Indonesian Journal of Science and Education
Volume 05, Nomor 02, 2021, pp: 111~125
ISSN: 2598-5213e-ISSN: 2598-5205, DOI: 10.31002/ijose.v5i2.4405
e-mail: ijose@untidar.ac.id, website: jurnal.untidar.ac.id/index.php/ijose

Biology Teachers' Tpack in Their Instructional Planning for Online-Based Practical Work

Rifaatul Mutmainnah[1a], Siti Nurkamilah[2]
[1, 2]Pendidikan Biologi Institut Pendidikan Indonesia Kab. Garut, Jawa Barat
e-mail: [a]rifabio88@gmail.com

Received: September, 13th 2021 *Revised: October, 8th 2021* *Accepted: October, 30th 2021*

ABSTRACT

The transition from hands-on to online practical work, in response to the Covid-19 pandemic, was unprecedented. Biology teachers are expected to integrate technology, pedagogy, and content knowledge to carry out online practical work successfully. Teachers' TPACK is performed, in part, during instructional planning. Therefore, study on how biology teacher performs their TPACK during online practical work is crucial. This study investigates biology teachers' TPACK on their instructional planning in practical work during online learning. The descriptive method was used with 42 participants who joined as senior high school biology teacher association in Garut city. The Data was collected through a questionnaire, instructional planning document, and online interviews. The result shows several findings. First, biology teachers have a great belief in their TPACK. This indicates sustained integration of technology in learning even after this challenging time, for example, when blended learning is in the future. Second, biology teachers' TPACK based on their instructional planning is on three-level: recognizing, accepting, and adapting. Third, several opportunities, obstacles, and suggestions have been discussed by biology teachers. It is implied that this research promotes teacher professional development programs to enhance their TPACK.

Keywords: Biology Teacher, TPACK, Practical Work, Online Learning

INTRODUCTION

In response to the COVID-19 pandemic, schools in a different region of Indonesia were obliged to switch to entirely online teaching and learning. This was a significant change in the way learning was delivered (Goddard, 2020). Teachers were asked to redesign their lesson plans to facilitate their students in an online environment. This demanded a complete change in the pedagogical approach to teaching and learning, as well as the implementation of a variety of technology (Gurley, 2018). Therefore, technology is one of the essential components of teaching (Koehler et al., 2013), and online methods have grown increasingly popular for educational purposes (Rodrigues et al., 2019).

The transition to online learning presents challenges associated with the use of various digital tools and resources to implement new methods. This required extended teacher knowledge that should be generally capable of applying technologies to pedagogical concepts and teaching practice or TPACK (König et al., 2020). TPACK framework describes the kinds of knowledge required by teachers for the successful integration of technology in teaching (Koehler & Mishra, 2006). TPACK is the intersection of teachers' knowledge of curriculum content, general pedagogies, and technology understanding (J. Harris & Hofer, 2009). It is comprised of three particular aspects, namely pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK).

Online learning during this pandemic COVID-19 crisis requires teachers TPACK to conduct lessons for minds-on knowledge and hands-on skills, especially in science, including biology (Brinson, 2015). One of the lesson activities that can cover students those requirements is practical work. Practical work is an essential component in teaching and learning that can develop students’ scientific knowledge and knowledge of science as a whole (Millar, 2004). Through practical work, the student can make observations, manipulate objects, interact with actual materials, and associate them with ideas or concepts so that the student learns biology thoroughly (Abrahams & Millar, 2008). So, putting practical work into practice, even though using online approaches, is still crucial.

In biology education, the use of technology for practical work has been attempted before. Many researchers also have applied online practical work such as using virtual microscopy for student centered-learning (Goldberg & Dintzis, 2007), web-based computer-aided learning to enhance student learning outcomes in molecular biology class (Gibbins et al., 2003), virtual laboratory programs to improve students confident in operating laboratory equipment (Dyrberg et al., 2017), and online-based practical work using various technology (Špernjak & Šorgo, 2018). As a result, the integration of various technologies for practical work is possible and favorable. It is in line with another research state that laboratory-based practical work is limited by space, whereas online practical work offers a collaborative learning environment in which teachers and students can interact and carry out experiments in their place (Gamage et al., 2020).

As an important figure in online-based practical work, teachers are expected to represent their TPACK into their instructional planning (J. Harris & Hofer, 2009). Teachers' instructional planning comprises making decisions on the selection, arrangement, and sequencing of routinized activities, as well as the use of digital technology (Tubin, D., & Edri, 2004). Therefore exploring teachers' knowledge on integrating technologies while conducting online-based practical work is critically needed. Thus, this study investigates biology teachers' TPACK on their instructional planning in practical work during online learning. The overview of biology teachers' TPACK might help them in identifying the obstacles and opportunities in integrating technology into teaching during online learning and considering strategies and policies to address them.

METHOD

This study used the descriptive method. The idea of a descriptive study was to inform about what is happening, opportunities, or other aspects of one phenomenon that had not previously been understood (Loeb et al., 2017). In this study, the descriptive method is used to describe teachers’ TPACK in their instructional planning for practical work during online teaching.

