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Research Article

Content and Pedagogical Knowledge of Prospective Teachers in Mathematics Learning: Commognitive

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Abstract

One research framework that can provide teacher teaching information in learning mathematics is commognitive. The aim of this research was to describe the content and pedagogical knowledge skills of prospective teacher in learning mathematics from a commognitive perspective. This research was qualitative in nature and employed an exploratory descriptive method. The subjects of this study were the 7th-semester students of mathematics education at Madura University Indonesia who were taking a professional placement. Research subject do teaching and recording is done in the form of video recordings. Teaching video recordings were analyzed by researchers to observe the ability of pedagogical and content knowledge of prospective teacher from a commognitive perspective. Data analysis in this study is inductive, that is an analysis based on data obtained, researchers present the data that has been reduced which then concludes. In this study, there are fundamental differences in the commognitive components of content knowledge and pedagogical knowledge of prospective teacher. The findings of this study, which relate to the pedagogic ability of prospective teachers in commognitive can be called pedagogical commognitive.

Keywords:
commognitive, content knowledge, pedagogical commognitive

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Introduction

Teacher communication is an important component in achieving learning objectives, especially in improving student learning outcomes. Teacher communication influences student learning outcomes, if teacher communication skills are low, it can lead to failure of student learning outcomes (Sahabuddin, 2016; Khan, et al, 2017). Teacher communication that occurs in the classroom will determine interactions in existing learning, both student interaction with the teacher, fellow students, and learning resources. Teacher communication can also determine the model of learning interactions that occur in the classroom (Martino & Maher, 1999). Communication in learning is not only in the form of conversations between teachers and students, or students and students, but also in the form of interaction in group discussions to clarify, ask questions, and expand the subject (NCTM, 2000; Inah, 2015). In general, class communication is dominated by teachers (Setyaningrum, 2009; Viseu & Oliveira, 2012). Therefore, the teacher must be able to communicate well and have knowledge while learning in the classroom.

The influence of teachers on student learning outcomes is influenced by teachers ability in understand and apply the knowledge possessed to carry out teaching activities (Ball, 1990; Shulman, 1986; Wilson, Shulman, & Richert, 1987). Competent teachers will be better able to create effective learning environments and will be better able to manage their classes so that student learning outcomes are at an optimal level (Aritonang, 2008; Hamalik, 2009). One of the knowledge that should be developed by teachers are content and pedagogical knowledge. Content knowledge is emphasized more on the amount of knowledge that is in the mind of the teacher (Shulman, 1986). Also, the teacher should not only know the facts and concepts of certain subject matter (content knowledge) but also have to understand how to connect the structure of ideas in conveying subject matter (pedagogical knowledge). A deep understanding of mathematical knowledge is needed but it is not enough to teach mathematics (Turnuklu & Yesildere, 2007).

One research framework that can provide teacher teaching information in learning mathematics is commognitive. Tuset (2018) investigates being able to provide pre-service teacher teaching information in achieving mathematics teaching goals using a commognitive framework. Commognitive can have an impact on the professional development of prospective teachers in increasing students' exploratory participation in elementary and secondary schools (Metzuyanim & Tabach, 2017). Also, commognitive has been used to examine teacher discourse about teaching, including teacher professional identity and mathematical discourse (Shabtay and Metzuyanim, 2017).

Research on content knowledge has been widely carried out (Even, 1993; Briand-Newman, et al, 2012) and other studies relating content knowledge to

pedagogics (Hannula, 2017; Ding, 2014; Lee, Capraro, & Capraro, 2018). In addition, commognitive research focuses more on learning and teaching in general (Berger, 2013; Nardi, et al, 2014; Viirman, 2015; Tabach & Nachlieli, 2016; Metzuyanim & Tabach, 2017; Tasara, 2018; Fauzi, 2019). Commognitive research that has been conducted so far emphasizes more on the aspects of content knowledge in learning. However, content and pedagogical knowledge in learning have to be done by prospective teacher to become professional teachers. By understanding the content and pedagogical knowledge, prospective teacher can have the ability to convey or teach their knowledge (transfer of knowledge) to students effectively and efficiently. By mastering the content and pedagogical knowledge of student teachers can truly understand the condition of students and be able to help finding their identity, find their character, develop their potential and solve their problems properly. Research on commognitive research related to the content and pedagogical knowledge capabilities of prospective teacher has never been done by other researchers. So it is important to research the ability of content and pedagogical knowledge possessed by the teacher seen from the commognitive perspective. In this study, researchers aimed to describe the content and pedagogical knowledge skills of prospective teacher in learning mathematics seen from a commognitive perspective.

