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TEACHER LEARNING MANAGEMENT: INVESTIGATING BIOLOGY TEACHERS' TPACK TO CONDUCT LEARNING DURING THE COVID-19 OUTBREAK

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ABSTRACT

Adaptation of new habits in many aspects of life, including education, is required amid the COVID-19 outbreak. Many countries, including Indonesia, suddenly implement online learning as a realization of social distancing policies. This sudden change in the learning system has become a challenge for teachers. They must be able to integrate technology, pedagogy, and content knowledge to conduct online learning well. Therefore, this study investigates the readiness of biology teachers to face online learning based on their Technological Pedagogical Content Knowledge (TPACK). The purposive survey method was used by distributing questionnaires and conducting online interviews. The questionnaire consists of 30 statements about the TPACK readiness of biology teachers and ten questions about the online learning process during the COVID-19 outbreak. A total of 121 biology teachers in West Java, Indonesia, participated in this study. The findings indicate that biology teachers have sufficient TPACK skills in implementing online learning. However, their technological capabilities still need to be improved. The flexibility of place and time, availability of learning resources, and increased independence of teachers and students in using technology are the advantages of online biology learning during the COVID-19 outbreak. Meanwhile, the problems faced by teachers include technical connectivity and student honesty in taking exams in the implementation of online learning. The uncertainty of when the pandemic will end makes this study important to carry out for evaluation and potential improvement of online biology learning systems.

Keywords: Biology learning; COVID-19; online learning; TPACK

INTRODUCTION

As COVID-19 spreads to many countries worldwide, education activists face a significant challenge to keep learning amid disruptive COVID-19 (Huang, 2020). The government enforces the policy to put a restriction on the number of people in public places. Such a policy has disrupted the normal function of schools and universities and was implemented indefinitely. This outbreak is not the first time conventional educational activities have been suspended. Therefore, educational institutions' leaders need alternative methods so that teachers and students can continue their learning process (Reimers et al., 2020).

The SARS Coronavirus (SARS-CoV) also harms conventional educational activities in most countries around the world. It forces academic experts to reconsider the conventional learning method (face-to-face learning) and begin to shift to distance online learning as a viable option for learning before conventional activities can be continued (Adnan & Anwar, 2020; Pratama et al., 2020). There has been a sudden and massive shift from conventional learning to online learning using the Internet. Some schools may have

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adequate educational technology and cultural infrastructure, making such changes normal for them. However, others find that this shift will be a significant dislocation for teachers and students in providing education (Sandars et al., 2020). This gap occurs in almost all countries, including Indonesia.

The Indonesian government implements a distance learning policy using an online system or the School from Home (SFH) system. It transforms face-to-face learning into learning from home. Based on the regulations of the Indonesian Ministry of Education and Culture, in the implementation of online learning, schools can change the target online learning output to suit the demands of meaningful learning. Thus, students are not burdened with the online learning process (Rasmitadila et al., 2020). This challenges teachers, including biology teachers, to conduct online learning.

Technology has brought new challenges to teachers in learning, including how to develop technical knowledge and to integrate it with content, teaching, and learning in a specified context. The technology referred to is the technology that can help teachers represent concepts, principles, or laws. Therefore, teachers should have competencies that include content knowledge, pedagogical knowledge, technological knowledge, or TPACK (Oliver, 2011; Voogt et al., 2013; Sang et al., 2016). Lack of teachers' TPACK and skills will lead to ineffective learning. This problem is essential to be solved.

The TPACK framework combines technology with Shulman's work, namely Pedagogical Content Knowledge (PCK). Shulman explains that pedagogy and content are related to the effectiveness of teaching (Shulman, 1986). His work bridges the debate about the importance of content knowledge compared to pedagogical knowledge (Young et al., 2012). Mishra and Koehler then describe a model to answer the teacher's need to understand how technology, pedagogy, and content can limit each other (Koehler & Mishra, 2005b; Mishra, & Koehler, 2006). Bringing technological sophistication to the educational process is something that is not sure to change education. However, technology with teacher pedagogical skills can transform education (Koehler & Mishra, 2005a; Mishra, & Koehler, 2006; Harris et al., 2009). Therefore, it is essential to know the technological, pedagogical, and content knowledge of teachers to manage the learning process during the COVID-19 outbreak.

