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Description of Technological Pedagogical Content Knowledge Mathematics Teachers during the Covid-19 Pandemic

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Abstract

This study aims to determine the description of mathematics teachers' technological pedagogical content knowledge (TPCK) in online learning. The type of research used is qualitative research with a descriptive approach. The research participant is the VIII grade mathematics teacher of SMPN 1 Baraka. The data collection instruments were self-assessment questionnaires, observation sheets, and interview guidelines. The results showed that the knowledge of TPCK of teachers was very good in developing lesson plans and learning evaluation, choosing the technology or learning media used, mastering teaching materials, and regarding combinations of technological, pedagogical, and content aspects. As for the realization of this knowledge, some aspects still need to be improved, such as components in the lesson plans that are incomplete, the learning process that is not fully in accordance with the lesson plans, methods, and strategies to make the learning process effective so that students understand statistical topic needs to be maximized. Participants need to explain a little material or make students find their understanding and must be more active in utilizing learning support tools and special software to understand statistics and probability material. Participants can use technology, pedagogy, and content separately, but combining pedagogy, content, and appropriate technology simultaneously needs to be improved.

Keywords: Technological pedagogical content knowledge; Teachers; Mathematics Learning; Online Learning.

INTRODUCTION

The world is currently facing a difficult time due to the outbreak of *The Corona Virus Disease 2019* (COVID-19). At least 290.5 million students worldwide were disrupted by their learning activities due to COVID-19, which spread more widely (Wiryanto, 2020). In Indonesia, the government took steps in the form of a sudden decision by closing all types of school activities, including face-to-face learning activities, and replacing them with learning from home (Nahdi and Jatisunda, 2020). Furthermore, the Minister of Education and Culture issued circular Number 4 of 2020 concerning the implementation of education during the emergency period of the spread of COVID-19 on March 24, 2020, which contains directions so that the teaching and learning process is carried out in their respective homes remotely by utilizing technology and internet networks (Wiryanto, 2020). The COVID-19 pandemic has resulted in changes, especially in mathematics learning. The math teacher should know how to explain the subject matter and other factors that may be involved in teaching, such as; teacher understanding of the curriculum, designing learning and syllabus, understanding of student background and pedagogics that allow teachers to relate and use appropriate pedagogic approaches for content knowledge to learners. The use of technology in the learning process requires a competent teacher. The competent in question is a teacher who can integrate professional abilities, pedagogical abilities, and technology in learning, referred to as *Technological Pedagogical Content Knowledge* (TPCK).

Technological Pedagogical Content Knowledge (TPCK) is a framework for understanding and describing the types of knowledge needed by a teacher to streamline pedagogy practice and concept

understanding by integrating technology into the learning environment (Misra et al., 2008). TPCK was first developed by Mishra and Koehler (2006) by adapting the *Pedagogical Content Knowledge* (PCK) model from Shulman (1986). The results of research by Kurniawan and Zarnita (2020) show that the internet network is often the main obstacle in implementing online learning, especially in improving the ability of teachers to innovate, which requires an internet network. Apart from the facilities and availability of internet networks, the good or lack of ability of teachers to integrate pedagogy and content in the use of technology also affects online learning. The results of Wahyuni's research (2019) namely that the TPCK of mathematics teachers is at a simple level because mathematics teachers have a good knowledge of TPCK but cannot apply their TPCK knowledge to the learning process. Furthermore, the results of Anggriawan (2020) show that *Technological Pedagogical Content Knowledge* (TPCK) in mathematics teachers based on performance in their implementation is in the moderate category due to the lack of teacher willingness to prepare mathematics learning tools, such as syllabus, lesson plan, monotony in teaching, using mediocre and less attractive methods in learning and lack of teacher desire to think about content ideas creative in mathematics learning. According to Fauziyah (2021), teachers can use technology, pedagogy, and content separately, but integrating pedagogy, content, and the use of appropriate technology needs to be improved.
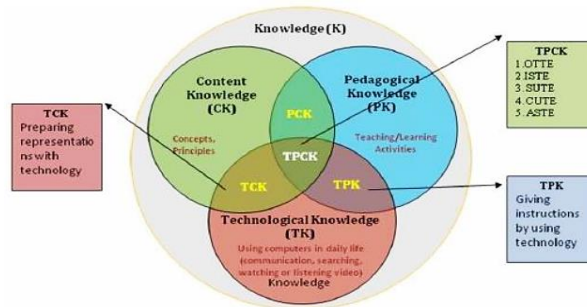

