Jurnal Pembelajaran Dan Biologi Nukleus p-ISSN: 2442-9481
Vol 10 (3): 820-830, November 2024 e-ISSN: 2685-7332

Analysis of Technological Pedagogical and Content Knowledge and Authentic Assessment of Biology Preservice Teachers in Implementing School Field Introduction (ISFI)

Priskila Uli Arta Lumban Tobing(*)[1], Ely Djulia[2], Herbert Sipahutar[2]

[1]Postgraduate Program Biology Education Study Program, Medan State University;
[2]Departemen of Biology Education Study Program, Medan State University
Jl. William Iskandar Ps. V, Kenangan Baru, District. Percut Sei Tuan, Deli Serdang Regency, North Sumatra, Indonesia, Postcode 20221

***Corresponding author:** priskilauli347@gmail.com

Submitted July 05Th 2024 and Accepted October 22Th 2024

Abstract

This research describes the educators serve as facilitators who can enhance the efficacy of the learning process. The success is contingent upon the teacher's proficiency in understanding students, the curriculum, instructional methodologies, and assessments to effectively convey scientific information. Consequently, educators must enhance their quality and proficiency to achieve the objectives of Indonesian national education, namely to cultivate the nation's well-being. The National Science Teacher Association delineates three tiers for the preparation of science educators, encompassing biology instructors: preservice (student teacher candidates), novice teachers (induction), and professional teachers. Professional educators must be adequately prepared from the outset, even as student teacher candidates. Technological Pedagogical and Content Knowledge (TPACK) assists educators in enhancing the quality of classroom learning. This research uses quantitative descriptive research that captures information about the cognitive abilities of TPACK and authentic assessments of prospective biology teacher students at Medan State University and the ability to integrate TPACK in the implementation of ISFI II

Keywords: *Analysis; Authentic Assessment; Biology Preservice Teachers; Implementing School Field Introduction (ISFI); Technological Pedagogical And Content Knowledge (TPACK)*

https://doi.org/10.36987/jpbn.v10i3.5936

INTRODUCTION

Teachers are essential facilitators in the learning process (Nofiani & Julianto, 2018). The success of learning is determined by the teacher's knowledge of students, curriculum, instructional strategies, and assessments, which enable the effective transformation of scientific knowledge (Sukaesih et al., 2017). For this reason, teachers must improve their quality and competence to achieve Indonesia's national education goals, namely to educate the nation's life (Rosyid, 2016).

According to the National Science Teacher Association (NSTA, 2012), the preparation of science teachers, including biology teachers, must go through three levels: preservice (student teacher candidates), novice teachers (induction), and professional teachers. Technological Pedagogical And Content Knowledge (TPACK) is a conceptual framework that combines technological, pedagogical, and content knowledge. According to Mishra & Koehler (2008), TPACK consists of three main components: content knowledge, pedagogical knowledge, and technological knowledge, which form Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical And Content Knowledge (TPACK).

TPACK helps teachers improve the quality of learning by making teaching more effective, interactive, and personalized (Schmidt et al., 2009; Irdalisa et al., 2020; Utami et al., 2024). However, biology teachers often face challenges in implementing TPACK, such as a lack of digital competence and limited access to training and resources (Irdalisa et al., 2020; Lachner et al., 2021; Aumann et al., 2024). teachers often have difficulty connecting the theory obtained during training with practice in the field (Valtonen et al., 2022).

Authentic assessment is an integral part of learning evaluation, which allows teachers to assess students' abilities in natural contexts (Shofiyah & Budi, 2018; Djulia et al., 2020). The link between TPACK and authentic assessment is essential because TPACK helps teachers understand how technology can be used to develop and implement more authentic and meaningful assessments. Therefore, it is necessary to research to analyze TPACK abilities and authentic assessments of prospective biology teacher students at Medan State University who have implemented ISFI II.

METHOD

This research was conducted at Medan State University from October 2023 to March 2024. The research population was all Biology Education students in the 2020 class at Medan State University, totaling 128 students. The sample was taken using a purpose sampling technique, namely 55 students who had carried out ISFI II at the class XI high school level. This research uses a quantitative descriptive method to describe the cognitive abilities of Technological Pedagogical And Content Knowledge (TPACK), authentic assessment of preservice biology teacher students, and the ability to integrate TPACK in implementing ISFI II. Data on students' abilities in the seven components of TPACK was obtained through a multiple-choice test of 50 questions.