Content and Pedagogical Knowledge

Teaching can be interpreted as professional practice which involves activities that require careful planning in learning certain content to help students who are being taught (Ball & Forzani, 2009). In learning mathematics, teaching is a mathematical problem solving (Ball & Bass, 2003). In solving problems in the learning process, teachers need strong knowledge about mathematical the content, methods used to teach content, and a strong understanding to make students think and come up with different ideas (NCTM, 2007). Knowledge related to content is emphasized more on knowledge about mathematics and the skills used in managing learning implementation (Ball, et al, 2008). Therefore, content knowledge and pedagogical knowledge are very important in the process of teaching activities.

Content knowledge is generally expressed by recognizing students' thinking in describing wrong solutions or when there are textbooks that provide incorrect definitions or inadequate examples of certain topics (Ball, et al, 2008). A deep understanding of mathematical knowledge is needed but not it is enough to teach mathematics (Turnuklu & Yesildere, 2007; Subanji, 2015). Also, content knowledge is in when writing the right mathematical notation or providing the right algorithm for different problems. Further, the teacher should not only know the facts and concepts of certain subject matter (content knowledge) but also have to

understand how to connect the structure of ideas in conveying subject matter (pedagogical knowledge).

Shulman (1986) categorizes teacher knowledge into 7 categories, including pedagogical knowledge wihch is the principles and strategies of class management and cross-curricular organizations. This pedagogic knowledge includes classroom management, knowledge of teaching methods, knowledge of classroom assessment, knowledge of the learning process, and knowledge of individual student characteristics (Voss, et al, 2011). Pedagogic knowledge is the teachers ability in creating a diverse atmosphere and learning experience (Nurfuadi, 2012). Pedagogic knowledge as an ability in the students management following the applied curriculum (Sagala, 2009). Pedagogic knowledge is one of the determining indicators of the success of the learning process which includes planning, implementation, design, learning outcomes, evaluation and participant development (Mulyasa, 2005).

Commognitive

Commognitive is composed of two words communication and cognition (Sfard, 2008). Sfard argues thinking is a form of communication and defines thinking as communication individualization (Sfard & Kieran, 2001; Sfard, 2007, 2012). Thinking is done in a person and cannot be accessed by others directly. However, this activity is a form of individual communication (Sfard, 2008), in this case, the activity of an individual who communicates with himself (Sfard, 2001, 2012). Sfard defines communication as a person's activities followed by other individual activities. The first individual activity must be well defined as a communication activity and the second individual activity is a reaction to the previous actions (Sfard, 2008). The similarity of sending and messages received from an idea becomes something important in the effectiveness of communication (Sfard, 2001).

The main principle of commognitive thinking is as a form of intra-personal communication. Commognitive provides an alternative to communicate learning with various conceptual tools to consider learning, especially in terms of the process (Sfard, 2008). Routines are recurring communication patterns that produce certain supported narratives. Routines often use visual mediators such as digits, algebraic notation, and graphics. Commognitive also increases the exploratory participation of elementary and middle school students by providing professional development for teachers in their positions (Weingarden, et al, 2017). In this context, commognitive has also been used to examine teacher's discourse about teaching, including professional identity and mathematical discourse (Shabtay and Heyd-Metzuyanim, 2017).

Commognitive is defined as a different type of communication, determined by the object (word use), all types of mediators are made and followed up for

communication (visual mediators), a set of level rules followed by ole (routine), and the results of the process (narrative) produced in the discourse community. as shown in table 1. The commognitive component carried out in the learning process to provide access to the activities undertaken and are expected to modify the thinking they have and change the rules of discourse on explorative discourse, they must be exposed to meta discursive communication about how words are used and what routines are used. considered as accepted in the new discourse.

Table 1.

Description of the Commognitive Component

Commognitive component	Description
Word use	The use of words in mathematics learning
Visual Mediator	Objects used in learning mathematics
Routine	The process of rules that describe a pattern in learning mathematics
Narrative	Mathematical language used in learning mathematics about definitions, theorems, principles, and facts.