Figure 1. TPCK component diagram

In accordance with the TPCK component relationship diagram above, the relationship between the TPCK components used in this study is as follows (Koehler et al., 2013):
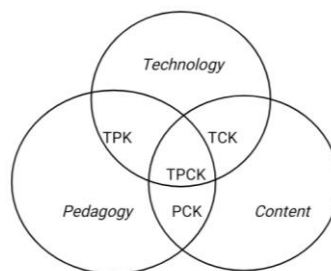

Figure 2. Relationship of TPCK components

From Figure 2, the three main components of TPCK knowledge have a relationship or combination with each other to form the other four components, so there are seven components (Agyei and Voogt, 2012). The explanation of the seven components based on Koehler et al. (2013), Mishra and Koehler (2006), and Chuang and Ho (2011) are as follows:

1. *Technological Knowledge* (TK) is the teacher's knowledge of what and how technology, *software*, or applications can be used for learning.

2. *Pedagogical knowledge* (PK) is the teacher's knowledge of student characteristics, development of learning plans, classroom management, teaching, and evaluation of learning outcomes, as well as the methods/models/strategies that can be used in learning.

3. *Content knowledge* (CK) is the teacher's knowledge of mastery of the subject matter or the substance of the material broadly and deeply.

4. *Technological Content Knowledge* (TCK) is the teacher's knowledge of the ability to deliver material using technology.

5. *Pedagogical Content Knowledge* (PCK) is knowledge of pedagogics, teaching practices, and the right planning process to be taught in the material lessons to be taught

6. *Technological Pedagogical Knowledge* (TPK) is knowledge of the influence of technology on teaching and learning as well as technological advantages and constraints related to pedagogical design and strategy.

7. *Technological Pedagogical Content Knowledge* (TPCK) is knowledge of the complex interaction between the three components of basic knowledge (CK, PK, TK) that a teacher has when teaching content using appropriate pedagogic methods and technologies.

The following is a table of components and indicators of TPCK teachers of mathematics by Koehler et al. (2013) and Mishra and Koehler (2006):

Table 1. Table of TPCK Indicators of Mathematics Teachers

No.	Component	Indicator
1.	*Pedagogical Knowledge (PK)*	Teacher's knowledge of the characteristics of students
		Development of a learning implementation plan
		Class management
		Methods/models/strategies used in learning
		Assessment and evaluation of learning outcomes
2.	*Content knowledge (CK)*	The teacher's mastery of the subject matter or the substance of the material is broad and in-depth.
3.	*Technological Knowledge (TK)*	Teacher knowledge of what and how technologies, *software*, or applications can be used for learning
		Ability to adapt and learn new technologies
4.	*Pedagogical Content Knowledge (PCK)*	Knowledge of learning models/methods/approaches that are in accordance with the subject matter
		Proper learning planning to teach the subject matter to be given
		Knowledge of learning management in accordance with the material
		Knowledge of the solution to students' difficulties in the learning process
5.	*Technological Pedagogical Knowledge (TPK)*	Knowledge of the use of technology in learning management
		Knowledge of the advantages and constraints of technology related to pedagogical design and strategy
6.	*Technological Content Knowledge (TCK)*	The performance in determining and using technology to create new representations in transferring learning materials appropriately.
		Knowledge of the advantages and constraints of technology related to the characteristics of the learning material
7.	*Technological Pedagogical Content Knowledge (TPCK)*	Knowledge of combining the three components of basic knowledge, namely teaching content using appropriate pedagogical methods and technologies

METHOD

The type of research used is qualitative research with a descriptive approach. This study aims to describe *teachers' technological pedagogical content knowledge* in mathematics learning during the COVID-19 pandemic. This research will be carried out at SMP Negeri 1 Baraka, Baraka District, Enrekang Regency, South Sulawesi Province. The research participant was 2 class VIII mathematics teachers at SMP Negeri 1 Baraka, Baraka District, Enrekang Regency.