The research subject was 42 teachers from various senior high schools, members of a biology teacher association in Garut city. Teacher demographic data are shown in Table 1.

Table 1. Participants Demographic

Demographics Variable	N	%
Gender		
Male	6	14.28
Female	36	85.72
Teaching experience		
< 5 years	9	21.42
5-10 years	7	16.67
10-15 years	8	19.04
15-20 years	9	21.42
>20 years	8	19.04
School Status		
Public	31	73.81
Private	11	26.19

Data collection on teachers' TPACK was done through a questionnaire, instructional planning document, and online interviews. The questionnaire used is a modification of TPACK assessment developed by previous research that measures Asian teachers TPACK (Chai et al., 2013; Schmidt et al., 2009). The development of this questionnaire was adjusted to biology content, practical work, and the integration of technology during online learning. The questionnaire consisted of 20 items statements that asked teachers to rate their TPACK. Teachers answered each statement using the following five-level Likert. An example of the questionnaire statements used is shown in Table 2. Two open-ended questions were added to determine teacher perception of integrating technology related to challenges, advantages, and disadvantages in online-based practical work. The questionnaire covers four knowledge domains of TPACK, namely pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and the intersection of three domains.

Teachers' instructional planning document is a modified lesson plan which includes decision-making about the selection, organization, and sequencing of practical work during online learning. There were five aspects of instructional planning as a basic in this study: 1) choosing learning goals; 2) practical pedagogical decisions; 3) sequencing appropriate practical work activity; 4) selecting assessment strategies; 5) selecting technological tools and resources (J. Harris & Hofer, 2009).

Table 2. Example of Questionnaire Statements

Domains	N	Statement
PCK	5	I can design practical work to guide student scientific process skills.
TCK	2	I know technologies that I can use for understanding biology content.
TPK	4	I can choose technologies that enhance practical work during distance learning.
TPACK	7	I can organize teaching during distance learning that appropriately combines biology, practical work, and technologies.

Furthermore, to obtain more in-depth teachers' TPACK, researchers asked follow-up questions in response to the information that teachers shared through questionnaires and instructional planning documents. The researcher used four domain knowledge as a guide for the interview. The following table shows an example of a question in the interview. The data were analyzed through descriptive analysis (Loeb et al., 2017). The researchers identify patterns and characterize a teachers' TPACK to five increasing ability TPACK levels for teaching (Niess, 2007). The data from the open-ended questionnaire were analyzed to determine the challenges and possibilities faced by biology teachers in practical work during online learning. To focus on the data analysis process, the problem formulations used in this study are: 1) how biology teachers perceive their TPACK abilities in conducting practical work during online learning?; 2) how are biology teachers' TPACK levels in their instructional planning for practical work during online learning?; 3) how do biology teachers face the obstacle and opportunities during online learning in their instructional planning for practical work?.

Table 3. Example of Follow-up Questions.

Domains	Question
PCK	Why you choose this concept to teach through practical work?
TPK	How did you decide which technology-based materials and tools to use in practical work?
TCK	How did the technology-based tools and resources that you used fit the biology concept of this unit?
TPACK	Why was this specific combination of biology content, practical work, and chosen technology most appropriate for this unit plan?

RESULT AND DISCUSSION

Descriptive findings on a questionnaire related to how biology teacher perceived their TPACK in conducting online-based practical work are provided to investigate the first research question. As shown in Figure 1, more than 70 % of biology teachers agree they have sufficient TPACK to successfully carry out practical work during online learning. Figure 1 also shows a consistent result in the other three of TPACK domain, namely PCK, TCK, and TPK.

This result indicates that teachers report that their TPACK is good related to their abilities to teach biology content through practical work, select various technology that can be resources for learning biology content, choose technologies that can be the best fit to support online-based practical work, and appropriately matched to students' needs and preferences. However, despite this report, data show that 30 % of teachers did not conduct practical work during this sudden application of online learning during pandemic covid-19.

