The Descriptions of TPACK Oriented Mathematics Learning for Elementary Students

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Abstract

The teachers' online teaching competencies play a crucial role in the COVID-19 era, as those who are unprepared to use technology in the classroom experienced difficulties in designing and conducting the class. This research aims to describe the implementation of mathematics learning that is oriented, pedagogical content knowledge (TPACK) of elementary school teachers. The research was conducted in the city of Bukittinggi, involving 6 elementary schools, 6 teachers, and 12 students. This research is a qualitative descriptive study. The research method is in the form of a survey. Data collection techniques used are literature studies, interviews, and questionnaires. The data obtained were analyzed using descriptive analysis. The results of this research indicated that teachers have implemented TPACK approach which includes the planning, implementations and assessment processes. The teacher has implemented the TPACK-based learning process in learning mathematics. The learning process is structured by combining technological tools during the planning, implementation, and assessment processes. Teachers equip students with technology-based learning

resources and teaching materials. During TPACK teachers were facilitated to access information for teaching references. The use of technology gives a positive impact on learning and creates an enjoyable learning experience for the students. This research also encourages further research that can improve the quality of TPACK-based digital learning implementation.

Keywords: Covid-19, Teacher, TPACK, Mathematics, Survey

Abstrak

Kompetensi pendidik pada masa new era Pandemi Covid 19 menjadi sorotan penting, pendidik yang belum siap menggunakan teknologi akan mengalami kesulitan dalam mendesain serta melaksanakan pembelajaran dikelasnya. Penelitian ini bertujuan untuk mendeskripsikan pelaksanaan pembelajaran matematika yang berorientasi pada technological, pedagogical content knowledge (TPACK) guru sekolah dasar.Penelitian dilakukan di kota Bukittinngimelibatkan 6 SD, 6 guru dan 12 siswa sebagai. Penelitian ini merupakan penelitian deskriptif-kualitatif. Metode yang digunakan dalam penelitian ini adalah metode penelitian survei. Teknik pengumpulan data yang digunakan adalah studi literatur, wawancara, dan kuisioner. Data yang diperoleh dianalisis dengan menggunakan analisis deskriptif. Hasil penelitian ini menunjukkan bahwa guru telah menerapkan pendekatan TPACK yang meliputi proses perencanaan, pelaksanaan dan penilaian. Guru telah menerapkan proses pembelajaran berbasis TPACK dalam pembelajaran matematika. Proses pembelajaran disusun dengan menggabungkan perangkat teknologi selama proses perencanaan, pelaksanaan dan penilaian. Guru membekali siswa dengan sumber belajar dan bahan ajar berbasis teknologi. Selain itu, penggunaan teknologi dalam pembelajaran matematika di sekolah dasar memberikan dampak positif kepada siswa. Sehingga pembelajaran matematika menjadi lebih menyenangkan dan mengasyikkan. Penelitian ini juga mendorong penelitian selanjutnya yang dapat meningkatkan kualitas implementasi pembelajaran digital berbasis TPACK.

Kata Kunci: *Covid-19, Guru Sekolah dasar, TPACK, Pembelajaran Matematika*

INTRODUCTION

The advance of technology is evolving rapidly, and as a result, teachers and prospective teachers are required to master technology and use it to support learning instruction. For this reason, blended learning, which is suggested by NACOL (North American Council for Online Learning), is widely used nowadays (Powell & Patrick, 2006). Blended learning is a learning model that integrates

technology in the learning process so that learning becomes more meaningful (Darma, Karma & Santiana, 2020). This learning combines face to face learning with technology-based learning or online learning (Hockly, 2018; Shu & Gu, 2018; Hrastinski, 2019). Instead of focusing on face-to-face interactions in the class, this method uses internet-based technology (online learning) to support learning.

Due to the COVID-19 pandemic in Indonesia, starting in early March 2020, teachers, students, and parents are conditioned to adopt the distance learning method as an effort to avoid the spread of the virus in schools. Various applications and technologies are used as tools to support learning activities (Wijanarko & Ganeswara, 2021). One of the learning tools is the framework of *technological pedagogical content knowledge* (TPACK) (Schmidt et al., 2009). TPACK is a learning model that focuses on utilizing education system implementation which emphasizes on technology and certain content in teaching-learning process. As stated by Brinkley & Eizkorn (2018), TPACK is an integration of technical knowledge, pedagogical knowledge and content knowledge.

TPACK can be seen as a process of delivering learning material or content using technology with appropriate delivery techniques or pedagogical abilities so that learning can be understood by students well (Shamir-Inbal & Blau, 2016). Every school in Indonesia prioritizes students' safety and took preventive measure to ensure teaching-learning process to proceed well during the COVID-19 pandemic. The elementary schools in Bukittingi conducted distance learning to accommodate mathematics learning.