Data collection in this study began with disseminating the TPCK questionnaire for mathematics teachers who were *self-assessments* of the participant. Furthermore, data analysis of the results of the questionnaire was carried out. The way to analyze the questionnaire data is to use a percentage analysis of the results of the questionnaire answers converted into numbers. The number 5 to strongly agree, the number 4 to agree, the number 3 to neutral, the number 2 to disagree, and the number 1 to strongly disagree with the calculation of data analysis techniques using a percentage scale. The formula used is (Sugiyono, 2015):

$$Achievements = \frac{total\ score}{skor\ ideal} \times 100\%$$

for the interpretation of a given percentage, the researcher uses his scoring criteria based on intervals:

a. Very Good if the percentage obtained = 80% - 100%
b. It is good if the percentage obtained = 60% - 79.99%
c. It is enough if the percentage obtained = 40% - 59.99%
d. It is not good if the percentage obtained = 20% - 39.99%
e. It is not very good if the percentage obtained = 0% - 19.99%)

Then the researcher conducts an interview related to the results of the questionnaire filled out by the participant. Researchers also made observations related to the TPCK of mathematics teachers to see the realization or practice of the teacher's TPCK knowledge.

The data validity testing techniques used are (1) *credibility* test, (2) *transferability* test, (3) *dependability* test, and (4) *confirmability* test. Researchers use *credibility* tests with triangulation techniques, namely triangulation techniques or methods and triangulation of sources. Triangulation of this technique is used to check the validity of data on the knowledge of the two participants. In contrast, triangulation of this source is used to check the validity of the data on its implementation. The data analysis techniques in this study are in accordance with what was stated by Miles et al. (2014), namely: (1) data condensation, (2) data presentation, and (3) concluding.

RESULT AND DISCUSSION

Pedagogical Knowledge

Results of questionnaires and interviews:

1. **Pedagogical Knowledge 1**

The data from the questionnaire showed that the ability of the two participants to understand the characteristics of online learners had a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities was very good. Based on the interview transcript, the way participant 1 and participant 2 identify the characteristics of learners is by looking at the attendance and activeness of learners both through the attendance list and how students ask and respond to the online mathematics learning process. In addition, the second way the participant faces students with their various characteristics is to adjust the way of teaching and the media used. If there are students who ask questions, the participant adjusts the way students want to be guided, whether individually or in groups, or guided outside of class hours.

2. Pedagogical Knowledge 2

The questionnaire results related to the participant's ability to compile an online mathematics learning plan have a percentage of 100%, meaning that the participant's knowledge level in these abilities is very good. Based on the interview transcript, the lesson plan compiled by participant 1 and participant 2 is adapted to the current conditions and situations, both the conditions of the learners and the content of the natural environment and the obstacles experienced, such as the internet network. The prepared lesson plan still refers to the Ministry of Education and Culture regulations and the online learning curriculum but only has to complete some curriculum achievements. Participant 1 simplifies the lesson plan and adapts the method to the material and learning time.

3. Pedagogical Knowledge 3

The results of the questionnaire showed that the participant's ability to choose an online mathematics learning model/approach/strategy that is in accordance with the characteristics of students during the COVID-19 pandemic has a percentage of 100%, meaning that the participant's level of knowledge in terms of these abilities is also very good. Based on the interview transcript, the learning model used by participant 1 is discovery learning. The method is discussion and question and answers by conditioning the time and way of learning both in WhatsApp and *google classroom*; the participant sends the material on both platforms then participant 1 can explain the core introduction of the material. The learner gets the opportunity to learn, time to learn, and understand the material, after which the participant guides the discussion or question and answer. Meanwhile, the model used by participant 2 is an online learning model. There are several methods, such as discussion, question, and answer, or learning independently. The method used by the participant still adapts to the situation and conditions of the learner to understand the material to be taught.