The sample was chosen because the 8th semester Biology Education students of the 2020 intake had taken courses that supported the formation of TPACK skills. The courses that the prospective teacher students had taken up to the 7th semester. In contrast, data on students' abilities to integrate TPACK in the implementation of ISFI II was obtained through analysis of RPP documentation prepared by students. Apart from that, students' ability to carry out authentic assessments during the implementation of ISFI II was measured using a questionnaire of 17 positive statements and eight negative statements. The calculated values obtained are interpreted based on specific criteria, as shown in Table 1.

Table 1. TPACK Ability Category for Preservice Biology Teachers (Listiawan & Baskoro, 2015)

Value Range	TPACK Ability Category for Preservice Biology Teachers
0 – 28	Very not good
29 – 46	Not good
47 – 64	Pretty good
65 – 83	Good
84 – 100	Very good

RESULTS AND DISCUSSION

The evaluation results of the preservice biology teachers' abilities at Universitas Negeri Medan in the three main TPACK components are as follows: Technological Knowledge with a mean of 89,39 ± 5,20 ($\bar{X}$ ± SD), Pedagogical Knowledge with a mean of 89,70 ± 6,96, and Content Knowledge with a mean of 88,48 ± 4,55. The evaluation of the combination of these three components shows a mean of 91,31 ± 5,04 for Technological Pedagogical Knowledge (TPK), 89,90 ± 3,87 for Technological Content Knowledge (TCK), 92,53 ± 4,40 for Pedagogical Content Knowledge (PCK), and 86,55 ± 4,38 for Technological Pedagogical And Content Knowledge (TPACK). These results indicate that the preservice biology teachers are proficient in all seven TPACK components, as seen in Figure 1.

In the Technological Knowledge (TK) component, students demonstrated excellent understanding in using Zoom Meeting ($\bar{X}$ = 94,55), Microsoft PowerPoint (92,73), various video conferencing tools (90,91), email (90,91), and Microsoft Excel (87,27), with a good understanding of using microscopes (80,00). This shows a significant potential for integrating technology into teaching, which can enhance students' effectiveness and learning experience. Incorporating technology into biology education increases learning efficiency and creates a more enjoyable, personalized, and relevant experience in the digital era. Optimal technology utilization makes biology education more dynamic and responsive to students' needs, fostering critical skills development, global collaboration, and preparation for future challenges (Cartono, 2022). These findings are supported by Handayani et al., (2022), who found that Problem-Based Learning (PBL) via Zoom Cloud Meeting successfully improved students' critical thinking skills and received positive feedback.