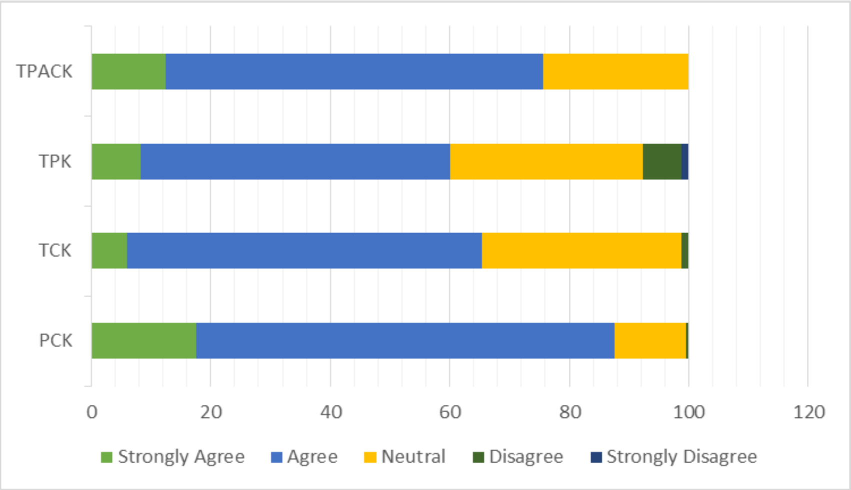

Figure 1. Biology Teachers' TPACK Questionnaire Results

Biology teachers responding to questionnaires about their perceived TPACK show the highest value for the PCK domain. PCK combines both content and pedagogy to improve teaching practice in the content areas (Koehler & Mishra, 2006). PCK in this study refers to teacher knowledge on how to make students learn biological content through practical work. The data shown indicate that biology teachers feel confident to use their skills that require the aspects of both pedagogy and content, such as the ability to identify content biology that potential for teaching through practical work, select an effective type of practical work that can guide student thinking, and recognize student misconceptions. This teachers' perception is crucial because other studies show that pedagogical content knowledge and teachers' belief are highly correlated and influence one another (Thomson et al., 2017). It helps biology teachers set their intention to develop students' understanding of biology and science process skills through practical work during this challenging time.

As we know, biology content has a broad scope (Reiss et al., 1999), starting from microscopic to macroscopy, ranging from abstract to concrete concept, ranging from facts to theories and even law. So, every topic in biology has its potential, which can be learned through various learning methods. In addition, the forms of practical work as a learning method are very diverse; there are expository, inquiry, discovery, and problem-based practical work (Domin, 1999). To conduct practical work, teachers need specific knowledge about the potential subject of biology that can be delivered to students through practical work. Besides that, a teacher needs to possess knowledge on identifying student misconceptions. A teacher's ability to identify students' difficulty in understanding a subject matter is a form of pedagogical content knowledge, is a part of science teacher competence (Sadler et al., 2013).

There is a content area and pedagogical area in teaching. Teachers need specific knowledge to use technology in the pedagogical area; teachers also need knowledge on using technology in content areas, known as TCK. Biology teachers should know the biology concept they teach and how to represent it with technological tools. In other words, technology can serve as a model for specific biology content (Schmidt et al., 2009). Data show that biology teachers perceived TCK value as less than their PCK value. It means that they feel firm in biology content, but when technology is required to represent content, they feel less potent. However, they still believe that they know about the technology that can represent biology content. For example, biology teachers use animation on YouTube about diffusion and osmosis or simulation about the metabolic process on carbohydrates. The use of technology aids in the finding of new content or descriptions of existing content. Teachers must know which technology is best for a specific content and how content influences or develops the use of specific educational technologies (J. Harris & Hofer, 2009).

Teachers also believe that online biology resources are more accessible nowadays and make learning biology easier. This belief is crucial for developing teacher professionalism in teaching like other studies state that teachers who use technologies in their content area develop a new skill, plan more dynamic activities, and actively find an answer for students questions (Perrault, 2007). In contrast, the previous study shows that although there is an increase in seeking resources using various technology applications, teachers usually limit their information-seeking primarily within search engines and do not take full advantage of educational-related digital libraries, online databases, or other resources (Hiong & Osman, 2013). Hopefully, this belief found in this study can be a force for biology teachers to interact more with a wide variant of technology-based resources to enrich their TCK.

Biology teachers perceived TPACK value dropped in domain TPK. TPK means how various technologies can be utilized in learning and transform the way teachers teach (Schmidt et al., 2009). Biology teachers felt that their knowledge associated with using particular technologies in practical work was not as strong as their knowledge related to PCK. Data show that 69 % of biology teachers use technological tools for teaching and learning. However, they did not specifically mention the technology used to conduct practical work during online learning. Most biology teachers said that they urgently need a development program to enhance their TPK. This statement, in line with another study, concludes that TPK should be included in regular teacher professional development programs to provide teachers with continuous online teaching capabilities (Ma et al., 2021).

The questionnaire data to explore biology teachers' perceived knowledge within the TPACK framework reveals that they were confident in their abilities to undertake online-based practical work. Tough they were less confident in their abilities regarding technology and using technology to deliver content to students, they still felt capable and good at what they did. The issue of dealing with and learning new technology runs throughout the survey's open-ended responses from teachers. One teacher said that he had no previous experience and preparation with online learning, and this happened suddenly. He believes that technology can be beneficial in online learning, including in practical work. But for its application, it may take stages and time. In addition to teachers, students experience the same thing. This statement is in line with research that says that this pandemic potentially accelerate the rate of teacher technology engagement, and the student has learned useful skillsets (Winter et al., 2021).

This comment appears to reflect how biology teachers felt about their expertise within the TPACK framework when they conduct online learning. Their ratings indicate that their content knowledge and pedagogical knowledge are both strong. The issue emerges when they apply what they've learned to the best approach to impart content to students using technology. Despite this, they are determined to identify what works best, and they are willing to explore new ways and strategies to do so. This statement is in line with another study that assessed Philippine teacher intention in continuance of teaching in online education amid the COVID-19 crisis (Cahapay, 2021) and a researcher in Java, Indonesia, that identifies chemistry teachers' TPACK and attitude in online distance learning during the Covid-19 outbreak (Kartimi et al., 2021). Both study results show a positive sign toward successful learning because teachers' positive perception of using technology for online distance learning is likely to positively influence the way teachers teach and students' learning experiences.