4. Pedagogical Knowledge 4

The result of the questionnaire shows that the participant's ability to manage mathematics learning online has a percentage of 80%, meaning that the participant's level of knowledge in terms of impact is very good. Based on the interview transcript, the way participant 1 manages learning from beginning to end is to prepare students to enter the learning class either in *WhatsApp group* or *google classroom*, then open the learning process and direct students to fill out the attendance list, then participant 1 sends the material, then allows students to learn it and opens time for discussion. If students are embarrassed to ask questions in the group, they can ask questions via private chat or video call. If there is still time, then participant 1 gives a practice question or task, then the participant responds if there are learners who ask about the given task. Then, the way participant 2 manages learning is first to organize students to enter the learning platform, either *google classroom* or *WhatsApp group*; after that, students fill out the attendance list. Then participant 2 sends the material and allows the learners to learn the material independently. As well as being instructed to provide responses or questions if there is an unknown problem, participant 2 proceeds with the assignment.

5. Pedagogical Knowledge 5

The results of the questionnaire for pedagogical knowledge aspects 5, namely the participant's ability to compile assessment tools that are in accordance with the learning objectives, have a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the assessment compiled by participant 1 and participant 2 is an attitude assessment in the form of notes/observations during the learning process; for the assessment of knowledge and skills, the participant gives practice questions or tasks. In line with the assessment, one of the evaluations in online learning is to provide practice questions or assignments through *WhatsApp groups*, *google classrooms*, or *google forms*.

The results of observations related to pedagogical knowledge aspects:

Based on the results of observations on the lesson plan compiled by both participants, one learning objective and some learning syntax need to be listed. In addition to the above, the learning implementation plan (lesson plan) prepared by the participant is good and in accordance with the student's current situation and conditions. Several steps still need to be carried out in the learning process, and the learning model in the lesson plan needs to be in accordance with the model of learning. There is a lesson plan; participant 1 uses a discovery learning model, while in the learning process of the second meeting, participant 1 uses an expository learning model. Then, both participants tend not to convey the learning objectives clearly, not providing motivation or getting the benefits of studying the material in everyday life. The online learning process participant 1 uses varied learning methods.

Meanwhile, the learning method used by participant 2 is always the same. The two participants' strategies in the learning process are different, especially the strategy used by participant 1. The learning process is carried out predominantly in *the WhatsApp group* because most students easily enter the *WhatsApp group* class instead of *google classroom*. In contrast, participant 2 prefers to be dominant using *google classroom* because it finds it easier and easier to control the learners.

Content Knowledge

Results of questionnaires and interviews:

1. Content Knowledge 1
   The results of the teacher's TPCK self-assessment questionnaire showed that the participant's ability to have a good knowledge of the statistical material and the opportunities he taught had a percentage of 100%, meaning that the participant's level of knowledge in terms of these abilities was also very good. Based on the interview transcript, participant and participant 2 made maximum efforts to know the basics of the material to be taught, starting from theories and concepts to problems related to the material. To introduce the concept to learners, participant 1 associates statistical material and opportunities with daily life and occasionally directs learners to watch videos related to statistics and opportunities. Regarding the given statistical problems, learners are required to collect their daily math test scores. For opportunity problems, participant 1 directs learners to conduct experiments in their respective places or look for things related to opportunities.

2. Content Knowledge 2
   The results of the questionnaire for the content knowledge aspect 2, namely the participant's ability to compile statistical materials and opportunities that contain appropriate, accurate, and easy-to-understand information by students, have a percentage of 100%, meaning that the participant's level of knowledge, in terms of these abilities is very good. Based on the interview transcript, participant 1 compiles statistical material by adjusting the KD and the goals to be achieved. Material preparation, apart from the package book, participant 1 also takes sources/teaching materials from the internet. Participant 2 also takes sources/teaching materials from the internet and then compiles files by investigating whether the material is appropriate.