The implementation of online learning is a solution during the COVID-19 outbreak and a problem for teachers who are not ready and do not have the skills to integrate technology, pedagogy, and content knowledge (TPACK) into learning (Nelson et al., 2018; Tanak, 2018). Previous TPACK research focused on training and development programs of teachers competence that have been planned, such as investigation of the biology teachers' TPACK in lesson study (Rochintaniawati et al., 2018), practical programs (Yeh et al., 2015), pre-service and in-service science teachers and professional development programs (Lin et al., 2013; Canbazoglu Bilici et al., 2016; Tanak, 2018) and especially on certified teachers (Antony et al., 2019; Hapsari et al., 2019). Besides, various methods to investigate teachers' TPACK have also been conducted, such as using observations of the lesson plans used by the teachers (Canbazoglu Bilici et al., 2016), online tasks (Oster-Levinz & Klieger, 2010), and surveys of teacher's TPACK in various planned programs (Koçoğlu, 2009; Giannakos et al., 2015; Getenet et al., 2016; Cheng, 2017; Ciptaningrum, 2017).

Online distance learning during the COVID-19 outbreak is an activity that has never been planned before. Besides, the burden on teachers to conduct online distance learning increases in science subjects, including biology, which requires not only minds-on knowledge but also hands-on skills (Hofstein & Lunetta, 2004; Brinson, 2015). This situation requires the readiness of teachers and good TPACK skills so that learning can run effectively. Therefore, investigations of teacher readiness and TPACK during the COVID-19 pandemic that are never planned are urgently needed. Thus, this research investigates the readiness of biology teachers to face online learning during the COVID-19 outbreak based on their Technological Pedagogical Content Knowledge (TPACK).

This study aims to provide an overview of the readiness of teachers and their TPACK skills in online biology learning. The mapping of knowledge, skills/abilities, and needs of biology teachers can help them identify the challenges and possibilities in teaching during the COVID-19 and consider strategies and policies to address them.

METHODS

A purposive survey method was used in this study. Data collection was done through an instrument in the form of a questionnaire. The

instrument used is a modification of the questionnaire developed by Schmidt et al. (2009) with five scales (from 1 [strongly disagree] to 5 [strongly agree]) (Schmidt et al., 2009). The instrument can describe the teacher's TPACK based on the TPACK framework developed by Mishra and Koehler. The instrument consists of seven knowledge domains with 30 survey items in total. The domains used are shown in Table 1 (Mishra & Koehler, 2006; Schmidt et al., 2009).

Table 1. Domains of TPACK and Reliability Test Results

Domain	Cronbach's Alpha
Technological Knowledge (TK)	.899
Content Knowledge (CK)	.886
Pedagogical Knowledge (PK)	.880
Pedagogical Content Knowledge (PCK)	.897
Technological Content Knowledge (TCK)	.911
Technological Pedagogical Knowledge (TPK)	.870
Technological Pedagogical Content Knowledge (TPACK)	.871

Besides, several open-ended questions were used to complete the biology teachers' TPACK questionnaire. The online questionnaire was distributed through the Biology Teacher Working Group (MGMP) in West Java via WhatsApp. The respondents in this study were randomly selected. A total of 121 biology teachers volunteered to participate in this study. Teacher demographic information is presented in Table 2.

