Implementation Of Pedagogical Content Knowledge Model In Mathematics Learning For High School

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Abstract. The purpose of this study was to analyze the creative aspects of the implementation of Pedagogical Content Knowledge (PCK) model in mathematics learning in high school. The research method used was a qualitative method. Data collections used communication, interview, documentation, and test. The research was done in high school in Purworejo Regency. PCK model integrated student plan, learning module, and student worksheet as a tool in learning mathematics. Characteristics of learning tools adapted to PCK theory containing components 1) Knowledge of Curriculum for Mathematics, 2) Knowledge of Instructional Strategies for Mathematics, 3) Knowledge of Student Understanding in Mathematics, and 4) Knowledge Assessment for Mathematics. The result showed that the PCK model was able to develop students' creativity components included fluency, flexibility, elaboration, and originality. A degree of student creativity was at a good level with percentage score is 80.6%. Pedagogical Content Knowledge (PCK) model applied comprehensively was capable of developing students' creative thinking skills more optimally.

1. Introduction

In mathematics learning, students are trained to do mathematical calculations compared to being educated for creative thinking. This must be corrected for better results in mathematics learning. PCK (Pedagogical Content Knowledge) can be implemented to construct learning by improving the quality of mathematics learning for finding the best solution to develop or achieve students' creative thinking skills (Jhon K. Lannin) [1]. Lack of creative thinking skills in solving problems can result in not achieving learning goals. For that reason, mathematics teachers should use learning approaches that lead to the level of creative thinking. Understanding student characteristics are one component in PCK. Loughran proposes definition of PCK et al. [2] [3] which stated that PCK is "a teacher's knowledge in providing situations to help learners understand the content of science". similar thing was also expressed by Etkina [4] stated the primary foundation that can be used as the basis for a teacher's knowledge is Content Knowledge (CK), Pedagogical Knowledge (PK), and PCK.

Shulman [5] [6] proposed three types of content that teachers must possess for effective teaching which is Subject Matter Content Knowledge, Curriculum Knowledge, and Pedagogical Content Knowledge or PCK. The results of Shulman and his colleagues' research showed that pedagogical content knowledge is the main determinant of the teacher's success in learning. Pedagogical Content Knowledge was a manifestation of content knowledge and pedagogical knowledge. Sigit Saptono et al. [7] Pedagogical Content Knowledge (PCK) is a thinking concept for understanding that to teach science is not only understand science material content (knowing science) but also how to teach.
From learning process perspective, pedagogic competence is teacher ability in student learning management. The teacher should implement in national education. Based on National Education Act of Indonesia, pedagogical skill is the ability to manage student learning including an understanding of students, learning design and implementation, evaluation of learning outcomes, and student development to actualize the variety of potential they have.

In product design of the mathematics-learning model by John K. Lanin, it showed four components namely Knowledge of Curriculum for Mathematics, Knowledge of Student Understanding within Mathematics, Knowledge of Instructional Strategies for Mathematics, and Knowledge of Assessment for Mathematics. The main products of PCK model are learning plan, module, media, and tool that contain PCK approach. These characteristics are operationalized in the form of learning strategies oriented to cooperative learning based on guided inquiry.

2. Research methods
The research used a qualitative method [8] and was carried out in high school students in Purworejo Regency who belong to eleventh grade and MPA (Math and Science) class. This research was conducted from April to May 2018 school. Available learning tools are the plan, modules, and media integrated to PCK model. Sampling in this research used literature study, observation, interviews, documentation, and tests. The test method used in this study was a test of creative thinking skills in solving mathematical problems in the sequence of numbers. The test material aimed to know aspects of students’ creative thinking skills from after PCK model implementation. Norfishah [9] stated that to analysis of student learning test results was based on creativity components such as fluency, flexibility, elaboration, and originality. Fluency is an ability to produce ideas correctly; flexibility is the ability to produce diverse ideas; elaboration is the ability to develop an idea alongside detail implementation; and originality the ability to produce unusual or rare ideas.

3. Results and discussion
3.1 PCK model design
The PCK model with four knowledge of curriculum for mathematics characteristics, knowledge of student understanding within mathematics, knowledge of instructional strategies for mathematics, and knowledge of assessment for mathematics are operationalized in the form of learning strategies oriented to cooperative learning based on guided inquiry.

![Figure 1. Design of the PCK model in high school mathematics learning](image-url)
to organize, strategies or methods of learning mathematics in class. Both characteristics suit principles of Cooperative Learning [10]. Features of Knowledge of Student Understanding within Mathematics explores students' beliefs in finding a concept and solving mathematical problems while the Knowledge of Assessment for Mathematics measures student learning outcomes, these two characteristics are in line with the Guided Inquiry principle [11]. Thus, from the four characteristics of PCK, they can be operated using Cooperative Learning and Guided Inquiry methods, which integrated into high school mathematics learning in the form of the lesson plan, module, and student worksheet [12].