The learning method utilized was Edmodo Learning Management System (LMS) (Helsa & Kenedi, 2019). Edmodo is one of the best learning websites that provides innovation to communicate in the online learning process (Almoeather, 2020). Several schools have used Edmodo before the pandemic, and for these schools, there are no significant difficulties in conducting distance learning during the pandemic. However, most schools, teachers, parents, and students were not familiar with the fully online learning method. Problems include teachers who try to help students to learn from home, but they do not know which strategies that could help the students to comprehend the mathematical concepts.

Utilizing technology to conduct online based learning is the best suitable solution to proceed with teaching-learning process during pandemic era (Mailizar

et al., 2020). An effective and appropriate use of technology in conducting online learning could help students to learn better (Mulenga & Marban, 2020; Perienan, 2020). Not only students, but also teachers could benefit from cost efficiency, time, ease and safety. According to Indonesian Ministry of Education & Culture (2021), online-based distance learning caused great impact on students' low learning outcomes. It believed that one of the crucial factors, which affecting learning outcomes in online mathematics learning, is teachers' role. Baier & Kunter (2020) also explained that both teachers' professional skills and the quality of presented materials are two important factors that lead to students' achievement

In regulation of Indonesian Minister of Education and Culture No. 16 2007 on Qualification and Standard Competency for Teachers was explained that a teacher must master 5 basic competences. 1) Mastering learning materials, structure, and field of knowledge which support the subjects being taught. 2) Mastering standard competence and the subject basic competences. 3) Developing teaching materials. 4) Developing professionalism through continual reflective action. 5) Utilizing technology and communication to hone skills. Hence, those five competences indicate that teacher should have broad knowledge and master technological knowledge, pedagogical knowledge, and content knowledge. It is known as *Technological Pedagogical Content Knowledge* (TPACK).

Distance learning is in line with the use of technology. Therefore, online teaching and online learning need enhanced competences (Mulenga & Marban, 2020). It includes the knowledge in integrating TPACK. This article aimed to describe the implementation of *Technological Pedagogical Content Knowledge* (TPACK)-based in mathematics learning for elementary school teachers. This article is expected to contribute to Indonesia education especially for TPACK development. In addition, it could be a reliable reference in improving elementary school teachers' competences during distance learning using online method.

METHODS

This is a descriptive qualitative research using the survey method. The research was conducted in several elementary schools in Bukittinggi. The schools were chosen based on the School National Exam (USBN) scores in academic

years 2018/2019, which was obtained from Bukittinggi Education & Culture Department. Out of 49 schools, six were selected, which based on their school national exam scores. It consisted of high, intermediate and low score with 2 schools represented each category. One teacher and and two students from each category participated as research subjects. Hence, the total sample are 6 schools, 6 teachers and 12 students.

Data collection techniques include 1) literature review, by collecting references from printed and digital media in the form of books, articles, and journals relevant to TPACK; 2) interviews, which is a preliminary data collection technique to find problems to be studied (Sugiyono, 2017); and 3) questionnaires, which is a data collection technique carried out by delivering a set of written questions or statements to be answered by the respondents (Sugiyono, 2017). Data were collected through the questionnaire distributed online using a Google Form This research used descriptive analysis to describe TPACK implementation at six chosen schools in Bukittinggi. The participant was told the research objectives and joined voluntarily. The schools' board openly welcomed this research. The three instruments used were in-depth interview, documentation, and online questionnaire. The in-depth interviews conducted with 6 teachers and 12 students followed interview guide that was approved by experts.

The participants were informed about the purpose of the study and they agreed to participate voluntarily. This study was approved by the school ethics committee. This study uses a qualitative phenomenological approach because the researcher seeks to reveal the participants' experiences in situations and phenomena from a personal perspective. The purpose of this study is to capture the experiences of lecturers and students in the phenomenon of TPACK at the primary school level. This study used three data collection instruments, namely: in-depth interviews, documentation studies and online questionnaires. Interview In-depth interviews were conducted with four lecturers using interview guidelines that have been validated by experts. The focus of the interview is to explore how TPACK has been implemented, from preparation to implementation and evaluation. Interview questions begin with open-ended questions such as "What was an important experience for you when doing TPACK?" After that, the questions were continued based on the responses from the participants. All

questions focus on the implementation of TPACK conducted by the participants for a full semester. Interviews were conducted with each for approximately 20 to 30 minutes. Interviews were recorded and then transcribed for analysis. The online learning process is carried out on materials related to mathematical concepts, while the face-to-face learning process is carried out if the material topics are related to practice and exercises. Online and face-to-face learning has a 50:50 share. The questionnaire used in this study aims to measure student experience in TPACK. All of these statements were developed by researchers based on indicators regarding student experience in TPACK according to Koehler (2009) which includes psychological, attitude, and emotional experiences. All items made were reviewed by two experts in the fields of TPACK and mathematics.

