Disclosure of Biology Teacher Technological Pedagogical Content Knowledge as an Indicator of Learning Quality in Jember, Indonesia

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Abstract. Understanding the quality of biology learning implemented by teachers in Jember is essential to pay attention to. This study aims to identify biology teachers' technological pedagogical content knowledge (TPACK) ability profiles. The research method combines quantitative and qualitative approaches with an explanatory sequential design. At the quantitative research stage, the questionnaire method was used as the main instrument, which was then strengthened with a qualitative approach through interviews and documentation studies. Data collection was carried out through surveys and interviews. The population of this study were biology teachers in Jember, Indonesia, with a total sample of 33 biology education teachers. The survey instrument used is based on previous research conducted by Muhaimin, with a standard validity coefficient of 0.71-0.93. The survey questionnaire was distributed using google forms, with the assistance of two high school teachers and two research assistants. The results showed that the TPACK ability of high school biology teachers in Jember was still low due to a lack of access to information about technological developments and new learning media. Information about technological developments and new learning media is only obtained from university students participating in the field experience program. Therefore, teachers must be encouraged to improve their TPACK skills to provide a more effective learning process.

Keywords: Biology teachers, technology pedagogical content knowledge, quality of learning

Introduction

In the era of globalization and advances in information technology, the integration of technology in the education system has become an urgent need. Several studies have recognized the critical role of learning technology in designing, implementing, and evaluating learning processes (Ramli et al., 2020; Walk, 2012; Youmei, 2008). Utilizing technology and applications in learning can create a comfortable environment for students, encourage active involvement in information seeking, and increase the effectiveness and efficiency of learning.

Many studies report that using educational technology in learning can increase student learning activities. Hernon et al. (2023) found that using technology in education can increase student engagement and encourage active participation in the learning process. In addition, Sudarsana et al. (2019), Xie (2022), Yang (2022), Zhou & Zhou
revealed that the use of technology in learning can increase student motivation, activeness in the learning process, and academic achievement. Enadula et al. (2021) and Meenakshi et al. (2017) states that the use of technology can make it easier for students to find relevant and in-depth information about the topic being studied, further helping to increase students' understanding and involvement in the learning process. Deng et al. (2022) and Wang et al. (2023) state that using technology in learning can encourage students to actively solve problems, collaborate with classmates, and apply knowledge directly.

However, the use of learning technology will be more optimal if it is supported by the teacher's ability to use technological pedagogical content knowledge (TPACK) in the learning process. TPACK is a technology-based learning framework that combines knowledge about the field of study (content knowledge/CK), teaching methods (pedagogical knowledge/PK), and mastery of technology (technological knowledge/TK). The teacher's ability to integrate technology with materials, strategies, and student characteristics in learning has been shown to support improving the quality of learning (Angraini et al., 2023; Kadioğlu-Akbulut et al., 2023; Tanjung et al., 2022).

Even though there are clear benefits from using technology in learning, attention to the application of learning technology in high schools throughout Jember, Indonesia, is still needed. Research reports show low student skills, lack of innovation in teacher development of lesson plans (RPP), and not using learning strategies that encourage critical thinking (Priawasana et al., 2020; Umamah et al., 2021; Wulandari et al., 2023).

Students' soft skills can be seen from; 1) students inability to understand reading texts and identify important information, 2) lack of skills in analyzing problems and applying learned concepts, and 3) difficulties in constructing logical arguments and supporting their opinions with relevant evidence. Lack of innovation in the development of lesson plans by teachers such as; 1) The lesson plans used are traditional and pay little attention to different approaches in teaching, 2) The lesson plans are only focused on knowledge transfer, without providing opportunities for students to think critically or participate actively in learning, 3) Lesson plans tend to be monotonous and do not utilize technology or available educational resources. Not using learning strategies that encourage critical thinking, such as; 1) teachers rarely ask questions that encourage students to question information, identify assumptions, or evaluate arguments, 2) lack of opportunities for students to discuss, debate, or collaborate in solving problems, 3) learning strategies that only focus on genuine understanding and ignore development critical thinking skills, such as analysis, evaluation, or synthesis.

Therefore, analysis of the TPACK ability of high school teachers in Jember, especially biology teachers, is essential to understanding the level of technology utilization in learning in the region. This study aims to analyze the TPACK level of biology teachers and understand their perceptions in Jember District, East Java, Indonesia. This research has significance because it is rare to find research reports exploring biology teachers' TPACK. The research aims to determine the levels of CK, PK, PCK, TK, TPK, TCK, and TPACK, as well as the obstacles faced by biology teachers in integrating technology into learning.