Table 2. Teacher Demographic Information

Variable		N	%	SD
Gender	Male	34	28.1	37
	Female	87	71.9	
Education	S1	88	72.7	43
	S2	29	24	
	S3	4	3.3	
Teaching experience	< 5 years	43	35.3	13
	5-10 years	14	11.6	
	10-15 years	16	13.2	
	15-20 years	15	12.4	
	>20 years	33	27.3	
School Level	Junior High School	36	29.8	40
	High school	82	67.8	
	Vocational Schools	3	2.5	
School Status	Public	90	74.4	42
	Privat	31	25.6	

There are 5 variables analyzed including gender, education, teaching experience, school level, and school status. The data obtained from the survey then were analyzed quantitatively. The percentage of teacher answers, factor analysis, Spearman correlation, and descriptive statistics were carried out in this study using SPSS. The data from the open-ended questionnaire were analyzed qualitatively to determine the challenges and possibilities faced by biology teachers in online learning during the COVID-19 outbreak. To focus on the data analysis process, the problem formulations used in this study are: (1) How are biology teachers' TPACK skills?; (2) How do biology teachers in online learning face the challenges and possibilities during the COVID-19 outbreak?

RESULTS AND DISCUSSION

The sudden application of online learning requires a fast and precise response from teachers, including biology teachers. Apart from all the infrastructure challenges, which are the main problems, the teachers' ability to conduct online distance learning is also a factor determining the success of learning. Apart from content knowledge and pedagogical skills, integrating technology into online learning is also crucial for teachers. Therefore, a survey on the TPACK of biology teachers was conducted online using Google Form. An in-depth discussion is conducted on the domain that supports TPACK. The teachers' responses to the questionnaire given are presented in Figure 1.

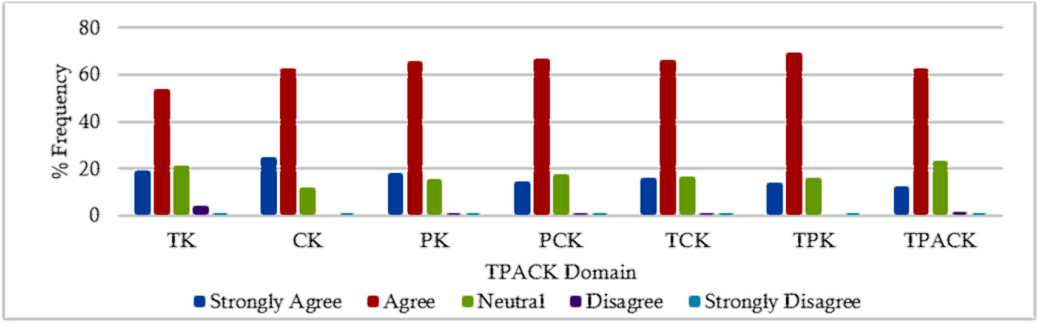

Figure 1. Biology Teacher TPACK Results

The Results data of KMO and Barlet's test are presented in Table 3. It displays the output of KMO and Bartlett's Test to determine a variable's feasibility to determine whether further analysis can be carried out by factor analysis.

Table 3. Result of KMO and Bartlett's Test

KMO and Bartlett's Test	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.931
Bartlett's Test of Sphericity Approx. Chi-Square	777.752
df	21
Sig	.000

Based on Table 3, the KMO value is 0.931 > 0.5. and Sig. value is 0.000 < 0.05, meaning that the variable meets the requirements for the factor analysis test. The factor analysis and correlation between TPACK domain results are presented in Tables 4 and 5.

Table 4. Factor Analysis

Domain	Anti-image Correlation	Communalities	Eigenvalues % of Variance	Loading Factor
TK	.956[a]	.667	76.638	.817
CK	.927[a]	.763	7.135	.874
PK	.908[a]	.807	4.650	.899
PCK	.944[a]	.754	3.813	.868
TCK	.963[a]	.717	3.377	.847
TPK	.913[a]	.840	2.406	.917
TPCK	.920[a]	.815	1.980	.903

Table 4 presents the various outputs from the factor analysis test results. In the anti-image correlation, the measure of sampling adequacy (MSA) value for all TPACK domains is greater than 0.5, meaning that all the domains are feasible. In the communalities section, all domains obtain values greater than 0.5, meaning that they contribute and can be used to explain the TPACK factor. In the Eigenvalues % of Variance section, it is known that one variation is formed, which can present a factor of 76.638%. In the factor loading section, the test result for each domain has a large correlation value to the factor, meaning that all the domains can explain the TPACK factor.