3. Content Knowledge 3
   The results of the questionnaire related to the last content knowledge are the participant's belief in his ability to teach the content of statistical material and the opportunity to have a percentage of 100%, meaning that the participant's level of knowledge in terms of these abilities is very good.

Based on the interview transcripts, participants 1 and 2 are confident about their ability to teach statistical material and opportunities based on educational background, length of teaching, and willingness to always learn and explore statistical material and opportunities to be taught.

The results of observations related to aspects of content knowledge:

Regarding the realization of the participant's knowledge of the content of the material taught, participant 1 explains the material or responds to questions through *the voice note* feature clearly and systematically. Meanwhile, participant 2's knowledge of the material content is not clearly visible in the learning process because the participant does not explain the material, provide feedback and responses, or draw conclusions related to the material. The participant compiles the material well, contains the correct information per the lesson plan, and is equipped with examples of questions and discussions. The language and terms used in the compiled material are also easy to understand by students; the material is equipped with pictures, graphs, and so on to make it easier for students to understand the material.

Technological Knowledge

Results of questionnaires and interviews:

1. Technological Knowledge 1

The results of the TPCK teacher self-assessment questionnaire showed that the technical skills possessed by the participant in using computers have a percentage of 90%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the form of technical skills in using a computer that participants 1 and 2 have is the use of Microsoft Office and sending ordinary files in the form of modules that the participant created in word document format or using power points. One of them also converts files with different formats.

2. Technological Knowledge 2

The questionnaire results related to the participant's ability to learn technology easily have a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, participant 1 and participant 2 learn new technologies by learning independently and sharing with peers who have more knowledge in the field of technology, as well as consulting with stakeholders.

3. Technological Knowledge 3

The questionnaire results showed that knowledge of how to solve one's technical problems related to the use of technology has a percentage of 100%, meaning that the level of knowledge of the participant in terms of these abilities is very good. Based on the interview transcript, participant 1 felt that there was a slight technical error in the learning process, but the problem did not interfere with the learning process. No technical problems occurred in the learning process of participant 2. Regarding how participants 1 and 2 solve their technical problems, i.e., continue to learn and explore using technology.

4. Technological Knowledge 4

The questionnaire results related to the participant's ability to follow the development of new technologies used today, such as digital technology that utilizes the internet network, has a percentage of 90%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, participant 1 continuously learns to correct mistakes, then learns to be independent by looking for information on developments on the internet or discussing with friends who have abilities in the field of technology. Cara participant 2 follows and

adapts to new technological developments, namely always learning and finding out the latest information independently through the internet, consulting with friends with good IT skills, and consulting with stakeholders.

5. Technological Knowledge 5

The questionnaire results showed that the participant's ability to use more than one online learning platform has a percentage of 100%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the way participant 1 and participant 2 use more than one online learning platform, namely using both in the learning process as a learning class, both a place to fill out the attendance list, send material that will be listened to by students, a place to give assignments and provide directions related to learning activities then two platforms, namely WA and *google classroom* it is also used simultaneously in the learning process.

The results of observations related to aspects of technological knowledge:

The participant can use two online learning platforms, such as WA and *google classroom* well; for *WhatsApp,* The participant can prepare the class before the learning process takes place, send material, and take advantage of features such as *voice notes*. For *google classroom,* the participant can create a class and invite students into the class, upload/send an attendance list, and send materials and assignments in class. Regarding the use of technology of software and hardware, the participant can use *Microsoft Office* and devices in the form of applications such as *WhatsApp, google classroom, YouTube, zoom,* and so on. Then for the hardware, the participant is able to use computers and *smartphones* well. In solving one's own technical problems related to the use of technology, the participant continuously learns to correct his mistakes independently, discussing with peers or stakeholders.

Pedagogical Content Knowledge

Results of questionnaires and interviews:

1. Pedagogical Content Knowledge 1

The results of the questionnaire showed that the participant's ability to overcome common misconceptions of learners regarding statistical material and the opportunity to have a percentage of 80% means that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, for example, if there are misconceptions related to concepts, then participants 1 and 2 teach the concept of the material in detail in depth and use appropriate procedures, and involve students actively, in addition to providing examples and non-examples. The participant also takes an overall or personal approach to correct the misunderstanding.