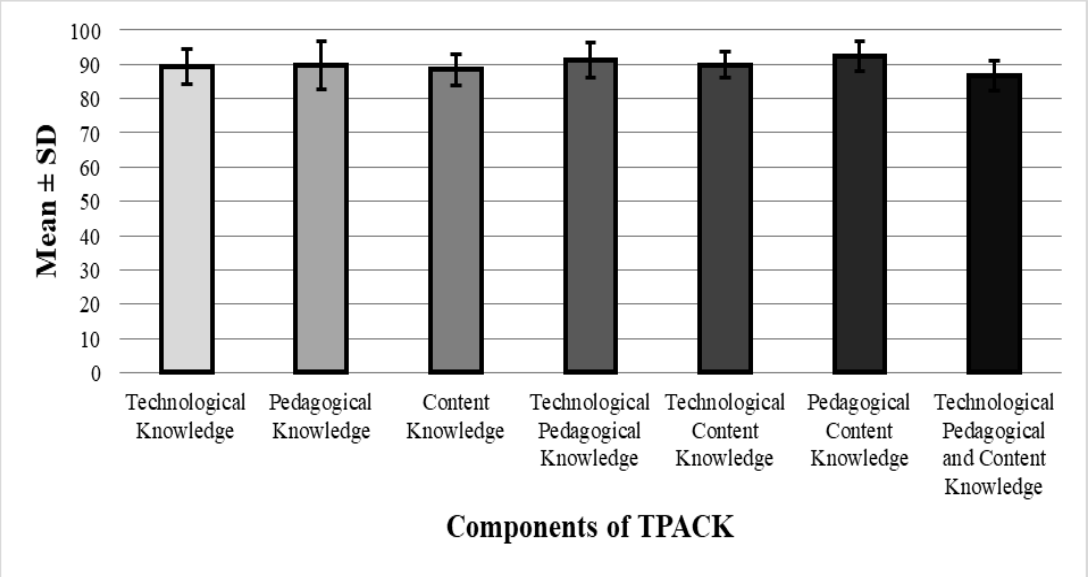

Figure 1. The Ability of Preservice Biology Teachers in the Seven Components of TPACK

In the Pedagogical Knowledge (PK) component, students showed an excellent understanding of using teaching methods and strategies ($\overline{X}$ = 96,36), differentiated instruction (94,55), guidance and support (94,55), lesson planning (89,09), and teaching steps (85,45). The understanding of teacher competencies was also rated as good, with a mean of 78,18. According to Suyamto et al., (2020), strong-skill teachers must understand and determine the appropriate teaching approaches, adjust to students' learning styles, and guide them in solving learning problems, increasing their engagement and motivation in learning activities.

In the Content Knowledge (CK) component, students demonstrated an excellent understanding of animal tissue structure ($\overline{X}$ = 94,55), movement mechanisms (90,91), food substance tests (90,91), plant tissue functions (87,27), and analyzing the relationship between the tissue structure of organs in the locomotor system concerning bioprocesses (85,45). Additionally, understanding the properties of meristematic/embryonic tissues in plants was rated good, with a mean of 81,82. According to research of Elvianasti et al., (2023) a prospective biology teacher must deeply understand biological concepts to deliver lessons and effectively achieve learning objectives. Preservice biology teachers who do not fully understand and master the material cannot effectively choose and determine how to teach it.

In the Technological Pedagogical Knowledge (TPK) component, students showed excellent understanding in designing lesson plans with Information and Communication Technologies (ICT) integration ($\overline{X}$ = 98,18), using technology in Problem-Based Learning (98,18), Google Classroom (94,55), Google Form (92,73), identifying technology for Blended Learning (90,91), integrating technology in the SAMR model (89,09), teaching strategies (87,87), and implementing Blended Learning (87,87). Understanding the use of technology (PowerPoint) as a teaching medium was rated as good, with a mean of 83,64. According to research of Nuruzzakiah et al., (2022), biology

teachers demonstrated strong abilities in selecting and using technology to enhance teaching approaches and learning. The teacher education program has encouraged deep thinking about the impact of technology in teaching and critical thinking about its use in the classroom. Flexibility in adapting technology for various teaching activities indicates readiness to integrate technology effectively in a dynamic educational context.

In the Technological Content Knowledge (TCK) component, students demonstrated excellent understanding of identifying cell division processes ($\overline{X}$ = 96,36), the function of stem parts through microscopic observation (92,73), the function of endoscopes in the digestive system (92,73), the effect of X-rays on watermelon seeds (90,91), types of epithelial tissue in organs (89,09), types of metals for screw materials (85,45), technology inspired by plant structures (85,45), and technology for addressing locomotor system disorders (85,45). This study shows that preservice biology teachers not only master biology content but also apply technology to enrich lesson materials and enhance students' understanding. Nuruzzakiah et al., (2022) supported this by stating that biology teachers understand the use of technology for teaching biology with a good rating of 80,27%.

In the Pedagogical Content Knowledge (PCK) component, students demonstrated excellent understanding in creating assessment plans for the digestive system ($\overline{X}$ = 98,18), problem-solving skills in muscle contractions (96,36), strategies and assessment instruments for using microscopes on plant tissues (96,36), explanations of reflex movement competencies (94,55), types of assessments for reports on plant tissue observations (92,73), bone structure in HCl (92,73), differences among the three types of muscle tissues in humans (89,09), follow-up learning on animal tissues (87,27), and formulating specific learning objectives from competency indicators (85,45). Großmann & Krüger (2022) emphasized that preservice biology teachers need conceptual and procedural knowledge to make appropriate decisions about biological content, learning outcomes, and activities that support effective learning, thereby improving the quality of biology lesson plans.