Problem of Study

Commognitive research that has been conducted so far emphasizes more on aspects of content knowledge in learning. In learning not only content knowledge that can be done by prospective teacher students to become professional teachers, but must also be pedagogical knowledge. Research on commognitive research related to the content and pedagogical knowledge abilities of prospective teacher students has never been done by other researchers. therefore, the problem in this research is how the content and pedagogical knowledge of prospective teacher students in learning mathematics based on commognitive?

Method

Research Model

This research was qualitative in nature and employed an exploratory descriptive method (As'ari et al, 2019). This research is for the analysis of the material knowledge abilities of prospective teacher in mathematics learning from a commognitive perspective.

Participants

The subjects of this study were the 7th-semester students of mathematics education at Madura University Indonesia who were taking a professional placement. Professional placement courses are subjects that must be taught by mathematics education students in the 7th semester.

Prospective research subjects are selected based on criteria established by researchers to achieve research objectives. The subjects in this study were selected based on initial observations. In the initial observation an in-depth observation of

the prospective teacher's students is actually obtained until the subject of the student is observed based on the learning process carried out while implementing peer teaching. Then, selected prospective teacher students who meet the criteria as research subjects.

Research subjects do teaching and recording is done in the form of video recordings. Teaching video recordings were analyzed by researchers to observe the ability of pedagogical knowledge and content knowledge of prospective teacher from a commognitive perspective.

Data Collection Tools

The data used in this study are data from video recordings and interviews. Video recording data in the form of learning conducted by prospective teacher, but researchers focus more on the ability of pedagogical knowledge and content knowledge of prospective teacher. The researcher did not intervene with the subject while carrying out the study. Important things that occur during the data collection process are recorded by researchers in the field notes sheet. The researcher did not intervene with the subject while carrying out the study. Important things that occur during the data collection process are recorded by researchers in the field notes sheet. Existing video recordings are then transcribed, coded and classified/categorized based on the patterns formed.

The next data is the interview data. The type of interview used is interviews where questions already exist/predetermined but can still be developed following the objectives of the study so that researchers have control over the topic for the interview. The teacher is asked to stop the video when he can recall what he thought and felt during the learning process. The teacher is asked to give a recording of his thinking as accurately as possible. From the statements given by the teacher, researchers explore by asking questions to explore the answers to the problems that have been determined, especially in the context of the commognitive component.

Data Analysis

Data analysis in this research is inductive, that is an analysis based on data obtained, then developed a certain relationship pattern or become a hypothesis. There are stages of data reduction namely eliminating some data that is not following the data expected in the research objectives. Furthermore, researchers present the data that has been reduced which then concludes. With first of conclusions from the data that has been collected and analyzed is used as the initial conclusions put forward are still temporary and may change if strong evidence is found. So in this study after concluding, researchers conducted verification to recheck conclusions with the results of the study.

Procedure

In the process of uncovering content knowledge and pedagogical knowledge of prospective teachers in learning in a commogitive perspective, researchers conducted a research phase consisting of the preparation phase, the data collection stage, and the data analysis stage.

Results

Pedagogic knowledge is one of the skills possessed by prospective teacher in teaching, which in this case can be seen from the process of communication and interaction with students. Meanwhile, content knowledge is the knowledge of prospective teacher related to mathematical material, which in this case can be seen from the student's cognitive process. Furthermore, commognitive is composed of two words communication and cognition. With these assumptions, commognitive can be used to analyze pedagogical knowledge and content knowledge of prospective teacher. The data in the study are in the form of learning conducted by prospective teachers during the implementation of professional placement. Data were obtained by recording the interaction between prospective teacher and students in learning mathematics through the passive participation method using a mobile recording device. Data retrieval is done in one time conducted by a prospective teacher during the learning process for the first day carrying out professional placement. The learning outcomes of prospective teachers undertake learning based on content knowledge and pedagogical knowledge as follows:

Preface Activities

In the learning activities, students carry out a number of learning steps such as greeting, asking one student to lead a prayer in accordance with their respective religions and beliefs, checking student attendance as a disciplinary attitude, conveying the scope of the material to be discussed, the learning objectives to be achieved, and the method to be implemented. The activities are as follow:

Subject: Assalamualaikum wr.wb
Student: waalaikumussalam wr.wb
Subject: Today is used to be a daily test 1 about the limit, right?, but Mr. Awal said the beginning of the test is cancel.
Student 1: Wow, I studied hard last night, Sis.
Student 2: it is easy if it is only about Limits.
Subject: so today we will discuss limits, so that if the best comes, you all will be ready.
Student: yes sis
Subject: But before we started, I am going to check the attendance. (checking each student)
Student: So sister, it is your turn to introduce yourself.
Subject: my name is sitti karimah sulfiah, called iim
Subject: Okey, now, please open your worksheet about limits.