2. Pedagogical Content Knowledge 2

The questionnaire results related to the participant's ability to choose effective online learning models/methods/strategies to guide students in understanding statistical material, and the opportunity to have a percentage of 80% means that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the learning model used by participant 1 is online discovery learning. The method is to use the method of discussion and question and answer by conditioning the time and learning material. The learning model that participant 2 used is an online

learning model. There are several methods, such as discussion, question, and answer, or independent learning. The method used by participant 2 remains to adapt to the situation and conditions of the learners and adapt to the material.

3. Pedagogical Content Knowledge 3

The results of the questionnaire showed that the participant's ability to help learners to understand statistical material and opportunities in various ways has a percentage of 90% meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview results, one way participant 1 and participant 2 said: in helping learners understand the material is to choose learning media that are in accordance with the characteristics of the learners and the learning materials of statistics and opportunities.

4. Pedagogical Content Knowledge 4

The data from the questionnaire results related to the participant's ability to overcome general learning difficulties of students related to statistical material and opportunities in online learning have a percentage of 100% meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, learning difficulties are commonly experienced by students related to statistical materials, and there are only a few opportunities. The biggest obstacle is students' access to the internet network and inadequate devices to access the material. Participant resolution in facing student obstacles, namely choosing easy-to-reach learning media such as *WhatsApp* and *google classroom*.

5. Pedagogical Content Knowledge 5

The questionnaire results showed that the participant's ability to guide meaningful discussions so that students understand statistical material and opportunities in online learning have a percentage of 90% meaning that the participant's knowledge level in these abilities is very good. Based on the transcript of the interview, the way the two participants guide meaningful discussions is the opportunity for students to ask questions; for example, if there is a problem that cannot be solved or there is a topic that is not understood, the participant guides students to discuss finding solutions to these problems either on the *WhatsApp group* platform or *google classroom* so that all students can follow the discussion well and understand the material or topic being discussed.

6. Pedagogical Content Knowledge 6

The questionnaire results related to the participant's ability to engage learners to solve contextual problems related to statistical material, and the chance of having a percentage of 80% mean that the participant's knowledge level in these abilities is very good. Based on the transcript of the interview, participant 1 and participant 2 involve students in solving problems, for example, collecting the daily test scores of students' mathematics, then directed to find the average, mode, and so on, and give an experiment for example by throwing a dice or coin so that in that way in this way students can be actively involved in the learning all.

7. Pedagogical Content Knowledge 7

The questionnaire results related to the participant's ability to involve students in the online mathematics learning process actively have a percentage of 80%, meaning that the participant's knowledge level in these abilities is very good. Based on the interview transcript, participants 1 and 2 involve students in the online mathematics learning process to prepare students for entry into

learning classes. Then, before giving the material, the participant provides an apperception that opens the opportunity to discuss, ask questions, or responsibility regarding the material or the assigned task.

8. Pedagogical Content Knowledge 8

The questionnaire results showed the participant's ability to manage mathematics learning well so that students understood the material with a percentage of 100%, meaning that the level of knowledge in the participant's ability was very good. Based on the interview transcript, the way participants 1 and 2 manage learning from beginning to end is to prepare students for admission in class previously, then open the learning process and direct students to fill out the attendance list. The participant sends the material, gives students the opportunity to learn it, and then takes time for discussion. Participant 1 and participant 2 still guide learners to ask questions, if learners are embarrassed to ask questions in the group, they can ask questions via private chat or video call. If no one has asked questions related to the material, and there is still learning time, then participant 1 gives practice questions or assignments. Respondent 1 responds if there are students who ask questions related to the given task.