In the TPACK component, students demonstrated an excellent understanding of appropriate teaching methods ($\overline{X}$ = 92,73), teaching strategies using technology for cell structure (89,09), teacher actions that encourage cooperation and collaborative learning (85,45), teaching strategies using animated media for the relationship between physical exercise and lactic acid accumulation (83,64), and the function of ICT-based teaching media for abstract material (81,82). These results indicate that preservice biology teachers at Universitas Negeri Medan are ready to integrate technology into biology teaching effectively. Research support from Bwalya et al., (2023) confirms that technology integration can effectively and innovatively support teaching biology content.

The ability of preservice biology teachers to integrate TPACK in the implementation of ISFI II can be detailed as follows: (1) The ability in the aspect of Technological Pedagogical Knowledge has an of 85,76, categorized as excellent, and (2) The ability in the aspect of Pedagogical Content Knowledge has an of 87,68, also categorized as excellent. Based on these results, preservice biology teachers at Universitas Negeri Medan can integrate TPACK to implement ISFI II.

To support learning, preservice biology teachers at UNIMED use various information and communication technologies (ICT) such as laptops, projectors, Microsoft PowerPoint, and the Internet. 92,7 % use laptops and projectors in their lesson plans, 90,9 % use Microsoft PowerPoint, and 50,9 % use the Internet. Students demonstrate good abilities in using ICT as active teaching media, creating teaching materials, and integrating ICT into teaching. For example, 90, 9% create teaching materials with PowerPoint, and 78,2 % create Student Worksheets (called LKPD). Additionally, 90,9 % use PowerPoint to present materials, 47,3 % display videos from YouTube, and 34,5 % present images related to the material. A total of 92,7 % can utilize ICT media to achieve teaching goals. However, only 3,6 % use ICT to confirm learning outcomes with existing theories, while 50,9 % do so without ICT, and 45,5 % do not confirm learning outcomes.

Preservice biology teachers at Universitas Negeri Medan apply various teaching models in their lesson plans. These models include Problem-Based Learning (43,6 %), Discovery Learning (40 %), Cooperative Learning (12,7 %), Guided Inquiry (12,7 %), Direct Instruction (10,9 %), Conventional/Lecture Model (3,6 %), Computational Thinking Learning (1,8 %), and Cooperative Make a Match (1,8 %). According to Alberida et al., (2023), teachers should be able to determine the appropriate teaching model to enhance learning outcomes and student motivation. Additionally, teachers must understand the importance of selecting suitable models in the school teaching process.

The methods used in lesson plans include group discussions (96,4 %), Q&A (72,7 %), presentations (61,8 %), lectures (29,1 %), experiments (12,7 %), observations (12,7%), jigsaw (12,7 %), observation (12,7 %), literature study (3,6 %), games (1,8 %), and stand-to-stand (1,8 %). Students combine these methods, with 50,9 % combining three methods, 20 % combining two methods, 16,4 % combining five methods, and 12,7% combining four methods in learning activities. This is consistent with research of Setyoningsih & Hariyatmi (2024), which shows that varied methods can make students active, work together to understand the material, and increase learning interest and interaction between students and teachers.

Several learning activities designed by preservice biology teachers to stimulate student engagement in the learning process in their lesson plans (RPP) include group discussions (96,4 %), summarizing lessons (72,7 %), responding to teacher questions (54,5 %), addressing group discussion results (34,5 %), asking questions (30,9 %), conducting observations and experiments (12,7 %), and providing opinions based on articles given by the teacher (1,8 %).

The media used in the lesson plans include PowerPoint (90,9 %), Student Worksheets (LKPD) (78,2 %), educational videos (49,1 %), images (32,7 %), teaching aids/models (16,4 %), electronic modules (10,9 %), animations (3,6 %), and internet articles (1,8 %). Pratiwiningrum et al., (2023) assert that media variety helps understand and achieve learning objectives. Preservice biology teachers at Universitas Negeri Medan create teaching media, including Power Point presentations (90,9 %), LKPD (81,8 %), and electronic modules (10,9 %), for use in teaching activities. 38,2 % combine three types of teaching media, 18,2 % combine four types, 16,4 % combine two types, and 10,9 % combine five types of teaching media in their activities. According to Setyoningsih & Hariyatmi (2024), to facilitate student understanding and create a non-

monotonous learning environment, teachers must be able to select, design, present, and develop different types of media. Similarly, research by Aliah et al., (2023) indicates that teachers frequently use projectors, LKPD, and PowerPoint to make material presentations attractive and understandable.