These items were then tested on 20 students to measure the level of readability. Participants were asked to provide a brief description of their experience following TPACK. Data Analysis Data obtained from interviews were analyzed using thematic analysis. The data are categorized based on the psychological, attitude, and emotional experiences of the participants in implementing TPACK. The results of the interview transcription were read over and over again to obtain coding which was then classified based on the classification of experience. For the lesson plan, the researcher examines the activities carried out by the lecturer in one semester of learning. The form of activities carried out will be analyzed. For the questionnaire, participant responses were made in terms of the frequency of statements covering the three dimensions above.

RESULTS AND DISCUSSION

The literature study results showed that Technological Pedagogical Content Knowledge (TPACK) concept was introduced by Koehler and Mishra in 2006. Pedagogical Content Knowledge (PCK) developed by Shulman in early 1986 served as ground work for Koehler and Mishra in developing TPACK framework further. According to Koehler, Mishra, Akcaoglu & Rosenberg (2013), TPACK is a framework to integrate technology in teaching. The three main knowledge in TPACK are technological knowledge, content knowledge, dan pedagogical knowledge. Koehler, Mishra, Akcaoglu & Rosenberg (2013) showed an interaction between these knowledges which were illustrated in Figure 1.
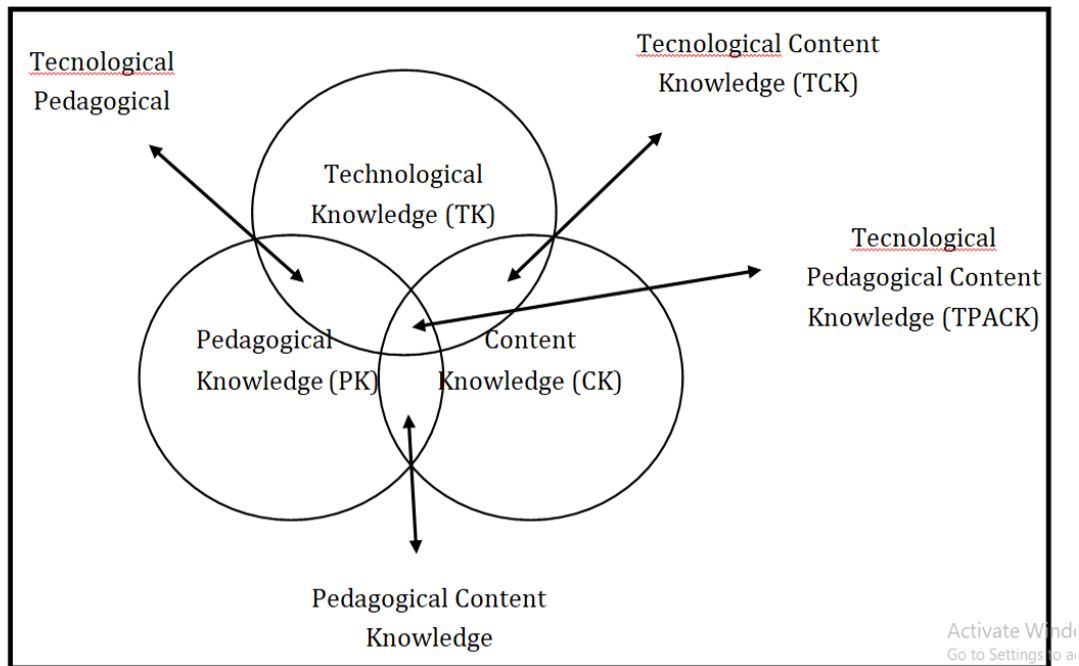
Figure 1. TPACK Framework Koehler et al (2013)

Technological Knowledge (TK) is an understanding on how to use computer softwares and hardwares, presentation equipment, traditional and latest technology in education field. It is an obligatory skill needed to keep up with the current trends and technology. Next, Content Knowledge (CK) is specific knowledge on certain subject or learning materials. Possessing the right approach for certain problem would make teachers gain advantage. Hence, it determines how to applied specific content on specific needs. Pedagogical Knowledge (PK) is teacher skill on managing and organizing materials and learning activities to achieve learning objectives. Meanwhile, Pedagogical Content Knowledge (PCK) combines content and pedagogical. Therefore, it covers an understanding on how topics, problems, and issue are organized, presented, adapted and delivered in learning for various students' ability or interest.