Table 5. Correlation and Sig between TPACK Domains

	TK	CK	PK	PCK	TCK	TPK	TPCK
TK	1	.635 .000	.646 .000	.607 .000	.671 .000	.740 .000	.727 .000
CK		1	.826 .000	.758 .000	.661 .000	.739 .000	.728 .000
PK			1	.802 .000	.695 .000	.778 .000	.747 .000
PCK				1	.679 .000	.742 .000	.726 .000
TCK					1	.751 .000	.739 .000
TPK						1	.855 .000
TPCK							1

Table 5 shows Pearson and Sig. (2-tailed) correlation data for each domain. All domains have a Sig. value of < 0.05, meaning that there is a significant correlation between the analyzed domains.

In general, Figure 1 shows the data that most teachers answer agree for each measured domain. This illustrates that biology teachers have quite good TPACK skills to face learning during the COVID-19 Pandemic.

From the qualitative analysis of open-ended questions to teachers, the researchers can determine the challenges and possibilities of online biology learning during the COVID-19 pandemic. The data presented in Table 6.

Table 6. Challenges and Possibilities of Online Learning

No	Possibilities	Challenges
1	More flexible in terms of place and time	Technical problems, such as the Internet network problem
2	Making teachers and students learn various kinds of learning technologies	Difficult to teach biology concepts that require lab works
3	Making students think critically and creatively	It cannot be used in assessing student character
4	The material accessed by students is more than in the textbook.	Can ask the closest person during the exam
5	Train students' independence to learn	Not effective for students with visual and kinesthetic learning styles
6	Bring up learning innovations from the teacher	Not all students have adequate cellphone facilities and quotas.

The teacher's TK can improve student learning outcomes (Nawzad et al., 2018). When technology is used correctly, it will bring many benefits. Technological knowledge is knowledge as well as skills used to master a specific technology. In applying digital technology, this knowledge is translated into knowledge of computer hardware and operating systems, including skills to master various software. Technological knowledge also shows how often teachers keep up with technological developments (Holland & Piper, 2016; Koh & Chai, 2016; Dalal et al., 2017).

Data analysis showed that 54% of teachers agree on their technological skills as seen from the media used such as Zoom Meetings, Google Classrooms, Cisco Webex, Quizziz, or WhatsApp. The use of various media shows the diverse skills of teachers. However, they did not specifically mention the technology used to represent the biology concept being taught. The same result is suggested by the study of Hsu et al. (2011) that teachers with good training experience will use various technologies. Besides, because this knowledge is a prerequisite for developing TPACK, the teacher must master it (Tanak, 2018).

CK (Content Knowledge) is the teacher's knowledge of the material or subject matter being learned or taught (Schmidt et al., 2009). Teachers need to understand the content in their area of expertise. This includes knowledge of concepts, facts, procedures, and theories, knowledge to combine and organize ideas, and knowledge of scientific evidence and facts. They must also understand the characteristics of this knowledge and find out the differences. Otherwise, their students do not understand the subject matter they learn (Mishra & Koehler, 2006).