### 3.2 Implantation:

Research implemented a trial for learning media that had been compiled. It was conducted to classroom consists of 31 students. Each received learning module and worksheet that integrated PCK model to develop creative thinking skills. After that, students were given the test to evaluate the learning outcome.

The purpose of this study was to analyze aspects of students' creative thinking skills from the results of the implementation of Pedagogical Content Knowledge (PCK) model. Related to this, content in student worksheet and module to develop creative thinking skills contained the characteristics of the PCK model (John K. Laniin) Knowledge of Curriculum for Mathematics, Knowledge of Student Understanding within Mathematics, Knowledge of Instructional Strategies for Mathematics, Knowledge of Assessment for Mathematics. Thus, the learning strategy encouraged the student to work in a group or individual that aims to facilitate students in interacting with the material provided. Modules and worksheets were prepared using the principles of the discovery of concepts and solving mathematical problems [13].

Questions could require students to find their ideas in problem-solving that aims to develop creative thinking skills. The learning strategy is to support the learning objectives of mathematics and can organize mathematics learning in the classroom better.

Analysis of the learning outcome test was carried out based on guidelines for scoring tests of creative thinking skills. Guidelines for scoring tests of creative thinking skills can be seen in Table 1 [9, 14].

**Table 1. Scoring guidelines for creative thinking skills tests**

| Aspect       | Score | Criteria                                                                 |
|--------------|-------|---------------------------------------------------------------------------|
| (Fluency)    | 1     | Write a number pattern.                                                   |
|              | 2     | Determine first term, second term, and the ratio.                         |
| (Flexibility)| 1     | Provides answers using only one method and there are errors in the calculation process where the results are wrong. |
|              | 2     | Give answer with one-way calculation process and the results are correct. |
|              | 3     | Give answers in more than one way (variety) but the results are wrong because there are errors in the calculation process. |
|              | 4     | Give answers in more than one-way calculation process and the results are correct. |
| (Originality)| 1     | Using a strategy or providing a common explanation in terms of concepts and their relationships and the context involved or giving explanations that are also offered by more than 20% of students. |
|              | 2     | Use strategies or provide common explanations or provide explanations that are also given by 10% - 20% of students. |
|              | 3     | Use strategies or provide common explanations or provide explanations that are also given by less than 10% of students. Note: explanations that students might give are related to other ways to solve problem. |
| (Elaboration)| 1     | There is a mistake in determining third term number and arithmetic series without details. |
|              | 2     | There is a mistake in determining third term number and arithmetic series with |
Extend process for determining third term number and arithmetic series correctly with less detail.

Expand the process of determining third term number and arithmetic series correctly with much detail.

Maximum score 13

Results of student work related to creative think skills can be seen in the following figures.

Figure 2. Student work that shows fluency aspect
Figure 2 shows that students can write down what they know from the problem correctly. Students write number patterns and look for values of $x_1 \cdot x_2$ and $x_1 + x_2$. From these results, it can be seen that students already understand the problem solving and this ability can be said as fluency.

Figure 3. Results of student work that shows flexibility (flexibility)
Figure 3 shows that students can work on a problem in two different ways with similar results, which is 36. Therefore, the student has the flexibility aspect of solving problems.

Figure 4. Student work that shows elaboration characteristic.
The results of the students’ work in Figure 4 show that students write down steps in problem-solving precisely. This indicates that students are capable to overcome problems with elaboration skills.
Figure 5. Student work that shows originality

Figure 5 shows that students use strategies or provide a common explanation that are given by less than 20% of other students. Explanations that students give are related to other methods to find a number for an nth term or $U_3$.

Thus, these students develop creative thinking skills in working on learning outcomes test for number sequence topic. Percentage of learning outcomes can be seen in the following Table 2.

| Table 2. Results of creative thinking skills tests |
|--------------------------------------------------|
| Test Results (KKM = 75) | Many Students | Percentage (%) |
|-------------------------|---------------|----------------|
| Students complete       | 25            | 80.6           |
| Students do not complete| 6             | 19.4           |
| Number                  | 31            | 100            |

The percentage of completeness is 80.6%. Based on the guidelines for the completeness of the learning outcomes that have been developed, the student activity sheets are declared effective because a score is passed more than 60%. This is like the research conducted by Siska Puti [15] that the learning model that has been developed can improve students' process skills.

4. Conclusion

Based on the results and discussion, it was concluded that creative thinking skills were good. This is indicated by the percentage of completeness of learning outcomes is 80.6%. Results of this study contributed to teaching practice improvement in high schools in Purworejo Regency, particularly eleventh-grade student. PCK implementation included fluency, flexibility, elaboration, and originality had developed creativity thinking skill in student to be good category based on completeness score. Therefore, PCK model that is given comprehensively can improve students' creative thinking skills more optimally [15].

5. References

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