Through this study, we know that teachers confidently could design a lesson plan that appropriately combines biology as content, technologies, and practical work during distance learning. Teachers start by choosing biological content that has the potential to be studied through practical work. Then teachers choose a form of practical work that allows being done by considering students' conditions, such as materials, tools, etc. Lastly, teachers choose what technology can facilitate designed practical work. These lesson plans designed by teachers are the result of the interaction of three basic knowledge that built TPACK. Exploring more in-depth teachers' TPACK can be seen in lesson plans that include decision-making about the selection, organization, and sequencing of practical work during online learning, known as instructional planning.

Teachers' TPACK is performed, in part, during instructional planning (J. B. Harris & Hofer, 2011). Table 4 provides descriptive findings related to biology teachers' TPACK levels based on their instructional planning for practical work during online learning to investigate the second research question. Nearly half of the biology teachers are at an accepting level of TPACK. In contrast, 29 % of the biology teachers are in recognizing level, and the rest (less than 20 %) are in adapting level.

Table 4. Biology Teachers' TPACK Levels

TPACK Level	Brief Description	%
Recognizing	Teachers recognize the alignment of technology with biology content and practical work. However, they do not integrate technology in teaching and learning biology content, especially online-based practical work.	31
Accepting	Teachers form a favorable attitude toward using appropriate technology for teaching and learning biology content, especially online-based practical work.	50
Adapting	Teachers engage in activities that adopt teaching and learning biology content through practical work with appropriate technology.	19
Exploring	Teachers actively integrate technology in various way for teaching and learning biology content, especially online-based practical work.	-
Advancing	Teachers redesign curricula and evaluate the decision to integrate teaching and learning biology content with an appropriate technology.	-

Biology teachers in recognizing level can recognize the idea that technologies can display biology content. They view technology as a tool that does biology or media that represents biology content than teaching biology content. Other studies reveal similar findings that technology is mostly used as a source of information rather than an approach to construct a piece of knowledge (Ramma et al., 2018). Whereas, when technology is utilized as a pedagogical tool for teaching and learning, it makes a difference (Westera, 2015).

Their knowledge and belief about teaching and learning biology describe as a subject that memorization of concept and hands-on activity without using technology. In other words, they retain traditional beliefs about how students learn biology like they used to do in face-to-face learning. Content knowledge, self-efficacy, pedagogical beliefs, and subject culture may become a variable on why teachers are reluctant to incorporate technology in teaching (Ertmer & Ottenbreit-Leftwich, 2010).

Still biology teachers in recognizing level can use the technology, motivated to explore technology for learning and recognize the alignment of technology with biology content. Yet, they do not integrate technology in learning, especially in practical work. Their belief about student condition challenges motivation for exploring, experimenting, and practicing integrating technologies in learning biology. For example, they say not all students have enough good technological tools such as smartphones, have a good bandwidth, and afford internet costs. They say that students do not have the skill to use technology either.

In general, recognizing level teachers' instructional planning for practical work during online learning is determined by individual student practice, repetition of ideas during face-to-face learning, and resist consideration to change to integrate technology. This sentiment discourages the integration of technology into practical work. Similar findings reveal that interactions between the teachers' perceptions of technology could be a crucial factor in the proper implementation of TPACK (Cheah et al., 2019).

Meanwhile, biology teachers in accepting level can find particular biology concepts well represented by technology and accept the idea that some technologies can be a helpful tool for online-based practical work. The idea about technology as a teaching and learning tool is better expressed thoroughly by this teacher. Teachers in this level mention various technology applications that they can use to conduct online-based practical work such as Google Classroom, Zoom Meeting, WhatsApp group, YouTube, etc.

Overall, they express a desire to integrate technology but demonstrate difficulty identifying technology tools that fit their teaching approach. Technological tools they use only facilitate student-teacher communication, such as collecting practical work reports, giving task instruction, informing announcements, or just marking attendance. These are the differences in the use of technology as a pedagogical tool. The level of student engagement and the nature of participation produced reveal a pedagogical value of technology (Johnson & Golombek, 2016).

However, teachers are worried that students' attention is being diverted to focus more on operating technological applications than learning biology concepts. Also, teachers find that introducing new technological tools to students is taking away time for learning biology. Without face-to-face engagement, students are more likely to become distracted and lose track of deadlines (Sadeghi, 2019). This kind of teachers' anxiety is common to be found in online learning (Fernández-Batanero et al., 2021).

The last finding in this study within teachers' TPACK is an adapting level. Biology teachers in adapting level acknowledge some benefits of incorporating technology for teaching and learning, especially in online-based practical work. Teachers discuss a desire to explore, experiment, and practice integrating technologies to enhance practical work, primarily to provide students with a new approach to understanding biology and hands-on skill.