The data collection shows that the biology teacher's content knowledge is in a good category. 62.8% of them agree or feel that they have good content skills. Content knowledge skills are fundamental to becoming a biology teacher, so they need to have these skills (Bravo & Cofré, 2016). The teachers show that they not only master concepts but can teach these concepts to students using technology. Teachers who master the concept well will be able to map and simplify the concept so that it can help their students to understand it better (Liu & Lee, 2013). The data obtained also show that the teachers not only understand the concept but can determine how far and how deep a concept should be taught. This is important to avoid overlapping with the next subject matter so that students can map and learn concepts according to their level (Buntting et al., 2006; Liu, 2011; Liu & Lee, 2013).

PK (Pedagogical Knowledge) is knowledge of processes and practices or teaching and learning methods to achieve the goals of education (Mishra & Koehler, 2006; Schmidt et al., 2009). Through pedagogical knowledge, teachers can understand how students learn classroom management skills, develop lesson plans, implement them, and evaluate student learning outcomes. The knowledge includes techniques or methods used in the classroom, student characteristics, and student understanding evaluation strategies. A teacher with good pedagogical knowledge will understand how to encourage his students to build their knowledge, develop thinking skills, and acquire skills. Therefore, this knowledge requires cognitive and social understanding, learning theory, and teaching methods (Mishra & Koehler, 2006).

Teachers' pedagogical knowledge also shows a good percentage, with 65.5% of them who agree with their pedagogical knowledge. However, during the COVID-19 pandemic, many learning models/methods are limited by distance as the government encourages teachers to conduct online learning. A variety of teaching methods does not follow the many online learning platforms used by the teachers. The method used is mostly discussion after watching the video or assignment. Some teachers send the materials in the form of PPT. Biology teachers certainly have constraints in online learning. Based on the answers to open-ended questions from the questionnaires distributed, the teachers revealed that most students did not understand and were willing to be explained directly by their teacher. This pedagogical knowledge is fundamental for teachers to convey concepts that students can accept with appropriate delivery methods. Teachers can design collaborative, interactive online learning and offer new relationships between teachers and their students through innovations in the learning process (Ferdig, 2006).

PCK (Pedagogical Content Knowledge) is a framework introduced by Shulman (1987) about the success of teachers in learning with an understanding of content and pedagogy in specific. PCK is defined as knowledge of the material, the reasons for choosing the material, and plans to teach the material to students (Magnusson et al., 1999; Dunlosky et al., 2013). PCK is an amalgamation of content knowledge and pedagogical knowledge (Shulman, 1987). Content knowledge is the teacher's knowledge of concepts and relationships between concepts and methods for obtaining and applying them (Worden, 2015; Blömeke et al., 2016). Pedagogical knowledge is the teacher's knowledge of student brain development, cognition, learning, and reasoning (Nouri 2014; Meschede et al., 2017).

A total of 66.5% of biology teachers agree with their PCK skills. It means that they are required to choose learning methods based on the concepts presented. Their answers show that if the material taught is in the form of concepts (memorization), they use Youtube or PowerPoint in teaching. However, if it is in the form of discussion material, the teachers will take advantage of the WhatsApp group facility for discussion. Youtube can be used as a learning medium and is considered adequate to improve the learning experience if it is relevant to the subject being discussed (Moghavvemi et al., 2018). Youtube and WhatsApp groups can be viewed as informal learning media. Informal online learning interactions are enjoyable experiences for students, support their learning, and expand their interaction and social engagement with one another. However, the concern is how to support students in this process and guide them to have digital literacy in

informal learning settings. This also needs to be considered without limiting students' informal learning environment, self-direction, enjoyment, exploration, and independence (Tan, 2013).

TCK (Technological Content Knowledge**)** is knowledge about the reciprocal linking of technology with content (Spector et al., 2014). Teachers should know the subject matter they teach and how to modify it with technology applications. In other words, technology can be a representative model for specific content. (Schmidt et al., 2009). The selection of learning content can limit the technology to learning and vice versa (Mishra & Koehler, 2006).