Mr Awal has been discussed on page 22 no 18. So we continue from number 19, okey?
Student 1: it is not a discussion, but a quiz.
Student 2: Let's discuss it together, sis.

Based on the conversation above, word use in content knowledge is carried out by prospective teacher at the beginning of learning to say "limit". Furthermore, the pedagogical knowledge of prospective teacher is saying greetings "Assalamualaikum wr.wb", conveying the purpose of the implementation of learning by saying "Today is used to be a daily test 1 about the limit, right?, but Mr. Awal said the beginning of the test is cancel", providing motivation by saying "so today we will discuss limits, so that if the best comes, you all will be ready". Also, pedagogical knowledge of prospective teacher in conducting the attendance of each student by asking the identity of each student present and checking who was absent. The visual mediator used in the beginning of learning on pedagogical knowledge is to use student worksheets as presented by prospective teacher in the conversation above. Let's open the Student Worksheet about limits. We started discussing it on page 22 no 18. So, we will continue from number 19, okey?.

Core Activities

In the core activities, students carry out several steps of learning such as delivering learning materials, applying learning models, utilizing media/resources in learning, managing and involving participants in learning. The activities are as follow:
Subject: Okey, let me create a group first. There are 33 students. So there will be 6 groups, and, each group consists of 5 people because 3 students do nocome to the class. Now please gather with your respective groups.

Figure 1.
The Subject Divides Groups of Students

Subject: now which one you prefer, talking about daily tests from the beginning or starting from number 19?
Student: please discuss only the UK one sis, those with tables have not been discussed by Mr Awal

Subject: yes, now we are discussing the UK 1. Group 1 please do numbers 1 and 2, group 2 please do number 3 and 4. Group 3 please do numbers 5 and 7, group 4 please donumber 8 and 9, group 5 please do number 10.
Student: Don't understand sis, this hasn't been taught yet.
Subject: fine, just do as for as you can do
Student: we should write the answer, Sis? In a piece or paper?
Subject: write them in the book, everyone have to write down the results of their work.
Subject: you have 10 minutes.
Students: How about 15 minutes sis?
Subject: 10 minutes only. Starting from now
Student: alright sis.
Subject: group 4, do you have any problem?
Student: yes, sis, still confused. This has not been explained yet by Mr. Awal.
Subject: in which condition, we can say that limits exist?
Student: I don't know sis.
Subject: well, I will explain you since none form group 4 and 5 can make it.
Student: oke
Subject: No 1

Consider the following table of f (x) values

X	*f (x)*
1	*3*
1.5	*3.5*
1.9	*3,9*
1.99	*3.99*
1,999	*3,999*

Subject: what is the question?
Student: Value f(x) =. . .
Subject: who can read f(x) correctly?i will give a reward to whoever can read it.
Student 1: limit x approaches f (x) approaches 2
Student 2: limit f (x) approaches 2 from the left.
Subject: I am sorry, both are still incorrect. So the correct limit is f (x) where x approaches 2 from the left.
Subject: So what do you understand about the limit?
Student: approach
Subject: right the value which is only close to it. So let's look at this table, all of these x values are close to 2 from the left, so for the value of x that is close to 2 from the left, so, what value is getting closer to the value of f(x)?
Student: approach to 4
Subject : yes right , so the value f(x) is 4

Based on the above interview excerpt, the prospective teacher's word use in content knowledge carried out in the core learning activities are f (x), f (x), limit x approaches f (x) approaches 2, limit f (x) approaches 2 from the left and others. The visual mediator in conducting the explanation is that the prospective teacher gives the question "who can read f (x) correctly". The question is as a medium to stimulate students to understand something. The narrative component conducted by students is to use the concept of a limit. Routine component in content knowledge that is done by prospective teachers includes re-explaining again the understanding of the limit.

The use of the word use component in pedagogical knowledge in core learning activities includes saying and asking students to create groups "okey, let me create groups first", saying and asking students to work on problems "do it as far as you know, I will explain later", say the time in solving the problem "10 minutes. Let's start doing it ". Visual mediators, in this case, are using a blackboard (writing in the division of group names), using student writing books (asking students to work on books), using existing worksheets (UK work done is on worksheets). Routine done in this case is the skill in dividing groups and sitting based on the members of the group, dividing the questions that exist in each group, giving time in the task, giving rewards to students can read f(x) correctly? I will give a reward to whoever can read it. The narrative in this activity is more to explain the concept of limits to students and students's better understanding, including providing scaffolding in explaining the concept and the process of solving problems.

