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THE PEDAGOGICAL CONTENT KNOWLEDGE DIMENSIONS OF MATHEMATICS TEACHER IN MATHEMATICS MODELING LEARNING

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Abstract

This study aims to explain the dimensions of pedagogical content knowledge of mathematics teachers in learning mathematical modeling. Four dimensions of teacher pedagogical content knowledge for mathematical modeling: (1) Dimension of mathematical modeling theory, (2) Dimension of cognitive, (3) Dimension of learning, and (4) dimension of evaluation. The data collection is observation and interview. Based on the basic assumptions about the impact of teaching on learning, teacher competence will result in quality teaching and quality student learning. Therefore, all of dimensions should be included as mandatory components in teacher education and professional development.

Keywords: pedagogical content knowledge, mathematical modeling, four dimension

Abstrak

Penelitian ini bertujuan untuk menjelaskan dimensi pedagogical content knowledge guru matematika dalam pembelajaran pemodelan matematika. Empat dimensi pengetahuan konten pedagogis guru untuk pemodelan matematika: (1) Dimensi teori pemodelan matematika, (2) Dimensi kognitif, (3) Dimensi pembelajaran, dan (4) dimensi evaluasi. Pengumpulan data adalah observasi dan wawancara. Berdasarkan asumsi dasar tentang dampak pengajaran terhadap pembelajaran, kompetensi guru akan menghasilkan pengajaran yang berkualitas dan pembelajaran siswa yang berkualitas. Oleh karena itu, semua dimensi harus dimasukkan sebagai komponen wajib dalam pendidikan dan pengembangan profesional guru.

Kata kunci: pengetahuan konten pedagogis, pemodelan matematika, empat dimensi

INTRODUCTION

Mathematical modeling is the result of a theoretical study where this approach focuses on learning mathematics by using the context of real-world phenomena so that the use of mathematics can be used to describe a process of understanding, simplifying, and solving problems in the form of mathematical modeling for deeper understanding interactions (Ang, 2016; Blum & Ferri 2009 ; COPAM & SIAM, 2019). The application of mathematics learning cannot be separated from the use of models and the modeling process (Bahmaei, 2011). Especially on math problems that require students to be actively involved in discussion groups about real world phenomena or "realistic contexts", the resulting impact of course students must be good at using the process of generating models so that they can access the real world in mathematical form (Kurniadi, 2019). Blum, et al (2011) say that real-world problems based on phenomena and life activities are inseparable from the process of mathematical modeling,

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especially for students, without them realizing that sometimes they have made connections between mathematics and the real world. The modeling process carried out by students is a bridge for them to construct mathematical problems with real world life. Blum and Niss (2001), stated that the use of mathematical modeling is to help students understand the world in more detail, to motivate mathematics learning in the form of simple motivation, concepts, formations, or the ability to understand a real-world problem, to make students more likely to contribute to the development of various kinds of learning. mathematical competence and the right mindset, and make it easier for students to sketch mathematics between the real world and mathematics (Ebby, 2000; Camberlin & Coxbill, 2012).

The teacher's role is very important to be able to produce quality mathematics learning with a mathematical modeling approach (Eric, 2015). However, based on the results of the study concluded that there are still few teachers who use the mathematical modeling approach in their students' learning activities in the classroom (Freudenthal 1973; Pollak 1979; DeLange 1987; Burkhardt 2004; Ikeda 2007). This is due to the low competence of teachers' mathematical knowledge to develop appropriate task ideas and learning activities, and even, the low confidence of teachers to be able to carry out more open mathematics learning and complex assessments in the learning approach of mathematical modeling. Therefore, it is important to conduct research that examines the dimensions of the pedagogical content knowledge of mathematics teachers both at the level of elementary school and middle school. Based on Borromeo Ferri and Blum (2010), there are 4 dimensions of pedagogical content knowledge of mathematics teachers in mathematical modeling. The four things that will be studied in this study are 1) Dimensions of mathematical modeling theory, 2) Dimensions of student cognitive activity, 3) Dimensions of learning and 4) Dimensions of assessment.