Technology Content Knowledge (TCK) is a mutual relation between technology and content. Technology introduces new fresh approaches, which was difficult to manifest with the traditional approach, on how to present interesting content or learning materials. Technology Pedagogical Knowledge (TPK), which

is also a mutual relation between technology and pedagogy, helps teachers to determine the right approach or digital tools to achieve pedagogy objectives.

Technology Pedagogical Content Knowledge (TPACK) described as synthesis knowledge drawn from several knowledge, (TK, CK, PK, PCK, TCK, TPK). It emphasizes on how technology is made to fulfill pedagogy needs in choosing the right method for teaching certain subject or content. TPACK framework also serves as theory and concept for researcher in measuring teachers or teachers' candidate preparation to use technology effectively. Rosyid (2016) argued that TPACK had huge impact on teachers since technology, pedagogy and content are indivisible. Hence, teachers face a great challenge of shifting changes in technology, pedagogy, learning material and classroom content. The upper rank, teacher's educator, also plays a major role in providing learning approaches and guiding teachers on how to integrate technology into their teaching.

Questionnaire Results.

The study was conducted by distributing questionnaires to teachers and students. The results of questionnaires distribution are as follows:

a. 80% of teachers designed the lesson plans with elements of technology.

b. 100% of teachers have conducted syllabus reviews in preparing lesson plans for mathematics learning.

c. 80% of teachers chose a technology-based approach that is appropriate for learning mathematics in elementary school.

d. 80% of teachers stated that they have chosen appropriate strategies and modes of technology for mathematics learning activities in schools.

e. 80% of teachers stated that they presented mathematical concepts using technology.

f. 80% of teachers used the Internet to facilitate the learning of mathematics in schools.

g. 80% of teachers designed the learning process by applying TPACK.

h. 80% of teachers used technology-based learning resources during the learning process.

i. 80% of teachers used tools that support the TPACK-based learning process.

j. 80% of teachers carried out the learning assessments of mathematics using the TPACK system.

Questionnaire results showed that 80% elementary school teachers in 6 different schools in Bukittinggi have integrated technology to their teaching. It also displayed an interaction among Technological Pedagogical (TP), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), and Technological Pedagogical Content Knowledge (TPACK) in teaching-learning process.

INTERVIEW FINDINGS

From the results of the questionnaire distribution, it can be concluded that the mathematics teachers have applied the TPACK approach that includes the processes of planning, implementation, and assessment. The questionnaire results are also supported by the results of researchers' interviews with the teachers in elementary schools. From the interview, it can be concluded that the teacher has implemented the TPACK-based learning process in mathematics learning. The learning process is arranged by combining technological tools during the planning, implementation, and assessment processes. In addition, the interviews also found that teachers also provided the students with learning resources and technology-based teaching materials.
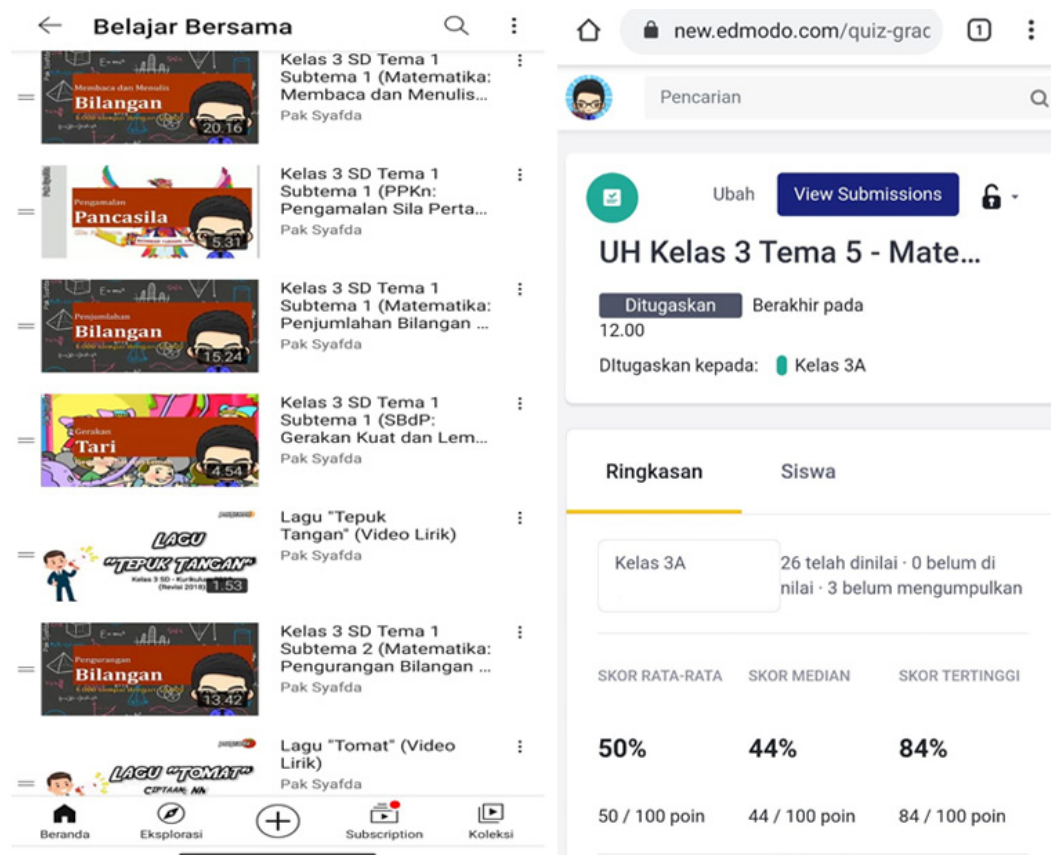
Figure 1(a)(b). Media Used by Teachers