Closing Activities

In the closing activity, prospective teacher carry out several steps of learning such as providing opportunities for students to discuss outside the classroom, and provide material to be studied at the next meeting and close the meeting with greetings. The activity are as follows:

Subject: later if anyone still get difficulties in understanding the subject, you can meet me outside the classroom
Student: yes sis
Subject: don't forget to re-read at home, Thursday we will learn about the derivative of algebraic functions, so please read about that also.
Student: yes sis
Subject: assalamualaikum warahmatullahi wabarakatuh
Student: waalaikumussalam warahmatullahi wabarakatuh.

Based on the quote above, the commognitive component is more emphasized on the pedagogical knowledge of prospective teachers, word use in this activity enunciates and provides opportunities for students who do not understand to learn outside the classroom, the material to be studied next, and the closing sentence

"assalamualaikum warahmatullahi wabarakatuh". Routine in this activity is to provide opportunities for students who do not understand to learn outside the classroom, motivate students to learn at home about the material to be studied in the next meeting and close the meeting.

Discussion and Conclusion

From the results of this study, commognitive analysis of pedagogical knowledge in providing interesting reviews on student learning prospective teachers which is in the use of word used for prospective teacher is important because if the word use conveyed incorrectly results in students will fail to understand. This can be seen when the teacher conveys the word limit "So the correct limit is f (x) where x approaches 2 from the left". In the right sense, the prospective teacher should say that a function f (x) where x approaches 2 from the left. This is consistent with the opinion of the use of words that are not consistent can make it difficult for students to understand the word in question (Park, 2013). Also, this sis importance for prospective teacher to listens carefully to what students are saying and using in learning to facilitate student understanding. This is also seen in the conclusions given by students that the limit is only approaching. Prospective teacher should provide more understanding about the actual concept of the limit. In this study prospective teacher only use symbolic mediators, that is, writing limit functions and others in the learning that is done, so that the learning that occurs is flat. Therefore, the use of ordinary visual mediators can result in students not being too interested in following the instructions made by prospective teacher. Prospective teacher in the use of varied visuals are needed by prospective teacher in attracting the center of attention and making students understand. This is in line with the use of mediators which are divided into iconic mediators (such as graphics and pictures), symbolic mediators and concrete mediators (Berger, 2013).

In the routine component the teacher's domination of students, so students do not have the opportunity to explore their abilities, but it is done because students do not understand the material being taught. Also, students, prospective teachers must deliver a representation of the explanation given due to the characterization of students in the classroom. In this study, prospective teacher are still dominant in learning. This can be seen from several opportunities for teachers to answer questions that should be answered by their students. Also, prospective teacher use questions as a tool to find out students' level of understanding. This can be seen from several segments, prospective students ask whether or not understand the explanation given. The use of questions made by prospective teacher is very good because by using questions, they can find out the extent of student understanding. Questions that ask facts can be interpreted to see the level of understanding, but also to get attention (Viirman, 2015). The question as one of the communication

tools and kinds of questions proposed by prospective teacher in teaching mathematics practice (Zayyadi, et al, 2019). Narrative component, the rules used in learning are not rigid and adapted to the state of the students. The narrative in this activity is more to explain the concept of limits to students and students better understand them, including providing scaffolding in explaining the concept and the process of solving problems. It is appropriate that commognitive can analyze students in solving problems (Zayyadi, et al, 2019).

Pedagogic and content knowledge in learning can be analyzed using commognitive. This shows that the commognitive can provide a conceptual framework in the learning process carried out by prospective teacher. This is following Sfard (2008) stating that commognitive provides an alternative way of communicating learning with various conceptual tools to consider learning, especially in terms of the processes that occur in learning. Also, the results of the study indicate that there are interactions conducted by the teacher and students that can be assessed with commognitive, such as when a teacher makes an example (visual mediator) to help make students answer the questions given. This is the following research Heyd-Metzuyanim, et al (2016) which states that commognitive can provide a picture and identify the interactions that occur in the learning process.