The problem in this study is "How are the results of exploring the dimensions of pedagogical content knowledge of mathematics teachers in learning mathematical modeling in elementary and middle schools?". This exploring dimension refers to the trajectory is expected to be a guide for teachers to be able to improve mathematical modeling competencies and increase teacher confidence in implementing mathematical modeling learning. In the end, mathematics teachers who implement mathematics learning using a

quality mathematical modeling approach will produce students who have mathematical modeling competencies so that they can compete in the global world.

METHODS

This study aims to produce an exploratory study through a design that includes learning trajectories to increase the dimensions of pedagogical content knowledge of mathematics teachers in learning mathematical modeling in elementary and secondary schools. This trajectory is expected to be a guide for teachers to be able to improve mathematical modeling competencies and increase teacher confidence in implementing mathematical modeling learning. The research method used in this research is educational design research. Design-based research in learning is not just one approach but is a series of approaches, with the aim of producing new theories, evidence, and practices that explain and have the potential to influence learning and teaching in a naturalistic setting. The subjects in this study were 4 elementary school teachers and 4 middle school teachers in Palembang.

In one cycle of learning design research has three stages, namely preliminary design, experiment and retrospective analysis (Gravemeijer & Cobb, 2006).

1. Preliminary design

At this early stage, at this stage, material studies, literature reviews, studies of various relevant research results, preparing research instruments, determining research subjects, preparing and constructing a Hypothetical Learning Trajectory (HLT) which serves as a guide in designing learning guides. HLT contains the objectives and activities of learning in mathematical modeling courses. The following HLT has been developed in the early stages of learning design which refers to the 4 dimensions of pedagogical content knowledge in mathematical modeling :

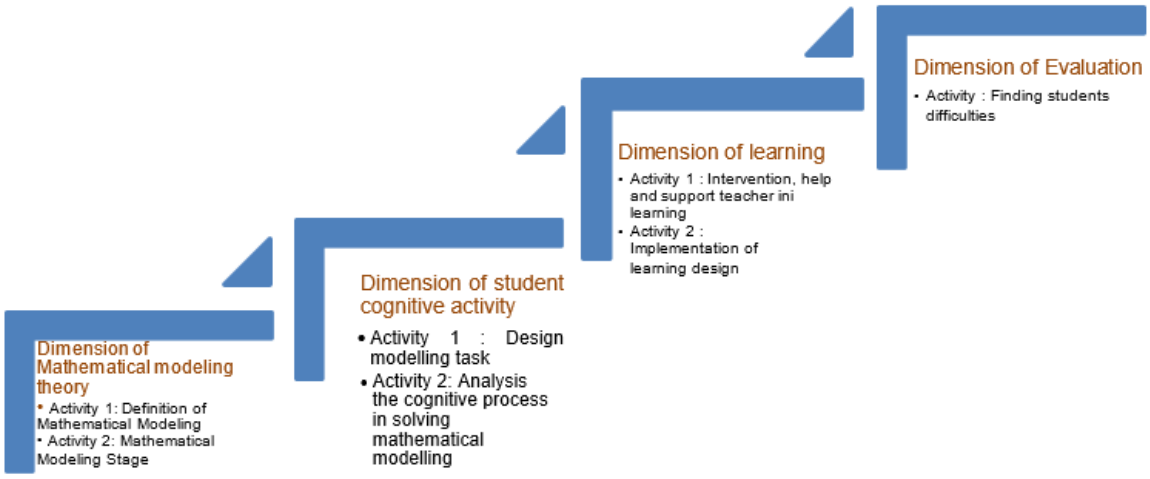

Figure 1. Hypothetical Learning Trajectory

2. Experiment

In the experimental stage, the HLT that has been designed will be tested on research subjects. This trial will see whether the things in the preliminary design are in accordance with reality or not. Things that happen during the experimental phase will be an improvement or modification of the HLT design. The function of HLT in this stage is to focus on research activities, learning processes and observations.