However, teachers are concerned about classroom management, student thinking process, and misconceptions while doing practical work using technology. For example, challenging to make sure students understand an instruction, observe student skills and attitude, assess products that students create, and so forth. Teachers also said that using technology requires more time because many variables need much intention. Other research also mentions similar challenges in delivering teaching and laboratory activities during online learning and the covid-19 pandemic (Blau et al., 2014; Gamage et al., 2020).

Teachers at adapting level did not put technology in the role of guide or exploration while doing online-based practical work. Instead, they use technology only to explain instruction, for example, using digital video or YouTube to demonstrate what students need to do. The technology they choose does not directly help students enhance their scientific process skills, much fewer hands-on skills. Overall, teachers' instructional planning for online-based practical work in the adapting level is primarily deductive, implying that teachers are directed to keep track of the progress of practical work, and a student only follows teachers' direction. This situation is in line with another study that says only a few teachers can employ technology in a variety of ways to generate student-centered learning (Bang & Luft, 2013).

This study did not find a teachers' TPACK in exploring level when teachers actively incorporate technology with both pedagogical and content areas in various ways. Teachers in exploring level expected to plan, implement, and evaluate practical work with concern for assisting students in understanding biology through technology. Teachers must transform from learner to knowledge maker of TPACK through design thinking for successful technology integration (Koh et al., 2015).

They also look forward to recognizing challenges for doing practical work with technologies but willingly explore strategies and ideas to minimize the impact of the challenges. In addition, they anticipate exploring various instructional planning for practical work (including both deductive and inductive strategies) with technologies to engage students more in scientific process skills. Teachers await to make an opportunity to engage students in explorations with the technology tools. Teachers with excellent TPACK are seen making a learning design effectively (J. B. Harris & Hofer, 2011).

After undergoing distance learning amid the COVID-19 outbreak, most biology teachers realize the importance of integrating or utilizing technology in practical work on learning biology. They say the technology could be a bridge to reduce learning losses that occur due to pandemics. So that students hopefully still get scientific process skills and hands-on skills through online practical work. For both teachers and students, online practical work has given many advantages. However, this does not mean that this approach does not have challenges in its implementation. Table 5 depicts the obstacles and opportunities that biology teachers faced when doing online-based practical work during this time.

Table 5. Biology Teachers' Response to Online-Based Practical Work

Aspect	Biology Teachers’ Response
Opportunities	Practical work is flexible since it may be done anywhere, at any time.
	It promotes students' digital literacy and makes them more tech-savvy.
	Facilitate carrying out difficult, costly, or even dangerous practical work that does not happen during face-to-face learning.
	Bring up new approach from teacher to conduct practical work.
	Stimulate student consciousness to learn independently.
Obstacle	Student get less experience in hands-on skill.
	Unable to cover all of learning aspect.
	Problems with technology, such as the Internet network.
	Students’ different ability in affording internet charges.
	Students’ diverse skill in operating various technology.
	Limited of teachers’ knowledge in virtual practicum.
	Teachers' knowledge about various technological applications that could be used for online-based practical work, such as virtual labs.
	Student self-determination to complete their task.
Suggestion for integrating technology in practical work	There should be a continuous program such as a seminar or workshop to enhance teacher use of technologies.
	Collaboration among teachers to inaugurate various technology applications such as virtual lab, plant identity apps, digital microscope; is needed.
	Discussion or sharing sessions among teachers, students, and school principals to find a solution for technological limitations such as bandwidth, internet cost, and even possession of smartphones.

Online teaching opportunities, including practical work, are widely open (Gamage et al., 2020). The most significant is online-based practical work allows both students and teachers to carry out complex, costly, or even dangerous practical work that does not happen during face-to-face learning. Numerous attempts for online-based practical work have been done, such as using a virtual microscopy to learn about human tissue histology (Goldberg & Dintzis, 2007), using virtual lab for PCR to detect modified genetic sequences (Gibbins et al., 2003); and using various technology for laboratory activities (Špernjak & Šorgo, 2018). This kind of practical work is hard to execute in conventional conditions because of materials tools' availability.

During this pandemic, both teacher and student were exposed to new technologies. This event stimulates them to learn a new skill and knowledge, and it changes each other. Teachers bring up new approaches and student promotes their digital literacy. Teachers with a successful implementation of TPACK positively influence student achievement (Farrell & Hamed, 2017; Winter et al., 2021).

The implementation of online-based practical work also brought several critical problems. First, technical issues, such as limited Internet access and mobile phones, are among them (Lestiyanawati, 2020).

Students in remote areas and poor technology supporting tools report difficulties in joining online-based practical work. Second, there is a sentiment that online-based practical work did not support student development of practical and procedural skills. However, there is no evidence in another study that students perform worse practical skills in online practical work than a traditional one; instead, they may acquire an entirely new skill (Faulconer & Gruss, 2018). Third, teachers believe that their knowledge about various technological applications for online-based practical work is still limited. This kind of belief hinders teacher intention and motivation to change and apply technology (Ertmer, P., Anne, O.-L., & Tondeur, 2015).