Some teachers (66.1%) agree with their TCK skills. Technological knowledge impacts teachers' knowledge and introduces a new way to describe previously impossible content. Today, teachers are challenged with how to make their students understand despite the distance. For example, teachers can use animation or simulation aids about metabolic processes in the body. Students can also be asked to design and create their understanding of a mini project in a digital form. Technology assistance enables the discovery of new content or descriptions of content. Effective teaching requires developing an understanding of how subject matter can be modified using different technologies. Teachers must understand which technology is the most appropriate for a subject and how content determines or shapes the use of specific educational technologies, and vice versa (Harris et al., 2009).

TPK (Technological Pedagogical Knowledge) is knowledge of how various technologies can be used in teaching and can change teachers' way (Schmidt et al., 2009). This knowledge can be defined as an understanding of the use of technology to change the teaching and learning process in specific ways according to learning objectives and context (Mishra & Koehler, 2006; Harris et al., 2009).

A total of 69.3% of the teachers agree with their TPK skills. In general, the latest technology is not explicitly designed for educational purposes. However, teachers can take advantage of these various technologies for learning purposes with their creativity. However, the application of general technology to specific educational purposes requires an understanding of context. By proposing a learning design activity where each group has different members, objectives, resources, and audiences, a different context is created for each learning activity. Teachers learn that the "appropriate" use of technology depends on the context (Koehler & Mishra, 2005b; Koehler & Mishra, 2005). The rapid development of technology enables new learning approaches to emerge in the learning process. The number of students who learn using the web, learning portals, and interact with others with the help of technological advances increases (Paquette, 2014). Technology can play a crucial role in supporting education reform and transformation. Technology has been used to support the revised education curriculum and the shift in pedagogy and assessment. Types of educational reforms associated with introducing ICT include curriculum reforms that emphasize a high-level understanding of critical concepts in the subject area and apply them to solve complex problems in real life (Kozma & Vota, 2014). Therefore, teachers' technological pedagogical knowledge is vital.

TPACK (Technological Pedagogical and Content Knowledge) is the knowledge needed by teachers to integrate technology and teach certain materials into a complete package. Teachers must have an understanding and intuition of the complex interactions between the three essential components of knowledge (PK, TK, and CK) by teaching certain materials using appropriate pedagogical and technological methods (Schmidt et al., 2009).

TPACK describes knowledge from each of the previously described knowledge areas with a focus on how technology can be confronted with the pedagogical need to teach the appropriate content in a particular context (Bunyamin & Phang, 2012; Getenet et al., 2016; Akyuz, 2018)

TPACK knowledge is a synthesis and integration of ICT in classroom learning. TPACK knowledge is a form of multi-integration and transformation (Sahin, 2011; Pamuk, 2012). The use of TPACK conceptual framework to study integrated ICT leads teachers to work with ICT in designing the syllabus, lesson plans, supporting learning tools, and the use of ICT in the classroom as a learning resource and literature source (Polly et al., 2010; Graham et al., 2012). The limitations of TPACK sometimes overlap. They grouped knowledge forms, for example, during TPACK knowledge discussion, such as online discussion and finding references (Dalal et al., 2017). The use of software such as Google Earth and SPSS can be classified as TCK if integrated with a pedagogical component. However, when the software is used for other general knowledge that does not contain a pedagogical component, it does not show the technology in TPACK. Besides, digitization of print-based materials can hardly be classified in TCK as digitization to be applied to all contents. Another example is the

knowledge of overhead projectors and other traditional media forms as technological knowledge (Schmidt et al., 2009).

In the TPACK scheme, there is a relationship between constituent components. There is also an intersection between material (C), pedagogy (P), and technology (T), which affects the learning context (Jimoyiannis, 2010). TPACK is an essential skill during the pandemic so that the TPACK framework should be developed in stages of understanding, training, observation, and reflection to explore teachers in increasing their capacity for online learning.