**Methods**

The type of research used is mixed methods using an explanatory sequential mixed methods design. This method combines quantitative and qualitative research sequentially. The collection procedure begins with collecting and analyzing quantitative data and then continues with collecting and analyzing qualitative data. The results of
these two methods provide a deeper explanation of phenomena that cannot be explained through quantitative research effects. In the first stage, research was carried out using a quantitative questionnaire. Qualitative methods support this stage through interviews and documentation studies. Using this method, this research aims to determine differences in the TPACK levels of biology teachers in Jember, Indonesia, regarding their teaching experience and perceptions of biology teachers. The second stage is surveys and interviews. The survey method is used to collect data that contains as much information as possible about the quality of the subject that can describe the subject's condition. Meanwhile, the interview method was used to obtain comprehensive and detailed information about the TPACK teacher's abilities in the learning process. Interview questions were adapted from question items in the survey. Informants are selected randomly, and the number of informants interviewed. The duration of the interviews ranged from thirty to forty minutes. These two data collection methods can provide complete and detailed information in research. The research population is biology teachers in Jember, Indonesia, with a total sample of 33 biology education teachers. This research was conducted for three months in Jember Regency, Indonesia.

The survey instrument used was adopted by Muhaimin et al. (2019) with an structural equation modeling SEM standardized validity coefficient of 0.71-0.93. The survey questionnaire was distributed using google forms with the help of two high school teachers and two research assistants. After the data is collected, the data is processed using microsoft excel. The data analysis technique calculates frequency, proportion, average and standard deviation (descriptive statistics) to determine the teacher's TPACK level.

**Results and Discussion**

The research results are presented in tabular form. Table 1 provides an overview of the TPACK proficiency level of biology teachers in the CK, PK, PCK, TK, TPK, TCK, and TPC categories. Table 2 shows the perceptions of technology integration related to TPACK, which describes how teachers understand and apply technology in the learning process. These tables help visualize TPACK proficiency levels and the degree to which biology teachers use technology in their learning contexts.

**Table 1.** Level of TPACK of biology teacher

<table>
<thead>
<tr>
<th>Constructs</th>
<th>Mean Score</th>
<th>S.D</th>
<th>Cronbach Alpha (a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TK</td>
<td>3.06</td>
<td>0.56</td>
<td>0.85</td>
</tr>
<tr>
<td>PK</td>
<td>3.21</td>
<td>0.65</td>
<td>0.85</td>
</tr>
<tr>
<td>CK</td>
<td>3.36</td>
<td>0.65</td>
<td>0.86</td>
</tr>
<tr>
<td>TPK</td>
<td>3.00</td>
<td>0.61</td>
<td>0.89</td>
</tr>
<tr>
<td>PCK</td>
<td>3.15</td>
<td>0.57</td>
<td>0.88</td>
</tr>
<tr>
<td>TCK</td>
<td>2.94</td>
<td>0.61</td>
<td>0.83</td>
</tr>
<tr>
<td>TPC</td>
<td>2.76</td>
<td>0.66</td>
<td>0.83</td>
</tr>
</tbody>
</table>

The results of this study indicate that the highest score was obtained for the CK component, followed by PK, PCK, TK, TPK, TCK, and TPC. The CK component refers to knowledge of subject matter, such as scientific, social, and linguistic knowledge, with three question indicators: 1) knowledge possessed, 2) good thinking skills, and 3) ability to develop knowledge. Meanwhile, TPC is the component that gets the lowest score. TPC
is knowledge about the application of technology to improve students’ understanding and learning, with four indicator questions, namely: 1) integrating science, technology, and learning approaches appropriately, 2) utilizing technology to improve the quality of learning, 3) the ability to integrate learning models with scientific approaches, technology, and learning, and 4) the ability to provide teaching in the learning process using science and technology appropriately. This finding aligns with previous research reports by Chieng & Tan, (2021) and Muhaimin et al. (2019), who also concluded that CK is the component that gets the highest score, followed by the other members.