Based on the results and discussion above, the conclusion of this is the ability of content knowledge in a cognitive perspective including word use, visual mediator, routine and narrative. Word used by prospective teacher in content knowledge in learning activities is f (x), f (x), limit x approaches f (x) close to 2, limit f (x) approaches 2 from the left and others. The visual component of the mediator in conducting explanations is the prospective teacher giving questions. The question is as a medium to stimulate students to understand something. The narrative component conducted by students is to use the concept of a limit. Routine component in content knowledge that is done by prospective teachers includes explaining again the understanding of the limit.

The ability of content knowledge in a commognitive perspective includes word use, visual mediators and routines. The use of the word use component in pedagogical knowledge in learning activities includes saying and asking students to create groups, saying and asking students to work on problems, saying time in solving problems. Visual mediators, in this case, are using a blackboard (writing in the division of group names), using student writing books (asking students to work on paper), using existing worksheets. This matter has a difference, the use of visual mediators using the GeoGebra software is easy enough to produce graphs of various functions (Berger, 2013). Routine that is done in this case is the skill in dividing groups and sitting based on the members of the group, dividing the questions that exist in each group, giving time in the work done, giving rewards to

students. This is also in accordance with the opinions expressed Viirman (2015) surprise is more often used to create a more short-term effect, using drastic wording to attract the students attention as an example of routine use. The narrative in this activity is more to explain the concept of limits to students and students better understand them, including providing scaffolding in explaining the concept and the process of solving problems.

In general, it can be concluded that the content and pedagogical knowledge of prospective teachers in implementing learning include: The use of words used in learning must be consistent and appropriate so that it can provide an easy understanding for students and not confuse students in understanding the material provided. The use of varied visual mediators in learning is desirable. Skills in learning on routine components should use student activity. In this case, students who are more active in the learning process and the use of appropriate methods can support active learning. In the narrative component, knowledge about mathematical content must be emphasized more help students' understanding of learning.

Recommendations

In this research, there are fundamental differences in the commognitive components of content and pedagogical knowledge of prospective teacher. All commognitive components both word use, visual mediator, routine and narrative occur in the content knowledge of prospective teacher in the learning process. However, in pedagogical knowledge of prospective teacher, the commognitive component is more dominant in word use, visual mediator and routine. The narrative component in commognitive emphasizes more on the knowledge content of prospective teacher, this is the finding of this study. Recommendations from this research, should more research on pedagogical knowledge of prospective teachers and teachers in a commognitive perspective. The findings of this study, which relate to the pedagodic ability of prospective teachers in commognitive can be called pedagogical commognitive. Pedagogical commognitive can provide a complete description of the activities carried out by prospective teachers in the learning process. Therefore, pedagogical commognitive must be studied in many subsequent research.

Disclosure and Conflicts of Interest

This research is original work and does not contain unlawful statements or infringe on the rights or privacy of others. The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

Aritonang, K. T. (2008). Minat dan motivasi dalam meningkatkan hasil belajar siswa. *Jurnal pendidikan penabur, 7*(10), 11-21.

As'ari, A.R., Kurniati, D., Abdullah, A.H., Muksar, M., & Sudirman, S. (2019). Impact of Infusing Truth Seeking and Open-Minded Behaviors on Mathematical Problem-Solving. *Journal for the Education of Gifted Young Scientists, 7*(4), 1019-1036. DOI: http://dx.doi.org/10.17478/jegys.606031

Ball, D.L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *Elementary School Journal, 90*(4), 449-466.

Ball, D.L., & Bass, H. (2003). Toward a practice-based theory of mathematical knowledge for teaching. In B. Davis & E. Simmt (Eds.), *Proceedings of the 2002 Annual Meeting of the Canadian Mathematics Education Study Group*, (3-14). Edmonton, AB: CMESG/GCEDM.

Ball, D. L. & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education,* 60(5), 497–511

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special?, *Journal of Teacher Education, 59*(5), 389–407.

Berger, M. (2013). Examining mathematical discourse to understand in-service teachers' mathematical activities. *Pythagoras. 34* (1), 1-10. https://doi.org/10.4102/pythagoras.v34i1.197

Briand-Newman, H., Wong, M. & Evans, D. (2012). Teacher subject matter knowledge of number sense. J Dindyal, L P Cheng, S F Ng. 130-137. Australia: Mathematics Education Research Group of Australasia.

Ding, L., He, J., & Leung, F. K. S. (2014). Relations between subject matter knowledge and pedagogical content knowledge: A study of Chinese pre-service teachers on the topic of three-term ratio. *The Mathematics Educator*, *15*(2), 50-76.