3. Retrospective Analysis

At this stage, all data obtained from the experimental stage will be analyzed. The analysis process is between components in the HLT before learning and after learning, followed by an analysis of possible causes according to the previous theory, and a synthesis of improvements/modifications of the HLT design that will be used for the next cycle. The data collection of this research are:

a. Observation

Observation is used to assess behavior or the process of occurrence of an activity that can be observed. Observation is used to see the cognitive perspective of prospective mathematics teachers during the course of mathematical modeling based on problem development.

b. Interview

Interviews are used as a data collection techniqueThe interview used in this research is an unstructured interview. Interviews were conducted face to face with the aim of knowing the cognitive perspective of prospective mathematics teachers in the subject of mathematical modeling based on problem development.

RESULTS AND DISCUSSION

Dimension of mathematical modeling theory

There were two activities namely design modeling task and. In this activity, we discussed about teacher perception in mathematical modeling theory. As we know that mathematical modeling is related to the real world problem and using the phenomena to learn more about mathematics. We interviewed the subject research asking their experience about using real world problem and phenomena nowadays in teaching mathematics

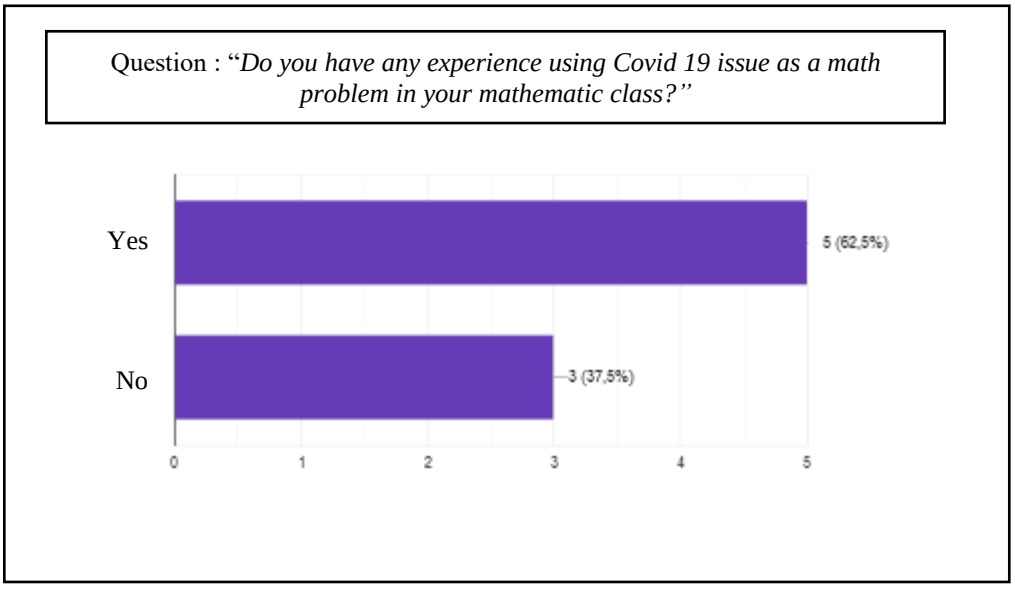

Figure 2. Covid 19 issue in mathematics class

