this study, design research was used to build HLT which was used to build students' PCK about flipped classroom strategy. In addition, researchers also used qualitative research to describe the PCK of undergraduate mathematics education students who attended Micro Teaching class C lectures in building a concept on material at the high school level using a flipped classroom strategy. This research was conducted in September 2022 - October 2023 and the research was conducted at Sanata Dharma University in the 2022/2023 academic year.

Instrument

The instruments used in this research are observation guidelines and interview guidelines. The validity of the instrument used in this study is expert validation. In this study, observation guidelines were used to observe the practices carried out by each practitioner/student in the pre-phase, self-learning phase, synchronous learning phase, and transfer phase. Then, the interview guidelines were used by researchers to find out more about the results of observations and explore information about PCK that had not been seen when carrying out learning practices.

The observation and interview guidelines prepared by the researcher refer to the PCK indicators compiled by (Chick et al., 2006) and then developed by the researcher which are adjusted to each phase of the flipped classroom strategy. The pre-phase is represented by one PCK indicator, the self-learning phase is represented by six PCK indicators, the synchronous learning phase is represented by six PCK indicators, and the transfer phase is represented by one PCK indicator. For more details, see below:

Table 1. Pre phase pck indicator

PCK Category	Description
Learning strategies	Explains the flipped classroom strategy for teaching material at the high school level

Table 2. PCK indicator for independent learning phase

PCK Category	Description
Appropriateness and detail when presenting concepts	Provide illustrations or descriptions, as well as teaching aids that are in accordance with the concepts related to the material presented
Resource related knowledge	Using various resources, such as technology and books that can support learning
Material knowledge objectives	Convey the goals and benefits of learning
Deep understanding of the fundamentals of mathematics	Demonstrate an in-depth understanding of mathematical concepts related to the material presented by the practitioner
Deconstructing content as the main component	Demonstrates the basic components that are important in learning a particular concept
Mathematical structures and connections	Link the material presented by the practitioner with other relevant knowledge

Table 3. Synchronous learning phase pck indicator

PCK Category	Description
Student thinking	Shows students' way of thinking by providing feedback, student misunderstandings, student understanding, and difficulties students face with a mathematical concept
Knowledge of curriculum	Demonstrates an effort to carry out learning involving the Pancasila Student Profile
Procedural related knowledge	Describe procedures and demonstrate skills in solving mathematical problems
Methods for solving problems	Demonstrate the methods used to solve problems
Capture and maintain student focus	Shows efforts to use strategies to involve students in the learning process
Class technique	Demonstrate classroom management techniques for implementing methods so as to create a conducive atmosphere

Table 4. Transfer phase pck indicator

PCK Category	Description
Cognitive task demands	Identifying the continuity and complexity of tasks given in the form of a project that can be reviewed from Bloom's taxonomy

Data analysis

According to Bimerdin (2022) data analysis can be interpreted as an effort in selecting, sorting, discarding, then classifying data used to answer a main problem. This is in line with the opinion of (Nasir & Sukmawati, 2023) who say that data analysis is a process of organizing by sorting data in various patterns, categories, and units so that it

can find themes and can formulate hypotheses. In this study, the data analysis technique used according to Miles & Huberman (1984) consists of three stages of data analysis, namely: data reduction, data presentation, and conclusion drawing.

In the data reduction stage, what was done was to make observations on each phase of learning by using the flipped classroom strategy. After making observations, the next step is to determine group boundaries by summing up the scores obtained based on PCK indicators and determining the average (mean) and standard deviation; and determining the boundaries of each group Arikunto (2010). To determine the scores obtained based on PCK indicators, a semantic differential measurement scale was adapted. This scale is usually used to measure certain attitudes or characteristics that a person has (Alatas et al., 2018). Based on the results of observations made by researchers on the learning practice process, it was found that a score of 3 had the perception that PCK indicators were visible and optimal, a score of 2 had the perception that PCK indicators were visible but not optimal, and a score of 1 had the perception that PCK indicators were not visible.