A high score on the CK component in the interview process shows that the teacher has good knowledge of the subject matter and can develop it effectively. However, teachers still face many obstacles regarding scientific approaches, technology, and appropriate learning models. The low level of TPK, TCK, and TPC components among teachers reflects obstacles in integrating science, technology, and education. Juanda et al. (2021) stated that the implementation of the learning process was still not optimal. These difficulties can be seen in teachers’ challenges in choosing appropriate technology to improve the quality of learning. In addition, teaching strategies that include these elements have not been fully implemented in the classroom, affecting the teacher’s ability to carry out the learning process. This aligns with Sulistiani et al. (2023) and Drajati et al. (2023), which states that attitudes towards TPACK competence positively correlate with self-regulation, self-efficacy, and intention to use technology in the learning process. Furthermore, teachers' TPACK abilities in the learning process still do not receive attention. Marlina et al. (2023) stated that not many researchers have done TPACK in education. Nevrita et al. (2020) stated that biology teachers currently only use technology-based learning media at the basic level. Furthermore, Putri et al. (2019) stated that it is necessary to improve biology teachers’ TPACK abilities.

Table 2. Perceived technology integration related to TPACK

<table>
<thead>
<tr>
<th>Theme</th>
<th>Representative statement</th>
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</thead>
<tbody>
<tr>
<td>Problems in technology integration</td>
<td>Low willingness and knowledge of teachers to use ICT in the learning process</td>
</tr>
<tr>
<td>Advantages of technology integration</td>
<td>Internet access at schools is still not smooth</td>
</tr>
<tr>
<td>Students centered learning</td>
<td>Seek to develop knowledge or information more quickly and efficiently so that the quality of learning becomes better</td>
</tr>
<tr>
<td>Knowledge of new technology and its classroom integration</td>
<td>Increase students’ motivation and cognitive abilities</td>
</tr>
<tr>
<td>Peer collaboration</td>
<td>Technology integration in the learning process can make students more active in the learning process, such as searching and requesting information quickly and effectively, making it easier for teachers in the learning process in class.</td>
</tr>
<tr>
<td></td>
<td>Teachers often get technological developments and new learning media from their University Field Experience Program.</td>
</tr>
<tr>
<td></td>
<td>Teachers often collaborate with University Field Experience Program students because University Field Experience Program students often bring information technology developments and new learning media.</td>
</tr>
</tbody>
</table>

Apart from that, the research results also report obstacles in integrating technology into the learning process, including 1) low willingness and knowledge of teachers to use ICT in learning and 2) internet access is not yet smooth in schools. These two obstacles have an impact on low PK, PCK, TK, TPK, TCK, and TPC scores. In addition, based on
interviews, it was found that sources of information related to knowledge about new technology and integration in learning are still limited. Teachers only get information about technological developments and new learning media through students who carry out PPL. Teacher collaboration with PPL students also occurs because PPL students often bring information about products in information technology and new learning media. This finding is in line with the statement of Christensen et al. (2018), which states that many teachers do not have experience facilitating and supporting the integration of technology effectively and innovatively in learning. Howard et al. (2019) state that integrating digital technology into learning is a complex system that involves interactions between teachers, students, and the digital technology used. Furthermore, Xianhan et al. (2022) stated that teachers’ ability to utilize science and technology in learning can be improved through several things, such as 1) reflection on the results of learning activities, 2) learning through media, and 3) interaction with peers and students.

The interview results also show that teachers are aware of the benefits of integrating technology into learning, such as faster and easier access to developing knowledge and information to improve the quality of education, student motivation, and cognitive abilities. This statement is in line with Ioannou et al. (2019), Idayanti et al. (2023), Lisnani & Emmanuel, (2020), and Apriani et al. (2021), which states that integrating technology into learning can improve learning outcomes and student motivation. Furthermore, Chaykina et al. (2022) stated that the application of blended learning in education can increase the effectiveness of learning outcomes. Li (2021) says that students' motivation, cognitive abilities, and independent learning abilities can be improved by implementing the blended learning model.

The teacher also revealed that the use of science and technology in learning makes students more active in the learning process, for example, looking for information quickly and effectively, making it easier for teachers to teach in class. This is in line with research by Theobald et al. (2020) and Ting et al. (2023), which states that science and technology-based learning can improve student learning achievement, especially for students with low academic abilities. Choo (2021) also said that students currently prefer the use of science and technology in education and are more active in participating in the learning process.

**Conclusion**

This research concludes that the TPACK ability of biology teachers in high schools in Jember is still low. This shows that teachers have not maximized the use of technology in the learning process. Several factors, including lack of access to information, limited training, lack of practical experience, and technical obstacles, cause this low TPACK capability. Information and training are only available through the PPL students. Therefore, it is necessary to use technology more effectively so that teachers can integrate learning technology into the learning process well. An optimal approach to technology will create a more dynamic learning environment and improve teaching quality.
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