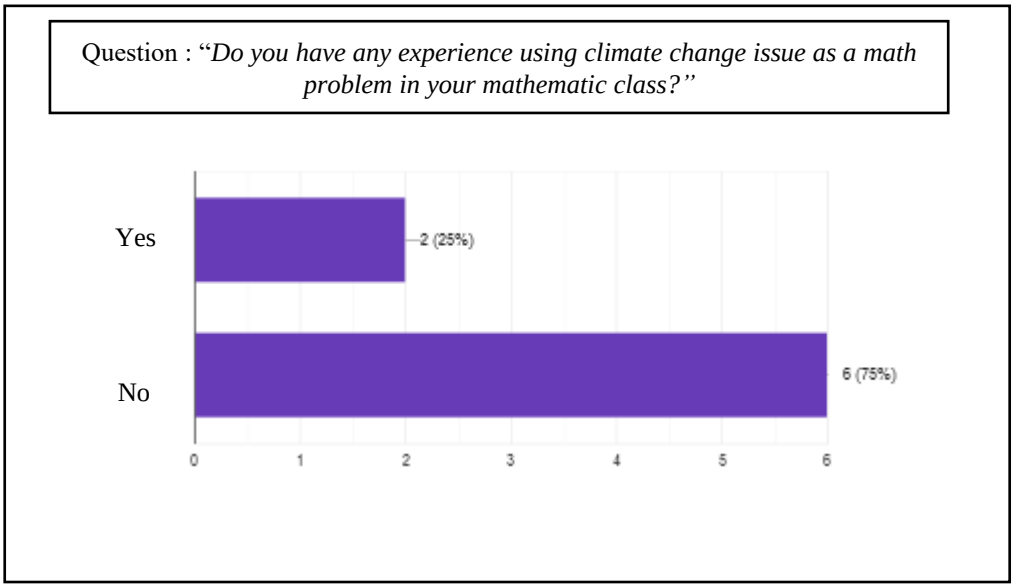

Figure 3. Climate change issue in mathematics class

According to those figures we can see that subject research have interest to use Covid 19 issue in their class but they have less interest for climate change issue. In mathematical modeling, real world problem can generate a rich conceptual understanding (Kaiser, Schwarz, & Tiedemann, 2010).To recognize and assess progress pedagogical content knowledge, a teacher needs rich conceptual understanding of specific subject content they teach. Rich conceptual understanding that combined with expertise in using the teaching procedures, strategies and approach, for use in a class, creating a blend of content knowledge and knowledge pedagogy (Schimdt, et al, 2007).

Dimension of students cognitive

There were two activities namely definition of mathematical modeling and analysis of students cognitive in solving mathematical modeling. In this activity, we discussed about teacher perception about students cognitive in mathematical modeling. As we know that mathematical modeling process is from understanding the real world problem, using mathematics to solve the problem and interpretation the solution. We interviewed the subject research asking how mathematical modeling process influence the progress of students cognitive.

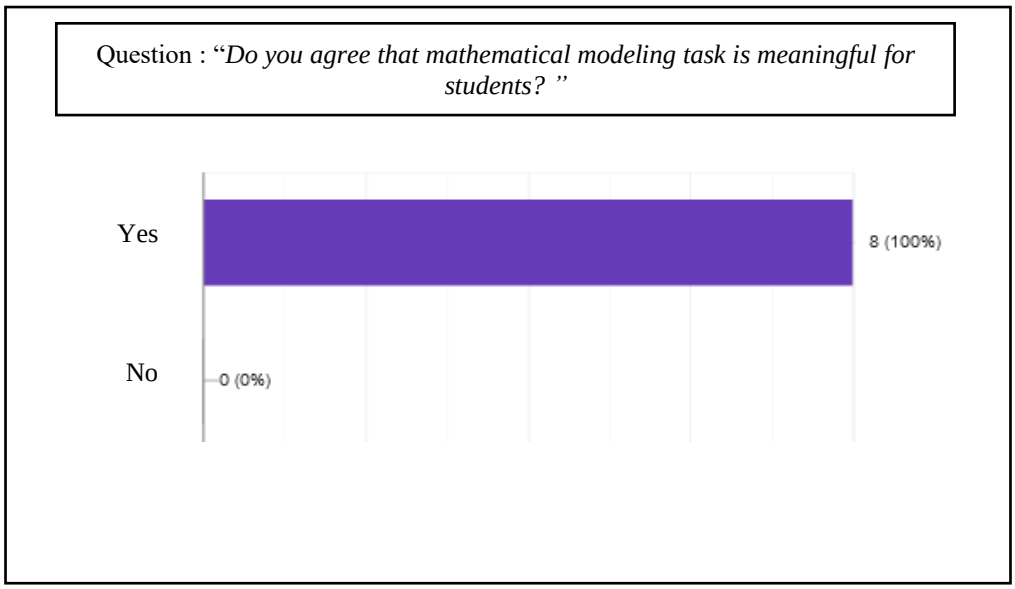

Figure 2. Agreement for mathematical modeling task

The mathematical modeling task based on the book GAIMME by COPAM & SIAM (2019) is a task on mathematical modeling, which is a process of using mathematics to describe