Based on Figure 1(a) above, the teacher not only uses Edmodo but also other resources such as YouTube. This web-based service allows users to download videos that can be shared with other people (friends, students, educators) through social media during learning. YouTube is also very practical and user-friendly. Through YouTube, the online teaching and learning process becomes as practical as inserting the URL of a selected video from a YouTube channel. Teachers can also have their own YouTube channels and create contents that help students to collaborate. Srinivasacharlu, (2020) stated that the benefits of YouTube as a learning medium are as an interesting learning resource, providing learning videos that are audio-visual in nature, can be studied and watched repeatedly, and are easy to share. In addition, today's learning activities could not be separated from smartphones. Utilizing YouTube as one of the learning media alternatives during this pandemic is a perfect solution. Teachers can also creatively modify

their YouTube content and adapt it to fit the learning content. In short, YouTube is a powerful learning tool despite its shortcomings. Several studies have shown that the use of YouTube as a learning medium in general has a positive impact on learning (Maziriri et al., 2020; Buzzetto-More, 2015). Teachers should be able to use YouTube in learning and try to prevent its negative impact.

Figure 1(b) above shows that students can do their daily assessments using the Edmodo application since Edmodo is available for smartphone use. Edmodo helps teachers who are unable to teach in the class to provide online learning materials by uploading them. Teachers can upload assignments and schedule its deadline and assessments. Using Edmodo also helps teachers conduct classes online, interact with students, monitor students' activity in groups, and conduct evaluations, as this application also allows students to take online exams. Students can take the exam at any place according to their location. However, there are some drawbacks to using Edmodo. Some students receive higher scores on the exam not solely for their abilities since they are helped by their parents or relatives during the evaluation. Another drawback of Edmodo is that the application does not allow teachers to disable students to send private messages among themselves. The following are the results of interviews with teachers:

Researcher : What was your preparation to conduct mathematics learning during COVID-19 pandemic era?

Teachers : We participated in several online webinars which discussed on how to conduct online learning during COVID-19 pandemic era. Then, we prepared the suitable teaching materials.

Researcher : What kind of strategy did you use to teach mathematics during COVID-19 pandemic era?

Teachers : I tried several strategies. The recent approach was using online learning platforms, such as Edmodo, Google Classroom, Youtube, Whatsapp and Zoom Meeting.

Researcher : What were the obstacles found in mathematics learning during COVID-19 pandemic era?

Teachers : We encountered lots of problem. Inaccessible internet connection, low students' participation and feedback during

online discussion, lack of support from students' environment, and several students did not own smartphone.

Researcher : What had you done to solve those problems?

Teachers : We made and printed teaching materials, shared the handout at school, asked the students' family to retrieve it, create learning video using power point, and sent the learning videos link on Youtube to make it accessible for every student.

Researcher : How did you sort out the appropriate learning materials taught to students?

Teachers : We followed the current curriculum standard.

Researcher : How did you deal with the students who do not understand the materials delivered on your online learning?

Teachers : Each class had their own WhatsApp group. If any student did not understand the topic explained in online learning. They could ask in that group.

Researcher : How did you conduct the assessment in mathematics learning?

Teachers : We used Edmodo, Google Classroom, Schoology and Google Form.

Researcher : Did you use TPACK for students' assessment?

Teachers : No, We do not even know what TPACK is.

Based on the in-depth interview results, it lead to conclusion that these elementary school teachers have implemented TPACK-based digital learning at school during COVID-19 pandemic era. Several learning platforms used are Edmodo, Google Classroom, Youtube, WhatsApp, and Zoom Cloud Meeting. The teachers agreed that technology could facilitate teaching-learning process. Thus, teachers should understand TPACK better in integrating technology into teaching-learning process. One of encountered problems was students failed to understand learning materials uploaded on Youtube. Teachers could explain how to use online platforms during face-face learning section at school. Teachers hoped that an intensive workshop or training shall be held to help them understanding

how to implement TPACK-based digital learning on primary level. Fortunately, several teachers have practiced Edmodo online platform before COVID-19 hit. So, during the pandemic, they have a chance to hone their skills. They are able to create learning videos, upload to Youtube & Edmodo, and even gain access to students' assessment using Edmodo.