More than half of the teachers (62.5%) agree with their TPACK skills. The findings on the understanding and skills in using computer-related technology will be more appropriate and meaningful, especially during the COVID-19 pandemic. Currently, teachers are demanded to create learning integrated with ICT to enhance the learning process to be creative and innovative. Teachers' learning needs to incorporate technology, curriculum, and the learning environment into the TPACK framework. Problem-based and project-based learning models can be used even though they are not as effective as before the pandemic.

Future opportunities for distance learning are unlimited, and it has many advantages (Sadeghi, 2019). The most significant advantage for teachers is that learning becomes more flexible in place and time (Sadikin & Hamidah, 2020). Online learning can be implemented anywhere. In online learning, online instructors' roles may be more complicated than those of traditional instructors (Leontyeva, 2018; Graham, 2019). Teachers and students simply agree to attend the predetermined online learning platform at a particular time. The most frequently used online learning platforms are Google Classrooms and Zoom. Both platforms allow students and teachers to meet face to face online. These platforms are also accessible using a mobile phone.

COVID-19 pandemic makes students and teachers understand the kinds of learning technologies (Mutton, 2020). Teachers know more about the types of online learning platforms and websites to download materials in the form of PPT, PDF, video, simulation, or animation files. In implementing online learning, teachers with adequate TPACK skills use different learning resources depending on the essence of the concepts conveyed. Meanwhile, for students, the recommendation of social distancing makes them adapt to the technology used by the teachers to know more about the types of online learning platforms.

The TPACK skills of teachers also affect their critical and creative thinking skills needed in science learning, especially biology (Tanak, 2018). Teachers with good TPACK skills will provide learning materials that can be accessed by students to be studied individually or discussed in groups (Mahdum, 2015; Akyuz, 2018). This can spur students to study and understand the material provided by the teacher. Social distancing to break the chain of COVID-19 has made students and teachers carry out online learning from home (Murphy, 2020; Viner et al., 2020).

The adaptation of online learning in dealing with the COVID-19 pandemic also has several problems. Among them are technical problems in inadequate Internet service and inadequate mobile phones and quotas (Lestiyanawati & Widyantoro, 2020). Biology subjects also require students to have good laboratory skills, but lab works are intricate during online learning (Ekwueme et al., 2015; Daba et al., 2016). These activities cannot be facilitated by online learning, so that teachers with sufficient TPACK skills will choose a teaching approach and the right technology to replace lab works (Frey, 2008).

Many teacher-researchers previously evaluated and used TPACK in various fields such as language (Koçoğlu, 2009; Tai et al., 2015; Cheng, 2017; Bustamante & Bustamante, 2019; Fuad et al., 2020), mathematics (Erdogan & Sahin, 2010; Polly et al., 2010), and science (Lin et al., 2013; Getenet et al., 2016; Tanak, 2018). Identifying TPACK of biology teachers in this study adds to the urgency of TPACK in various fields. Besides, the discussion about the challenges and opportunities for online biology learning during the COVID-19 pandemic is one interesting context in this study. Multiple opportunities and solutions to the problems of online biology learning have been discussed. This study is expected to provide updated information about the processes, challenges, and barriers to online biology learning during the COVID-19 period. However, this study is limited by the small number of respondents and the single instrument used. Future researchers can increase the survey area and use various valid instruments.

CONCLUSION

It can be concluded that biology teachers have sufficient TPACK skills in implementing online learning. However, their technological capabilities still need to be improved, given that science materials, especially biology, require lab works or hands-on activities. Besides, there are several challenges and possibilities faced by biology te-

achers in online learning during COVID-19. It is implied that this study encourages training in the use of technology for biology teachers and other teachers in general. Training can be focused on equipping teachers with the ability to develop online learning media such as instructional videos, animations, or practicum simulations (virtual laboratory). Teachers are also expected to create an exam portal that can ensure no cheating by students, such as getting answers from their relatives. Further research can examine the TPACK variables separately and their effect on student performance in class, through which an appropriate assessment/evaluation method for online learning will be discovered.

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