(represent), describe (analyze), make predictions or provide insight into real-world phenomena. In short, the aspect between modeling and the real world, using mathematical language to measure and analyze the real world, using mathematics to explore and develop an understanding of real world problems, and carrying out an interaction problem solving process where mathematics is used to investigate and deepen an understanding (Blum & Niss, 2001). Thereforeall subject research agree that mathematical modeling task is meaningful for increasing cognitive students.

Dimension of learning

Some important results from interviews about the learning process that has taken place in the classroom:

1. Some teachers are very supportive of the mathematical modeling learning process in classroom, students better understand math problems in a real context.
2. Two-way interaction always involving students in learning activities, especially in main activities.
3. The interaction between teachers and students is well established because mathematical modeling task is very possible to conduct questions and answers and class discussions, teachers can also guide students in working on questions by preparing the real world problem.

In learning process, this pedagogical content knowledge also includes the best forms that used to represent an idea best attempt to make an analogy, illustrate, explain, and demonstrate or in other words create a best way of representing right and formulate a subject so that make it something that can be fully understood (comprehensive). It also includes an understanding of what can be done in learning a specific concept that is easy or difficult for students (with various age and background) who have conceptions and misconceptions so that they learn more in mathematics classroom (Kunter, Baumert, Blum, et al., 2013).

Dimension of Evaluation

There was one activity in the last dimension. The activity is to find the difficulties of students in mathematical modeling learning. The difficulty is the student does not understand

the steps step of mathematical modeling, not yet able in assuming verbal sentences especially in assuming two variables the same, students have not been able to explain again why choose the symbol that is contained in a mathematical equation or model mathematics. Based on previous research (Kurniadi, et al, 2019; 2020) with the research subject of prospective mathematics teachers, he also found that here are still misunderstandings in interpreting assumptions and variables in solving mathematical modeling problems.

CONCLUSION

Based on the basic assumptions about the impact of teaching on learning, teacher competence will result in quality teaching and quality student learning. Therefore, teacher education is very important. Pedagogical content knowledge is needed primarily for teaching and modeling applications. In this study, there are four dimensions of teacher pedagogical content knowledge for mathematical modeling: (1) theoretical dimensions (including modeling cycles or goals and modeling perspectives as background knowledge), (2) task dimensions (including multiple solutions or cognitive analysis of the modeling task), (3) the instructional dimension (including intervention, support and feedback), and (4) the diagnostic dimension (including recognizing students, difficulties and errors). Also for teacher learning, no transfer is expected. Therefore, all of these elements should be included as mandatory components in teacher education and professional development.

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REFERENCES

Ang, K. C. (2016). “MathematicalModelling,Technology and H3Mathematics”. The Mathematics Educator.Association of Mathematics Educators. 9 (2) :33-47

Bahmaei, F. (2011). Mathematical modelling in primary school, advantages and challenges. Journal of Mathematical Modelling and Application : Vol. 1, No. 9, 3-13. Department of Mathematics, Shahid Chamran University of Ahvaz,Iran. www.proxy.furb.br/ojs/index.php

Ball, D.L., Hill, H.C. & Bass, H. (2005). Knowing mathematics for teaching. In: American Educator, 29 (3), 14-46.

Blum, W., & Ferri, R.B. (2009). Mathematical Modelling: Can It Be Taught And Learn? Journal of Mathematical Modelling and Application 2009. 1(1): 45-58.