The results of observations related to pedagogical aspects of content knowledge:

The learning process takes place on two online learning media*/platforms*, namely *WhatsApp* and *Google classroom,* according to the conditions and situations of students. The participant can choose and apply learning methods according to statistical materials and opportunities. In addition to students learning independently, the participant also tries to guide discussions, questions, and answers. Still, the teacher should give a brief explanation or make students learn to find their understanding (*discovery learning*) by actively motivating students to be active in the learning process. In addition to the discussion, the participant also seeks to engage learners to solve problems related to statistics and opportunities. The problem in the form of the given question is good enough to measure the ability of the learner. However, it is not a contextual type of problem because the participant directly presents the data that is only solved using a formula.

Technological Pedagogical Knowledge

1. Technological Pedagogical Knowledge 1

The questionnaire results showed that the participant's ability to facilitate students to use technology in finding information during online learning has a percentage of 100%, meaning that the level of knowledge in terms of the participant's ability is very good. Based on the interview transcript, the way participant 1 and participant 2 use internet media as a varied learning resource leads learners to open other learning sites such as the teacher's room, YouTube, and learning house to obtain additional information.

2. Technological Pedagogical Knowledge 2

The questionnaire results related to the participant's ability to use the online learning platform well so that the learning process takes place effectively and has a percentage of 100%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the way participants 1 and 2 use online learning platforms such as WhatsApp, *google classroom*, and so on in the online learning process so that learning takes place effectively, namely learning adapted to students and the natural environment. Whether it is effective or not, the participant cannot guarantee that learning will take place perfectly. However, we still try our best to utilize technology to maintain the learning process.

3. Technological Pedagogical Knowledge 3

The questionnaire results showed that the participant's ability to overcome common obstacles to using technology in the online mathematics learning process has a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, how to overcome common obstacles to the use of technology in the online mathematics learning process, namely choosing easy-to-reach learning media such as WhatsApp and *Google Classroom*, approaching students to find out the problem if there are network problems, for example, the problem can no longer be solved, so the last solution is offline.

The results of observations related to aspects of technological pedagogical knowledge:

Realization of participant knowledge on the combination of technology and pedagogy, namely learning takes place on *WhatsApp* and *google classroom*, goes well without any obstacles that hinder the implementation of the learning process. The participant seeks to manage learning from beginning to end well. Participants use internet media to support learning and varied learning resources by directing students to access other learning resources such as teacher rooms, YouTube, learning houses, and so on to increase students' understanding. Participant 1 and participant 2 also use teaching aids in the form of learning videos to improve student learning motivation.

Technological Content Knowledge

1. Technological Content Knowledge 1
The questionnaire results showed that the participant's ability to use *software* explicitly made to understand statistical material and opportunities in the online learning process has a percentage of 40%, meaning that the participant's level of knowledge in terms of these abilities is sufficient. Based on the interview transcript, participant 1 and participant 2 used *Microsoft Excel* for statistical material while for opportunity material the participant did not use special software; the Participant only gave an example of a dice or coin-throwing experiment in the form of a learning video.

2. Technological Content Knowledge 2
The data from the questionnaire related to the participant's ability to know the right technology used related to statistical content or material and the opportunities taught to have a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the way participants 1 and 2 choose the correct media in delivering learning materials is to see online learning media/platforms that are easily accessible and often used by students. Their features can support the transfer of statistical materials and opportunities.

3. Technological Content Knowledge 3
The questionnaire results show that the ability to use online learning platforms and other appropriate supporting media to represent the content of statistical material and the opportunity to have a percentage of 80% means that the participant's knowledge level in terms of these abilities is very good. Based on the interview transcript, the way participants 1 and 2 use WhatsApp and *google classroom* to send material to students and then explain through *WhatsApp* features such as *voice*

notes or *video calls*, and the material presented is supported by other learning resources from the internet.

Observation results related to aspects of technological content knowledge:

Relating to the realization of knowledge of the participant about the use of technology in teaching content to learners. The participants have been able to use media that can represent the content of statistical material and opportunities because the media supports the feature of uploading or sending and downloading files in the form of document files in word, pdf, or video formats. Participant 1 also uses *the voice note* or voice message feature to explain the material and answer the learners' questions. Participant 1 and participant 2 do not use special *software* in the learning process to understand the material, both statistics, and opportunities.