Teachers need to feel firm about their belief that they can successfully implement their TPACK in online-based practical work. A way to accomplish this goal is to create and promote a two-pronged approach, namely teacher education and professional development programs (Ertmer & Ottenbreit-Leftwich, 2010). Studies show that the success of online teaching can be affected by institutional support, which provides workshops or another educational program (Howard et al., 2018). Online teaching pedagogies should be incorporated into regular mandatory teacher professional development programs to provide teachers with ongoing skills in online teaching. Through open-ended questionnaires, biology teachers also mentioned this as their needs. Biology teachers also demanded collaboration or sharing sessions among teachers to inaugurate various technology applications. Another study affirms that group composition and facilitation influenced teachers' TPACK construction (Ling Koh et al., 2014).

As the COVID-19 pandemic lockdown affected education, teachers had to organize teaching and learning in a new way, including online-based practical work as an integral part of learning biology. Teachers' TPACK is a crucial factor that determines successful online delivery of teaching and learning (Koehler et al., 2013). Previous research had been identify teachers' TPACK during this challenging time on various contexts such as: TPACK and attitude on online learning (Kartimi et al., 2021); TPACK and teacher learning management (Juanda et al., 2021); teachers' TPACK self-efficacy (Cahapay, 2021), teachers' TPACK and intention on continuing online learning (König et al., 2020); teachers' TPACK and e-school application (Yang et al., 2019); teachers' TPACK for teacher education (Carrillo & Flores, 2020). Identifying biology teachers' TPACK in practical work adds to the urgency of TPACK research in various contexts. Besides, the discussion about the opportunities, obstacles, and suggestions give value for the future implementation of online practical work. This result may be used as a reference for developing a professional program to improve teachers' TPACK. Future research to find out the connection between teachers' TPACK and student areas will be valuable.

CONCLUSION

The transition from face-to-face to online practical work, in response to the Covid-19 pandemic, was unprecedented. This study investigates biology teachers' TPACK on their instructional planning in practical work during online learning. The result shows several findings. First, biology teachers have a great belief on their TPACK. Biology teachers agree they have sufficient TPACK to successfully carry out practical work during online learning. This indicates sustained integration of technology in learning even after this challenging time, for example, when blended learning is in the future. Second, biology teachers' TPACK based on their instructional planning is on three-level: recognizing, accepting, and adapting. Third, several opportunities, obstacles, and suggestions have been discussed by biology teachers. It is implied that this research promotes teacher professional development program to enhance their TPACK.

ACKNOWLEDGEMENT

We wish to express our gratitude to the directorate general of higher education (direktorat jenderal pendidikan tinggi), Republik Indonesia, which supported this research project.

REFERENCES

Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, *30*(14), 1945–1969. https://doi.org/10.1080/09500690701749305

Bang, E. J., & Luft, J. A. (2013). Secondary Science Teachers' Use of Technology in the Classroom during Their First 5 Years. *Journal of Digital Learning in Teacher Education*, *29*(4), 118–126. https://doi.org/10.1080/21532974.2013.10784715

Blau, I., Peled, Y., & Nusan, A. (2014). *Technological , pedagogical and content knowledge in one-to-one classroom : teachers developing " digital wisdom ." March 2015*, 37–41. https://doi.org/10.1080/10494820.2014.978792

Brinson, J. R. (2015). Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research. *Computers and Education*, *87*, 218–237. https://doi.org/10.1016/j.compedu.2015.07.003

Cahapay, M. B. (2021). Technological pedagogical knowledge self-efficacy and continuance intention of Philippine teachers in remote education amid COVID-19 crisis. *Journal of Pedagogical Research*, *5*(3), 68–79. https://doi.org/10.33902/jpr.2021370614

Carrillo, C., & Flores, M. A. (2020). COVID-19 and teacher education: a literature review of online teaching and learning practices. *European Journal of Teacher Education*, *43*(4), 466–487. https://doi.org/10.1080/02619768.2020.1821184

Chai, C. S., Ng, E. M. W., Li, W., Hong, H. Y., & Koh, J. H. L. (2013). Validating and modelling technological pedagogical content knowledge framework among asian preservice teachers. *Australasian Journal of Educational Technology*, *29*(1), 41–53. https://doi.org/10.14742/ajet.174.

Cheah, Y. H., Chai, C. S., & Toh, Y. (2019). Traversing the context of professional learning communities: development and implementation of Technological Pedagogical Content Knowledge of a primary science teacher. *Research in Science and Technological Education*, *37*(2), 147–167. https://doi.org/10.1080/02635143.2018.1504765.

Domin, D. S. (1999). A Review of Laboratory Instruction Styles. *Journal of Chemical Education*, *76*(2–4), 543–547. https://doi.org/10.1021/ed076p543

Dyrberg, N. R., Treusch, A. H., & Wiegand, C. (2017). Virtual laboratories in science education: students' motivation and experiences in two tertiary biology courses.

Journal of Biological Education, *51*(4), 358–374. https://doi.org/10.1080/00219266.2016.1257498

Ertmer, P., Anne, O.-L., & Tondeur, J. (2015). *Teacher beliefs and uses of technology to support 21st century teaching and learning. International handbook of research on teachers' beliefs*. *January*, 403–419.