Blum, W., & Niss, M. (2001). Applied Mathematical Problem Solving, Modelling, Applications, and Links to Other Subjects – State Trends and Issues in Mathematics Instruction. Educational Studies in Mathematics 22. : 37–68.

Blum, W, et al. (2011). Trends in Teaching and Learning of Mathematical Modelling: ICTMA 14. London : Springer

Borromeo Ferri, R. & Blum, W. (2010). Mathematical Modelling in Teacher Education–Experiences from a Modelling Seminar. In: Durand-Guerrier, V., Soury- Lavergne, S. &Arzarello, F. (Eds), CERME-6 – Proceedings of the Sixth Congress of the European Society for Research in Mathematics Education. INRP, Lyon 2010, 2046-2055.

Burkhardt, H. (2004). Establishing modelling in the curriculum: barriers and levers. In: Henn, Camberlin & Coxbill. (2012). Using Model-Eliciting Activities to Introduce Upper Elementary Student to Statistical Reasoning and Mathematical Modelling.

Cohen, Manion, & Morrison. (2017). Research Methods in Education. New York: Madison Avenue.

COPAM & SIAM. (2019). GAIMME (Guidlines For Assesment & Instruction In Mathematical Modelling Education). USA: COPAM, Inc. & SIAM.

DeLange, J. (1987). Mathematics, Insight and Meaning. Utrecht: CD-Press.

Doerr, H. (2007). What knowledge do teachers need for teaching mathematics through applications and modelling? In: Blum, W. et al. (Eds), Modelling and Applications in Mathematics Education. New York: Springer, 69-78.

Ebby, C. B. (2000) “Learning to teach mathematics differently: The interaction between coursework and fieldwork for preservice teachers”, Journal of Mathematics Teacher Education, Vol. 3, pp. 69-97.

Eric, C. C. M (2009). Mathematical Modelling as Problem Solving for Children in the Singapore Mathematics Classrooms. Journal of Science Mathematics Education in Southeast Asia. 32(1): 36-61

Eric, dkk. (2015). A case Study on Developing a Teacher's Capacity in Mathematical Modelling. Singapore: The Mathematics Educator. 16(1): 45-47

Freudenthal, H. (1973). Mathematics as an Educational Task. Dordrecht: Reidel. Hartono, Y. (2015). Matematika: Strategi Pemecahan Masalah. Yogyakarta: Graha Ilmu

Gravemeijer, K., & Cobb, P. (2006). Design research from a learning design perspective. In Educational design research (pp. 29-63). Routledge.

Ikeda, T. (2007). Possibilities for, and obstacles to teaching applications and modelling in the lower secondary levels. In: Blum, W. et al. (Eds), Modelling and Applications in Mathematics Education. New York: Springer, 457-462.

Kaiser, G., Schwarz, B. & Tiedemann, S. (2010). Future Teachers´ Professional Knowledge on Modeling. In: Lesh, R., Galbraith, P.L., Haines, C.R. & Hurford, A. (Eds): Modeling Students' Mathematical Modeling Competencies. ICTMA 13. New York: Springer, 433-444.

Kunter, M., Baumert, J., Blum, W. et al. (Eds, 2013). Cognitive Activation in the Mathematics Classroom and Professional Competence of Teachers – Results from the COACTIV Project. New York: Springer.

Kurniadi, E., et al.(2019). Kompetensi Mahasiswa dalam Mata Kuliah Pemodelan Matematika Berbasis Pengembangan Soal. Jurnal Elemen, 5(1), 54–63.

Kurniadi, E., et al. (2020). Analisis Kemampuan Pemahaman Konsep Dasar Mahasiswa dalam Mengidentifikasi karakteristik dan Menyelesaikan soal Pemodelan Matematika. Jurnal Gantang, 6(1), 9-18.

Schmidt, W.H., Tatto, M.T., Bankov, K., Blömeke, S., Cedillo, T., Cogan, L., et al. (2007). The preparation gap: Teacher education for middle school mathematics in six countries (MT21 Report). East Lansing: MSU Center for Research in Mathematics and Science Education.