Students were also participated in-depth interviews to obtain students' perspective on TPACK-based learning. The answered are varied. Students were more engaged when learning new subjects on Youtube and Edmodo. If they encountered difficulty, they would ask their teachers directly on WhatsApp group or others online learning platforms. They did homework and took pictures or videos of assignments at home under parents' supervision. Then, they sent it to their teachers before due time. All exams are conducted through online learning platforms, such as: Edmodo and Google Forms. Admittedly, some students prefer face-to-face classroom. To ensure the teaching-learning process runs well, both students and teachers should independently improve themselves using technology in learning process.

Based on the results and discussion above, the elementary school teachers have implemented TPACK in online teaching-learning process during COVID-19 pandemic era though they did not aware what TPACK was. The elementary school teachers in Bukittinggi are able to choose specific strategy that suitable to teach mathematics through online learning during COVID-19 pandemic era, able to use various strategies related to mathematics concepts through online learning, able to solve software and connection problems, able to follow the current online teaching platform, able to select appropriate learning materials based on curriculum standards, able to plan mathematics concept systematically, able to utilize video technology to demonstrate certain concepts for mathematics materials, able to use tools to assist them in online teaching, able to solve students' misconceptions, able to bridge students' concept understanding, able to create technology-based learning to improve students' knowledge and skills, able to use online assessment. Those results have proved that these elementary school teachers have integrated TPACK in their teaching-learning process. Moreover, they have had sufficient understanding about tecnological knowledge, content knowledge, dan pedagogical knowledge.

Willermark (2017) strongly believed that TPACK is a new kind of knowledge needed to integrate technology into learning activity. In addition, Koehler & Mishra (2009) also argued that TPACK urged the importance of implementing it into teaching-learning process, and improving teacher's knowledge in integrating technology into competence-based curriculum. TPACK facilitates teachers to explore learning strategy since they have to comprehend teaching model, method and strategy. (Voogt et al., 2012). TPACK also drives teachers to understand the learning materials better (Harris & Hofer, 2011). In brief, using technology brings positive impacts for students since they experience a new interesting learning method.

Based on the interviews with elementary school teachers, it can be concluded that elementary school teachers have started implementing TPACK-based digital learning in schools, especially during this pandemic. Some of the platforms and websites used include Edmodo, Google Classroom, Youtube, Whatsapp, and Zoom Cloud Meeting. The teachers agreed that technology can help facilitate the learning process. Therefore it is important for teachers to have a good understanding and ability of TPACK. In integrating technology into the learning process, some of the obstacles experienced by teachers include students not understanding the learning material provided through learning videos uploaded on YouTube or to WhatsApp groups. To overcome this, teachers need to explain further using online learning platforms and in schools directly when learning face-to-face. Teachers also hope that there will be training for teachers to be able to improve TPACK's ability to implement digital learning at the elementary school level.