Ertmer, P. A., & Ottenbreit-Leftwich, A. T. (2010). Teacher Technology Change. *Journal of Research on Technology in Education*, *42*(3), 255–284. https://doi.org/10.1080/15391523.2010.10782551

Farrell, I. K., & Hamed, K. M. (2017). Examining the Relationship Between Technological Pedagogical Content Knowledge (TPACK) and Student Achievement Utilizing the Florida Value-Added Model. *Journal of Research on Technology in Education*, *49*(3–4), 161–181. https://doi.org/10.1080/15391523.2017.1328992

Faulconer, E. K., & Gruss, A. B. (2018). The Role of Physical and Computer-Based Experiences in Learning Science Using a Complex Systems Approach. *International Review of Research in Open and Distributed Learning*, *19*(1), 154–168. https://doi.org/10.1007/s11191-020-00184-w

Fernández-Batanero, J. M., Román-Graván, P., Reyes-Rebollo, M. M., & Montenegro-Rueda, M. (2021). Impact of educational technology on teacher stress and anxiety: A literature review. *International Journal of Environmental Research and Public Health*, *18*(2), 1–13. https://doi.org/10.3390/ijerph18020548

Gamage, K. A. A., Wijesuriya, D. I., Ekanayake, S. Y., Rennie, A. E. W., Lambert, C. G., & Gunawardhana, N. (2020). Online delivery of teaching and laboratory practices: Continuity of university programmes during COVID-19 pandemic. *Education Sciences*, *10*(10), 1–9. https://doi.org/10.3390/educsci10100291

Gibbins, S., Sosabowski, M. H., & Cunningham, J. (2003). Evaluation of a web-based resource to support a molecular biology practical class - Does computer-aided learning really work? *Biochemistry and Molecular Biology Education*, *31*(5), 352–355. https://doi.org/10.1002/bmb.2003.494031050260

Goddard, A. R. (2020). Component of Remote Co-teaching. In *Teaching, Technology, and Teacher Education During Covid-19 Pandemic: Stories from the Field.*

Goldberg, H. R., & Dintzis, R. (2007). The positive impact of team-based virtual microscopy on student learning in physiology and histology. *American Journal of Physiology - Advances in Physiology Education*, *31*(3), 261–265. https://doi.org/10.1152/advan.00125.2006

Gurley, L. E. (2018). Educators' preparation to teach, perceived teaching presence, and perceived teaching presence behaviors in blended and online learning environments. *Online Learning Journal*, *22*(2), 197–220. https://doi.org/10.24059/olj.v22i2.1255

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related lnstructional planning. *Journal of Research on Technology in Education*, *43*(3), 211–229. https://doi.org/10.1080/15391523.2011.10782570

Harris, J., & Hofer, M. (2009). Instructional planning activity types as vehicles for curriculum-based TPACK development. *Research Highlights in Technology and Teacher Education 2009*, *2009*(2), 99–108. http://activitytypes.wmwikis.net/file/view/HarrisHofer-TPACKActivityTypes.pdf

Hiong, L. C., & Osman, K. (2013). A conceptual framework for the integration of 21st century skills in biology education. *Research Journal of Applied Sciences, Engineering and Technology*, *6*(16), 2976–2983. https://doi.org/10.19026/rjaset.6.3681

Howard, S. K., Curwood, J. S., & McGraw, K. (2018). *Leaders Fostering Teachers' Learning Environments for Technology Integration*. 1–19. https://doi.org/10.1007/978-3-319-53803-7_35-1

Johnson, K. E., & Golombek, P. R. (2016). Mindful L2 Teacher Education. In *Mindful L2 Teacher Education*. https://doi.org/10.4324/9781315641447

Juanda, A., Shidiq, A. S., & Nasrudin, D. (2021). Teacher learning management: Investigating biology teachers' tpack to conduct learning during the covid-19 outbreak. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 48–59. https://doi.org/10.15294/jpii.v10i1.26499

Kartimi, Gloria, R. Y., & Anugrah, I. R. (2021). Chemistry online distance learning during the covid-19 outbreak: Do tpack and teachers' attitude matter? *Jurnal Pendidikan IPA Indonesia*, *10*(2), 228–240. https://doi.org/10.15294/jpii.v10i2.28468

Koehler, M. J., & Mishra, P. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge PUNYA MISHRA. *Teachers College Record*, *108*(6), 1017–1054. http://one2oneheights.pbworks.com/f/MISHRA_PUNYA.pdf

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is Technological Pedagogical Content Knowledge (TPACK)? *Journal of Education*, *193*(3), 13–19. https://doi.org/10.1177/002205741319300303

Koh, J. H. L., Chai, C. S., Benjamin, W., & Hong, H. Y. (2015). Technological Pedagogical Content Knowledge (TPACK) and Design Thinking: A Framework to Support ICT Lesson Design for 21st Century Learning. *Asia-Pacific Education Researcher*, *24*(3), 535–543. https://doi.org/10.1007/s40299-015-0237-2