Assessments in the cognitive domain include written tests (61,8 %) and a combination of written and oral examinations (16,4 %). Psychomotor domain assessments include evaluating discussions and presentations, creating projects, and conducting observations and experiments. Affective domain assessments involve observing students. According to Hutapea (2019), cognitive learning outcomes are measured using test techniques, while affective and psychomotor domains are measured using non-test techniques. In their lesson plans, students use teaching media to reinforce concepts. For example, they use educational videos to illustrate ideas that are difficult to understand visually, then play them in class and guide discussions afterward. This helps strengthen students' understanding through diverse and interactive learning experiences (Lin & Yu, 2023).

Preservice biology teachers use images/photos/videos in their lesson plans (RPP) to show real-life examples related to the material. 41,8 % only ask questions verbally without using the available teaching media. According to Walan (2020), using digital media in science teaching at secondary schools effectively visualizes abstract concepts, provides clear demonstrations, enhances engagement, and adapts to students' abilities. Digital media is a valuable tool for showing real-life examples and reinforcing understanding of the lesson material. One of the indicators categorized as lacking is guiding students to conclude using the utilized teaching media ($\overline{X}$ = 38,18). According to Gillies (2020), media such as videos and animations can visualize complex phenomena, which helps students conclude interactive and directed learning.

The ability of preservice biology teachers to conduct authentic assessments during the implementation of ISFI II can be detailed as follows. First, the ability to plan authentic assessments has a mean of 93,94, categorized as excellent. Authentic assessments are essential in guiding students' abilities in knowledge, attitudes, and skills (Djamahar et al.,, 2020). Planning authentic assessments includes setting standards based on the established core and essential competencies, creating authentic tasks according to the emphasized competencies, developing criteria closely related to standards or competencies and real-world needs, and preparing assessment rubrics (Djulia et al.,, 2020).

Second, the ability to conduct authentic assessments has a mean of 94,55, categorized as excellent. According to Pramana & Putra (2019), the main focus of authentic assessment is to provide feedback on individual student performance. Comprehensive evaluations of each student's performance are conducted to obtain a complete picture of their abilities. When students' weaknesses are identified and given feedback, they can improve their learning abilities. Improving the quality of learning directly contributes to student learning outcomes.

Third, the obstacles in conducting authentic assessments have a mean of 75,00, categorized as good. This indicates that students can still overcome barriers in planning and conducting authentic assessments in the learning process. Two of the eight indicators are classified as excellent: students being hindered by time and the complexity of cognitive

domain assessment rubrics ($\overline{X}$ =83,64) and feeling burdened by authentic assessments (81,82). Indicators categorized as good include understanding how to create assessment instruments (80,00), time constraints and the complexity of attitude domain assessment rubrics (76,36), confusion in authentic assessments linking attitudes, knowledge, and skills (74,55), lack of authentic assessment guidebooks and being hindered by time and the complexity of psychomotor domain assessment rubrics (69,09), and the numerous assessment formats that burden students (65,45).

CONCLUSION

Based on the results of the research that has been conducted, it can be concluded that: (1) Biology teacher candidates excel in technology, pedagogy, and content. Students can grasp and apply plant, animal, motor, and digestive system material; (2) They can combine technology with pedagogical expertise and content. (3) Prospective biology teachers can mix technology, pedagogy, and content to assist learning, explain material, and connect theory with practice. They can design and implement effective learning using TPACK, ensuring that all elements support each other to improve student learning outcomes; (4) Prospective biology teacher students can help implement School Field Introduction (ISFI) II in 9th grade high school. They are ready to use technology and appropriate teaching strategies to assist field learning; (5) Prospective biology teacher students are skilled in authentic assessment. They may design and administer real-world tests and give students critical comments to boost learning. Simpler rubrics and better time management can overcome authentic assessment barriers.