Some teachers have also implemented digital learning using the Edmodo application before the pandemic. So that during the pandemic, the implementation of digital learning is further improved. Teachers can make learning videos and upload them to YouTube and Edmodo. Learning and assessment can be done using the Edmodo application. The assessment process using the Edmodo application can be seen in the image below.
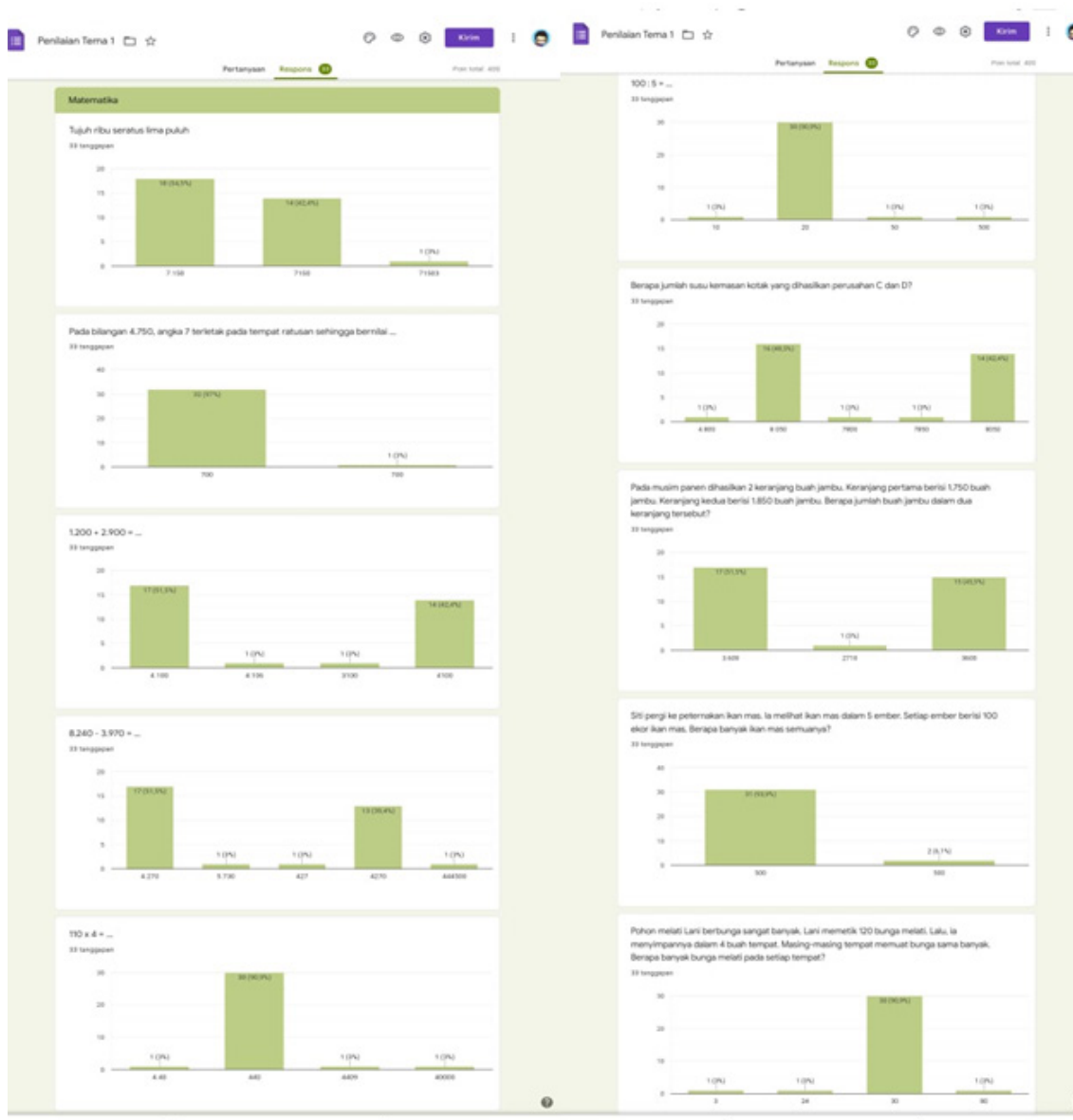
Figure 2 (a)(b). The Process of Assessment Using Edmodo LMS

Figure 2 above shows that the theme 1 assessment of mathematics lessons has 33 responses. The graph shows several math problems that students solved. Based on the finding on the assessment process, it is shown that TPACK has been integrated into the learning process. Jang & Tsai (2012), suggested that since teaching and learning express a reciprocal relationship, the changing perspectives of elementary school students on mathematics and science in the context of ICT-based learning also affect the implementation of ICT- based strategies the teachers

use in teaching mathematics and science. Furthermore, researchers have studied the TPACK development in-service science teachers (Guzey & Roehrig, 2009; S. J. Jang, 2010)and in-service mathematics teachers (Lee & Hollebrands, 2008). This study indicates that TPACK is implemented in mathematics learning, as teachers integrate more technology-related tools into their teaching. A possible reason may be that the teachers want to improve technological knowledge, and their knowledge of technology integration, content, and teaching strategies. Therefore, it is important to collect further qualitative data to verify this predictive reason and better understand whether mathematics teachers use more technology than teachers of other subjects.