König, J., Jäger-Biela, D. J., & Glutsch, N. (2020). Adapting to online teaching during COVID-19 school closure: teacher education and teacher competence effects among early career teachers in Germany. *European Journal of Teacher Education*, *43*(4), 608–622. https://doi.org/10.1080/02619768.2020.1809650

Lestiyanawati, R. (2020). The Strategies and Problems Faced by Indonesian Teachers in Conducting e-learning during COVID-19 Outbreak. *CLLiENT (Culture, Literature, Linguistics, and English Teaching)*, *2*(1), 71–82. https://doi.org/10.32699/cllient.v2i1.1271

Ling Koh, J. H., Chai, C. S., & Tay, L. Y. (2014). TPACK-in-Action: Unpacking the contextual influences of teachers' construction of technological pedagogical content knowledge (TPACK). *Computers and Education*, *78*, 20–29. https://doi.org/10.1016/j.compedu.2014.04.022

Loeb, S., Dynarski, S., McFarland, D., Morris, P., Reardon, S., & Reber, S. (2017). Descriptive analysis in education: A guide for researchers. *U.S. Department of Education, Institute of Education Sciences. National Center for Education Evaluation and Regional Assistance, March*, 1–40. https://eric.ed.gov/?id=ED573325

Ma, K., Chutiyami, M., Zhang, Y., & Nicoll, S. (2021). Online teaching self-efficacy during COVID-19: Changes, its associated factors and moderators. *Education and Information Technologies*. https://doi.org/10.1007/s10639-021-10486-3

Millar, R. (2004). *The role of practical work in the teaching and learning of science. Washington, DC. National Academy of Sciences.*

Niess, M. L. (2007). Developing Teachers' Technological Pedagogical Content Knowledge (TPCK) with Spreadsheets. *Proceedings of Society for Information Technology & Teacher Education International Conference 2007, January 2007*, 2238–2245.

Perrault, A. M. (2007). An exploratory study of biology teachers' online information seeking practices. *School Library Media Research*, *10*(March).

Ramma, Y., Bholoa, A., Watts, M., & Nadal, P. S. (2018). Teaching and learning physics using technology: Making a case for the affective domain. *Education Inquiry*, *9*(2), 210–236. https://doi.org/10.1080/20004508.2017.1343606

Reiss, M. J., Millar, R., & Osborne, J. (1999). Beyond 2000: Science/biology education for the future. *Journal of Biological Education*, *33*(2), 68–70. https://doi.org/10.1080/00219266.1999.9655644

Rodrigues, H., Almeida, F., Figueiredo, V., & Lopes, S. L. (2019). Tracking e-learning through published papers: A systematic review. *Computers and Education*, *136*(March), 87–98. https://doi.org/10.1016/j.compedu.2019.03.007

Sadeghi, M. (2019). A shift from classroom to distance learning: Advantages and limitations. *Internasional Journal of Reserach in Englissh (IJREE), 4(1)*(March), 80–88.

Sadler, P. M., Sonnert, G., Coyle, H. P., Cook-Smith, N., & Miller, J. L. (2013). The Influence of Teachers' Knowledge on Student Learning in Middle School Physical Science Classrooms. *American Educational Research Journal*, *50*(5), 1020–1049. https://doi.org/10.3102/0002831213477680

Schmidt, D. A., Baran, E., Thompson, A. D., Mishra, P., Koehler, M. J., & Shin, T. S. (2009). Technological pedagogical content knowledge

(Track): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, *42*(2), 123–149. https://doi.org/10.1080/15391523.2009.10782544

Špernjak, A., & Šorgo, A. (2018). Differences in acquired knowledge and attitudes achieved with traditional, computer-supported and virtual laboratory biology laboratory exercises. *Journal of Biological Education*, *52*(2), 206–220. https://doi.org/10.1080/00219266.2017.1298532

Thomson, M. M., DiFrancesca, D., Carrier, S., & Lee, C. (2017). Teaching efficacy: exploring relationships between mathematics and science self-efficacy beliefs, PCK and domain knowledge among preservice teachers from the United States. *Teacher Development*, *21*(1), 1–20. https://doi.org/10.1080/13664530.2016.1204355

Tubin, D., & Edri, S. (2004). Teachers Planning and Implementing ICT-Based Practices. *Planning and Changing*, *35*(3), 181–191.

Westera, W. (2015). Reframing the Role of Educational Media Technologies. *Quarterly Review of Distance Education*, *16*(2), 19–32.

Winter, E., Costello, A., O'Brien, M., & Hickey, G. (2021). Teachers' use of technology and the impact of Covid-19. *Irish Educational Studies*, *40*(2), 235–246. https://doi.org/10.1080/03323315.2021.1916559

Yang, J., Wang, Q., Wang, J., Huang, M., & Ma, Y. (2019). A study of K-12 teachers' TPACK on the technology acceptance of E-schoolbag. *Interactive Learning Environments*, *0*(0), 1–14. https://doi.org/10.1080/10494820.2019.1627560