Technological Pedagogical Content Knowledge

1. **Technological Pedagogical Content Knowledge 1**
   The questionnaire results showed that the participant's ability to develop the right online learning implementation plan by integrating content, technology, and pedagogy has a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, participants 1 and 2 compile the appropriate online lesson plan with reference to the syllabus and curriculum, adapting the media or technology used to the time and learning material. The lesson plan that the participant compiles contains a combination of content, technological and pedagogical aspects.

2. **Technological Pedagogical Content Knowledge 2**
   The results of the questionnaire related to the participant's ability to choose the right technology to improve the quality of the online learning process and make students understand the material being taught has a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the way participants 1 and 2 use the right methods and technology in teaching statistical content and opportunities is to teach it based on the lesson plan by considering how the technology is carried out, how the technology is managed, and adjusting to the content taught, for example, whether with the discussion method through WA The participant can convey statistical material and opportunities well to students or other methods that are adapted to the material and technology used.

3. **Technological Pedagogical Content Knowledge 3**
   The questionnaire results showed that the participant's ability to use the right strategies in combining content, technology and teaching methods in the online mathematics learning process has a percentage of 80%, meaning that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the strategy used by participant 1 in combining content, technology, and learning / pedagogic management in the online mathematics learning process is to use WhatsApp predominantly. Still, the participant also pays attention to classes in *google classroom* to conduct discussions and take advantage of the features of existing online learning platforms. The strategy used by participant 2 is predominantly using *google classroom.*

4. **Technological Pedagogical Content Knowledge 4**
   The data from the questionnaire related to the participant's ability to conduct assessments and evaluations by combining technology, pedagogics, and content has a percentage of 80%, meaning

that the participant's level of knowledge in terms of these abilities is very good. Based on the interview transcript, the way participant 1 and participant 2 conduct assessment and evaluation are that there are several ways used both in learning poses and at the end of learning, for example, observations or notes participant regarding student attitudes while practicing questions and assignments for the assessment of knowledge and skills of learners, For end-of-semester assessments using *google form*.

Observation results related to the aspects of technological pedagogical content knowledge:

Related to the combination of technology and pedagogic to teach the content of learning materials is excellent. The participant considers technology, for example, *what* learning platform is suitable for teaching the material, then adapts it to the learning model or method. Participant 1 performs the process of filling out the attendance list on both platforms, while participant 2 is only in *google classroom*. Still, the media chosen by the participant is already quite good in supporting the provision of statistical and opportunity materials. Although the selection of media used is good, there still needs to be appropriate methods to maximize the use of technology in the form of WA and Classroom media.

The strategies used in combining content, technology, and teaching methods in the learning process for participant 1 are quite good, while participant 2 of the observation results still needs improvement. The online lesson plan that the two participants have prepared obtained that the lesson plan compiled is in accordance with the characteristics of students and learning materials. Assessment consists of an assessment of attitudes assessed through observation at the time of learning, as well as an assessment of knowledge and skills in the form of written assessments and assignments. However, overall TPCK teachers are still at a sufficient level, meaning that teachers can use technology, pedagogics, and content separately, but integrating pedagogical, content, and appropriate technology needs to be improved.

CONCLUSION

The *knowledge of technological pedagogical content knowledge* (TPCK) of mathematics teachers is very good from the aspects of lesson plan preparation and assessment, learning management, selection of technology or learning media used, mastery of teaching materials and other TPCK parts, as well as knowledge about the combination of technological, pedagogic and content aspects. As for the realization of this knowledge, some aspects still need to be improved, such as components in the lesson plan that are not complete, the learning process that is not fully in accordance with the lesson plan, the methods and strategies used have not been maximized to make the learning process effective and make students understand statistical material and opportunities. The process of guiding discussion and question and answer is maximized, and the participant needs to explain a little material or make the learner find his understanding. The participant should be even more active in utilizing learning aids/supports and this software/application is made specifically to understand statistical material and opportunities. The participant can use technology, pedagogy, and content separately, but combining the use of pedagogic content and the use of appropriate technology simultaneously needs to be improved.

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