As shown in **Figure 3** above, there are 33 respondents for the assessment of theme 1. Below is the continuation of the graph.
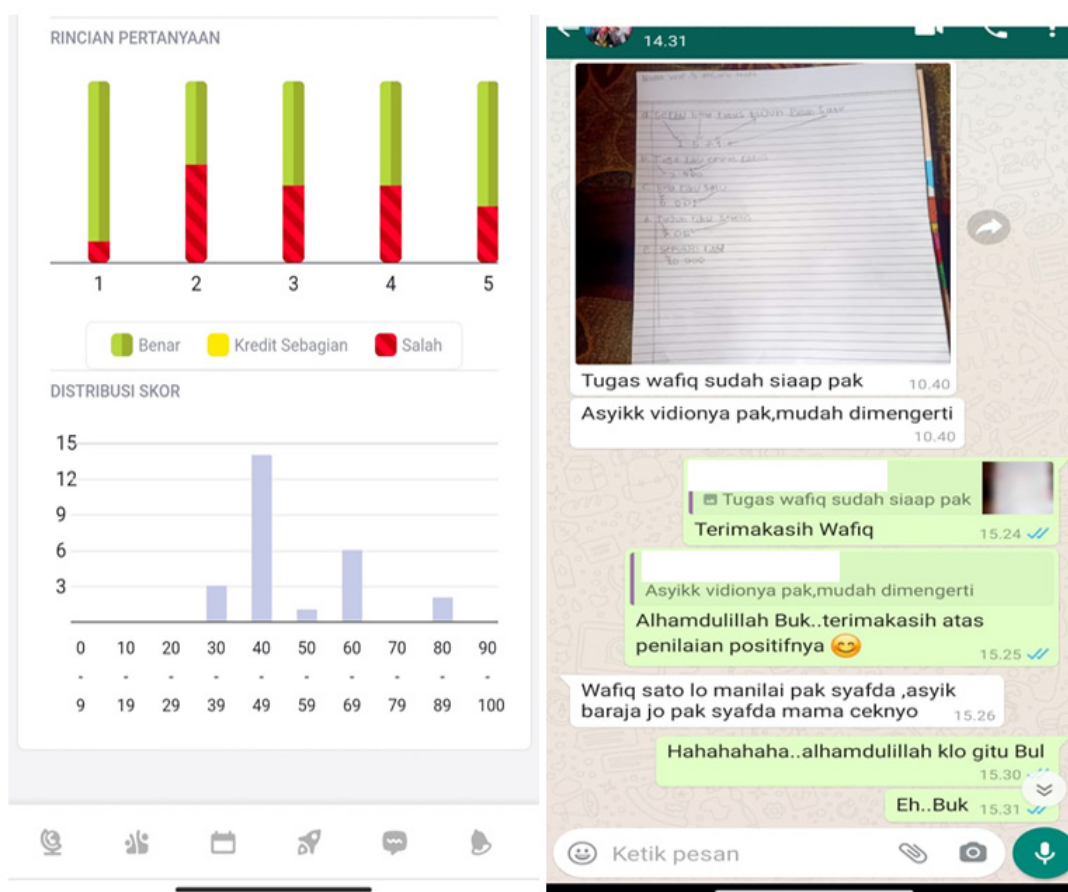

Figure 3 (a)(b). Question Details and Distribution of Student Score

Based on **Figure 3** above, according to the details of the questions given by the teacher, many students still received low scores. Of the 5 questions given by the teacher, on average many students still answered each question incorrectly. Most of the elementary students' scores ranged from 40-49, which is categorized as low. A possible explanation would be that the students are not yet independent learners. From the results of the questionnaire distribution and the interviews, it is concluded that the teachers have integrated TPACK into mathematics learning. To see how students, perceive learning using TPACK-based technology, several elementary school students were also interviewed. The documentation process with these elementary students can be seen in the images below.

Based on interviews, it can be concluded that students enjoy learning to use learning videos from YouTube and Edmodo. Students learn to use these learning videos, if something is not understood, students can ask the teacher via WhatsApp or other online learning platforms. Then for assignments, students do it at home and then take a photo and send it to the teacher. Meanwhile, the exams are conducted using applications such as Edmodo and Google Forms. However, there are also some students who prefer face-to-face learning at school. In order to be able to run online learning well, of course it takes the ability to use technology. Therefore, both teachers and students need to improve their ability to use technology for the learning process.

TPACK is a knowledge needed by teachers in integrating the learning activity with technology (Willermark, 2017). TPACK is important to be implemented in the learning process as it increases teachers' knowledge in integrating technology into the curriculum with skills-based references (Koehler & Mishra, 2009). TPACK also develops teachers' abilities in improving the learning strategies since teachers are facilitated to comprehend the models, methods, and strategies in the learning process in TPACK (Voogt et al., 2012). TPACK also facilitates teachers to have further understanding about the learning material to be delivered (Harris & Hofer, 2011). As teachers are facilitated to discover knowledge through new references during the process. The use of technology in teaching and learning has brought a positive impact on students, as it helps create more fun and exciting learning experience.

CONCLUSION

TPACK has proven to be beneficial in the learning process since it increases the teachers' knowledge in integrating technology into the curriculum with skills-based references. The teachers in this study have implemented the TPACK well, albeit experiencing some difficulties in the process. Furthermore, Edmodo LMS is proven to be a suitable learning solution during the pandemic. Utilizing technology in learning has brought a positive impact on students, as it helps to create a fun and exciting learning environment. This study also encourages further research to improve the quality of the implementation of TPACK-based digital learning.

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