PCK indicator scores are determined in each phase, namely the pre-phase, self-learning phase, synchronous learning phase, and transfer phase. The following are the details: the pre-phase has 1 indicator, so the maximum score is 3; the self-learning phase has 6 indicators, so the maximum score is 18; the synchronous learning phase has 6 indicators, so the maximum score is 18; and the transfer phase has 1 indicator, so the maximum score is 3. In this study, there are 3 grouping criteria, namely: high group, where the PCK score owned by the subject is greater than equal to the mean plus standard deviation; medium group, where the PCK score owned by the subject is less than the mean plus standard deviation and the PCK score is more than equal to the mean minus standard deviation; and low group, where the PCK score owned by the subject is less than equal to the mean minus standard deviation.

Table 5. Group criteria

Group Criteria	Limit
High	$X \geq \bar{X} + SD$
Medium	$\bar{X} - SD < X < \bar{X} + SD$
Low	$X < \bar{X} - SD$

After determining the group criteria, the next step was to conduct interviews. The interviews used in this study were unstructured interviews because the interview guidelines were only used as an outline. Interviews can be conducted by taking several subjects from each group.

The next stage is data presentation. Data presentation is a collection of various information so that it allows conclusions to be drawn and actions taken (Rijali, 2018). In this study, the presentation of data will be formed by narratives obtained from the data reduction process.

The next stage is conclusion drawing and verification. Conclusions are descriptions related to the description of an object that was previously unclear and after research becomes clearer. Meanwhile, verification is an effort to search, recheck, patterns, flows, explanations, regularities. In this study, researchers will verify the data by checking the results of the analysis using videos and recordings. After the data has been verified, the results of the analysis can be used as a benchmark in drawing a conclusion.

▪ RESULT AND DISSCUSSION

Hypothetical Learning Trajectory (HLT)

Hypothetical Learning Trajectory (HLT) used to teach high school level mathematics material using the flipped classroom strategy is arranged based on the phases of the flipped classroom strategy, namely as follows: Pre-phase, in this phase the researcher provides information regarding learning techniques and some information regarding the learning that will be carried out through WAG; Independent learning phase, in this phase the researcher provides a learning video related to the material on the probability of multiple events and at the end of the video the researcher gives a quiz to find out the extent of students' understanding regarding the material; Synchronous learning phase, in this phase the researcher and students carry out a review of the material in the learning video. Then, the researcher gave practice questions that students had to work on in groups. Then, ask group representatives to present the results of their work in front of the class and the researcher provides a re-explanation regarding the students' answers. Then, invite students to conclude and reflect on today's learning; and Transfer Phase, in this phase the researcher provides a project in the form of compiling teaching modules for practice III using the flipped classroom strategy.

Pedagogical Content Knowledge (PCK)

Based on the results of data analysis conducted by researchers regarding the pedagogical content knowledge (PCK) profile of undergraduate students in mathematics education in the Micro Teaching course class C for the 2022/2023 academic year in designing and practicing a flipped classroom strategy for teaching material at the high school level, it is shown in the table below:

Table 6. Student pck profile

No	PCK Category	Frequency	Percentage
1	Learning strategies	5	33.3%
2	Appropriateness and detail when presenting concepts	8	53.3%
3	Resource related knowledge	6	40%
4	Material knowledge objectives	14	93.3%
5	Deep understanding of the fundamentals of mathematics	11	73.3%
6	Deconstructing content as the main component	15	100%
7	Mathematical structures and connections	6	40%
8	Student thinking	12	80%
9	Knowledge of curriculum	12	80%
10	Procedural related knowledge	11	73.3%
11	Methods for solving problems	8	53.3%
12	Capture and maintain student focus	12	80%
13	Class technique	15	100%
14	Cognitive task demands	12	80%

The table above shows that the PCK category related to deconstructing content as the main component and classroom techniques is very good. It can be seen that all students are able to show the existence of deconstructing content as the main component seen in the learning video in the self-study phase by providing explanations, practice questions, and quizzes. In addition, all students were also able to show that there are techniques used to learn the material by using the flipped classroom learning strategy. Meanwhile, 5 students were able to explain the learning strategy using the flipped classroom well and the rest had explained the flipped classroom strategy in teaching high school material but it was not seen optimally. According to Sanjani (2021), learning strategies are important and not inferior to other learning components. This is in line with the opinion of Deekens et al. (2017) who say that the learning strategies used by teachers are important in learning. So it is necessary to understand the strategies used by students in carrying out learning practices because learning strategies can determine student learning achievement. This is in line with Sumar & Razak (2016) who say that the learning strategies used by teachers determine student success in learning.