Even, R. (1993). Subject-matter knowledge and pedagogical content knowledge: Prospective secondary teachers and the function concept. *Journal for Research in Mathematics Education, 24(*2), 94-116. DOI: 10.2307/749215.

Fauzi, T.C. Nusantara,T., Hidayanto, E., (2019). Kesulitan Siswa Dalam Menyelesaikan Masalah Materi Teorema Pythagoras: Perspektif Commognition. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*. *4*(12).

Hamalik, O. (2009). *Teknologi dalam Pendidikan*. Bandung: Yayasan Partisipasi Pembangunan Indonesia.

Hannula, J. (2017). Subject matter knowledge and pedagogical content knowledge in the learning diaries of prospective mathematics teachers. In T. Dooley, & G. Gueudet (Eds.), *Proceedings of the Tenth Congress of the European Society for Research in Mathematics Education*, 3312-3319.

Heyd-Metzuyanim, E., Tabach, M. & Nachlieli, T. (2016). Opportunities for learning given to prospective mathematics teachers: Between ritual and explorative instruction. *Journal of Mathematics Teacher Education, 19*(6), 547–574. https://doi.org/10.1007/s10857-015-9311-1

Inah, E. N. (2015). Peran komunikasi dalam interaksi guru dan siswa. *Al-Ta'dib, 8*(2), 150-167

Khan, A., Khan, S., Zia-ul-islam, S., & Khan, M. (2017). Communication Skills of a Teacher and Its Role in the Development of the Students. *Journal of Education and Practice, 8*(1), 18–21.

Lee, Y., Capraro, R. M., & Capraro, M. M. (2018). Mathematics Teachers' Subject Matter Knowledge and Pedagogical Content Knowledge in Problem Posing. *International Electronic Journal of Mathematics Education, 13*(2), 75--90. https://doi.org/10.12973/iejme/2698.

Martino, A. M., & Maher, C. A. (1999). Teacher Questioning to Promote Justification and Generalization in Mathematics : What Research Practice Has Taught Us. *Journal of Mathematical Behavior, 18*(1), 53–78. https://doi.org/10.1016/S0732-3123(99)00017-6

Metzuyanim, E. H., & Tabach, M. (2017). The Commognitive Theory Framework: From Theory to Implementation. In K-12 Mathematics Education in Israel, *Issues and Innovations*. 343–350.

Mulyasa. (2008). *Menjadi Guru Profesional*. Bandung: PT. Remaja Rosda Karya.

Nardi, E., Ryve, A., Stadler, E., & Viirman, O. (2014). Commognitive analyses of the learning and teaching of mathematics at university level: The case of discursive shifts in the study of Calculus. *Research in Mathematics Education, 16*(2). 182-198. https://doi.org/10.1080/14794802.2014.918338

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (2007) *Mathematics Teaching Today: Improving Practice, Improving Student Learning*. Reston, VA: NCTM.

Nurfuadi. (2012). *Profesionalisme Guru*. Porwokerto: Penerbit STAIN Press.

Park, J. (2013). Is the derivative a function? If so, how do students talk about it? *International Journal of Mathematical Education in Science and Technology*, *44*(5), 624–640. https://doi.org/10.1080/0020739X.2013.795248

Sagala, S. (2009). *Konsep dan Makna Pembelajaran*. Bandung: CV. ALFABETA.

Sahabuddin, C. (2016). Hubungan Komunikasi Belajar Mengajar terhadap Hasil Belajar Peserta Didik di Sekolah Menengah Kejuruan Negeri I Kabupaten Majene. *Pepatudzu: Media Pendidikan dan Sosial Kemasyarakatan, 10*(1), 17-30.

Setyaningrum, D. (2009). *Pengaruh Kemampuan Guru dalam Berkomunikasi dan Pengelolaan Kelas Terhadap Motivasi Belajar Akuntansi Siswa Kelas XI IPS di SMA Negeri 8 Semarang Tahun Ajaran 2008/2009*. (Doctoral dissertation, Universitas Negeri Semarang)

Sfard. A. (2001). There is more to discourse than meets the ears: Looking at thinking as communicating to learn more about mathematical learning. *Educational Studies in Mathematics*. 46(1-3). 13-57. https://doi.org/10.1023/A:1014097416157

Sfard, A. (2007). When the Rules of Discourse Change, but Nobody Tells You: Making Sense of Mathematics Learning From a Commognitive Standpoint. *Journal of the Learning Sciences. 16*(4). 565-613. https://doi.org/10.1080/10508400701525253

Sfard, A. (2008). *Learning in doing: social, cognitive, and computational perspectives*. Cambridge University Press.