Table 7. Group criteria

Group Criteria	Number of Students	Percentage
High	5	33.3%
Medium	8	53.3%
Low	2	13.3%

Then, based on the results of calculations using the mean and standard deviation, it was found that 33.3% of students had PCK in the high category because they were able to fulfill some of the categories of PCK. Based on the results of the interview, the student was able to explain how to provide illustrations/images to learn the material, the student was able to explain in detail how he explored students' difficulties by providing support questions to solve problems, the student was also able to explain how he designed sustainable tasks/problems in terms of Bloom's taxonomy. These things are important for a teacher to have in learning. This is in line with Krauss et al. (2008) who said that there are three dimensions of PCK that are important in learning mathematics, namely: (1) teachers' knowledge related to mathematics tasks/problems; (2) teachers' knowledge related to difficulties and misconceptions experienced by students; and (3) teachers' knowledge related to how to provide representations, analogies, illustrations or examples in teaching mathematics material. According to Park & Oliver (2008), teachers' knowledge related to students' misconceptions also plays an important role in shaping PCK.

Then, the percentage of students who have PCK in the moderate category is 53.3%. Based on the results of interviews with several students, they have not been able to explain how to relate the material taught with other knowledge that is relevant because according to him the material presented is difficult to connect with other knowledge and difficult to represent/provide illustrations before learning the material. According to him, the material presented is new material that he learned when he was in high school and the sources he obtained were also still limited. Thus, they lack mastery of the material to be taught to students. According to Driel et al. (1998) said that when someone teaches a new

topic they have difficulty in representing the right material. In addition, it is also important for teachers to master the material to be taught so that students can understand the material well. This is in line with the opinion of Hlas & Hildebrandt (2010) who said that a teacher needs to master the topic to be taught before delivering it to students and it is also necessary to ensure the accuracy of the facts and the clarity of the content of the lesson to be delivered.

Then, the percentage of students who have PCK in the low category is 13.3%. Based on an interview that the researcher conducted with one of the students, it was found that he had explained the learning strategy that would be used but it was less visible during the learning process. The selection of learning strategies that are in accordance with the learning material and mastery of good learning theories/concepts means that PCK skills are also good (Ningsih et al., 2020). In addition, students have not been able to explore misconceptions experienced by students because students tend to immediately give the correct answer without exploring the knowledge possessed by students first. According to Metz (2018), exploring the knowledge possessed by students is important because it helps teachers identify misconceptions and correct these misconceptions proactively. It is important for teachers or prospective teachers to know the errors that students make and form appropriate teaching strategies to address errors in mathematics teaching (Şahin et al., 2016). If the misconceptions experienced by students are left unchecked, then they will experience misconceptions continuously. This is in line with the opinion of Soylyu & Solyu (2005) who said that students who experience misconceptions will encounter problems in learning mathematics in subsequent periods if their learning difficulties and errors are not eliminated by the teacher. Misunderstandings experienced by students will be easily recognized when a teacher masters the material and concepts (Driel et al., 1998).

▪ **CONCLUSION**

Based on the results and discussion regarding the PCK profile of undergraduate students in Mathematics Education in the Micro Teaching class C academic year 2022/2023 in designing and practicing the Flipped Classroom strategy for teaching material at the high school level, it can be concluded that: (1) HLT is structured based on the phases of the flipped strategy The class consists of four phases, (a) pre-phase, namely the researcher provides information related to the activities to be carried out, (b) independent learning phase, namely the researcher provides a learning video regarding material on the probability of compound events, (c) synchronous learning phase, namely the researcher gives a quiz and practice questions for discussion, and (d) transfer phase, namely the researcher provides a project in the form of creating an open module to carry out learning practice on material at the high school level; (2) The PCK possessed by students is as follows: students are able to explain the purpose and benefits of studying the material, students are able to demonstrate the existence of deconstructing content as the main component seen in the independent learning phase and synchronous learning phase, students are able to explore students' thinking by providing written tests and supporting questions that can help students who experience difficulties in solving problems, students are able to develop a Pancasila student profile in the learning practices carried out, students are able to show how to take and maintain student focus by reprimanding students who are noisy and involving students in the process In learning, students are able to direct the techniques used to study the material using the flipped class

learning strategy, and students are able to design sustainable assignments/problems in terms of Bloom's taxonomy.

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