Sfard, A. (2012). Introduction: Developing mathematical discourse-Some insights from communicational research. *International Journal of Educational Research,51-52* (3). 1-9. https://doi.org/10.1016/j.ijer.2011.12.013

Sfard, A., & Kieran, C. (2001). Cognition as communication: Rethinking learning-by-talking through multi-faceted analysis of students' mathematical interactions. *Mind, Culture, and Activity, 8*(1). 42–76. https://doi.org/10.1207/S15327884MCA0801_04

Shabtay, G., & Heyd-metzuyanim, E. (2017). Teachers' Discourse On Students' Conceptual Understanding And Struggle. *The 41th Conference of the International Group for the Psychology of Mathematics Education*. Vol 4. 177-184. Singapore: PME.

Shulman, L. S. (1986). *Paradigms and research programs in the study of teaching: A contemporary perspective. In M. C. Wittrock (Ed.), Handbook of research on teaching* (pp. 3–36). New York, NY: Macmillan.

Subanji, S. (2015) Peningkatan Pedagogical Content Knowledge Guru Matematika Dan Praktiknya Dalam Pembelajaran Melalui Model Pelatihan Teqip. *Jurnal Ilmu Pendidikan Universitas Negeri Malang, 21*(1),71-79

Tabach, M., & Nachlieli, T. (2016). Communicational perspectives on learning and teaching mathematics: prologue. *Educational Studies in Mathematics. 91*(3). 299-306. https://doi.org/10.1007/s10649-015-9638-7

Tasara, I (2018) Commognitive analysis of a teacher's mathematical discourse on the derivative. In: Curtis, F, (ed.) BSRLM Proceedings. BSRLM 2017: *British Society for Research into Learning Mathematics Conference*, 11 Nov 2017, Liverpool, UK. BSRLM.

Turnuklu, E.B., & Yesildere, S. (2007). The pedagogical content knowledge in mathematics: Pre-service primary mathematics teachers' perspectives in Turkey. Issues in the Undergraduate Mathematics Preparation of School Teachers, *The Journal*, 1(1), 1-13.

Tuset, G. A. (2018). A commognitive lens to study pre-service teachers' teaching in the context of achieving a goal of ambitious mathematics teaching. *In Proceeding, Congress of the European Society for Research in Mathematics Education.*

Viseu, F., & Oliveira, I. B. (2012). Open-ended tasks in the promotion of classroom communication in Mathematics. *International Electronic Journal of Elementary Education, 4*(2), 287-300.

Voss, T., Kunter, M,. & Baumert, J., (2011). Assessing Teacher Candidates' General Pedagogical/Psychological Knowledge: Test Construction and Validation. *Journal of Educational Psychology, 104*(3). 952–969. DOI: 10.1037/a0025125.

Viirman, O. (2015). Explanation, motivation and question posing routines in university mathematics teachers' pedagogical discourse: a commognitive analysis. International *Journal of Mathematical Education in Science and Technology. 46*(8). 1165-118. https://doi.org/10.1080/0020739X.2015.1034206

Weingarden, M., Heyd-Metzuyanim, E. & Nachlieli, T. (2017). The realization tree assessment tool: Assessing the exposure to mathematical objects during a lesson, in *The Tenth Congress of the European Society for Research in Mathematics Education (CERME)10*, Dublin, Ireland.

Wilson, S. M., Shulman, L. S. & Richert, A. E. (1987). *150 Different Ways of Knowing: Representations of Knowledge in Teaching.* In J. Calderhead (Ed.), Exploring Teachers' Thinking. London: Cassess.

Zayyadi, M., Nusantara, T., Hidayanto, E., Sulandra, I. M., & As'ari, A.R. (2019). Exploring prospective student teacher's question on mathematics teaching practice. *Journal of Technology and Science Education, 9*(2), 228-237. https://doi.org/10.3926/jotse.46

Zayyadi, M., Nusantara, T., Subanji., Hidayanto, E., & Sulandra, I. M. (2019). A Commognitive Framework: The Process of Solving Mathematical Problems of Middle School Students. *International Journal of Learning, Teaching and Educational Research. 18*(2), 89-102. https://doi.org/10.26803/ijlter.18.2.7