REFERENCES

Alberida, H., Rahmi, Y. L., Fuadiyah, S., & Fadilah, M. (2023). Assessing Science Teachers' Pedagogical Content Knowledge (PCK) in the Context of Understanding about Instructional Strategies. *Jurnal Penelitian Pendidikan IPA*, 9(11), 9698-9703. https://doi.org/10.29303/jppipa.v9i11.3260

Aliah, N., Mutmainnah, and Saddia, A. (2023). Analisis Kemampuan Pedagogical Content Knowledge (PCK) Guru Fisika SMA/MA Berdasarkan Masa Kerja di Kabupaten Majene. *Journal of Health, Education, Economics, Science, and Technology*, 5(2), 235-245. https://doi.org/10.36339/j-hest.v5i2.98

Aumann, A., Schnebel, S., and Weitzel, H. (2024). Teaching Biology Lessons Using Digital Technology: A Contextualized Mixed-Methods Study on Preservice Biology Teachers' Enacted TPACK. *Education Sciences*, 14(5), 1-27. https://doi.org/10.3390/educsci14050538

Bwalya, A., Rutegwa, M., Tukahabwa, D., & Mapulanga, T. (2023). Enhancing Preservice Biology Teachers' Technological Pedagogical Content Knowledge Through a TPACK-Based Technology Integration Course. *Journal of Baltic Science Education*, 22(6), 956-973. https://doi.org/10.33225/jbse/23.22.956

Cartono. (2022). The Importance of Technology Integration in Biology Learning in the Digital Era. *Jurnal Infokum*, 10(5), 1238-1243. https://infor.seaninstitute.org/index.php/infokum/article/view/2113/1833

Djamahar, R., Ristanto, R. H., and Darmawan, E. (2020). Biology Teachers: Knowledge in Authentic Assessment Through Cooperative Integrated Reading and Composition Based Scientific Approach (Cirsa). *Indonesian Journal of Science and Education*, 4(2), 111-124. https://doi.org/10.31002/ijose.v4i2.2588

Djulia, E., Hasruddin, Arwita, W., Zulkifli Simatupang, Wasis Wuyung Wisnu Brata, Mariyati Sipayung, Aryeni, Amrizal, Halim Simatupang, Salwa Rezeqi, Nanda Pratiwi, & Dirga Purnama. (2020). *Evaluasi Pembelajaran Biologi*. Medan: Yayasan Kita Menulis.

Elvianasti, M., Rahmadani, M., Meitiyani., & Sari, P. M. (2023). Technological Pedagogical Content Knowledge (TPACK) Prospective Biology Teachers in Distance Learning. *Studies in Learning and Teaching*, 4(2), 240-249. https://doi.org/10.46627/silet.v4i2.191

Gillies, R. M. (2020). *Inquiry-Based Science Education*. Boca Raton: CRC Press. 245 p.

Großmann, L., and Krüger, D. (2022). Identifying Performance Levels of Enacted Pedagogical Content Knowledge in Trainee Biology Teachers' Lesson Plans. *SpringerLink*, 28(1), 1-20. https://doi.org/10.1007/978-3-031-32225-9_7

Handayani, Nurjanah., Muizz, Abdul., Wahidin., Nur, Sofyan. (2022). Implementation Of A Problem-Based Learning (Pbl) Model Assisted By Zoom Cloud Meeting In Improving High School Students' Critical Thinking Skills And Learning Motivation on The Concept Of Environmental Pollution. Edunity: Social and Educational Studies. 1(4), 95-110. https://doi.org/10.57096/edunity.v1i04.27

Hutapea, R. H. (2019). Instrumen Evaluasi Non-Tes dalam Penilaian Hasil Belajar Ranah Afektif dan Psikomotorik. *Jurnal Teologi dan Pendidikan Kristen Kontekstual*, 2(2), 151-165. https://doi.org/10.34307/b.v2i2.94

Irdalisa, Paidi, and Djukri. (2020). Implementation of Technology-Based Guided Inquiry to Improve TPACK among Prospective Biology Teachers. *International Journal of Instruction*, 13(2), 33-44. https://doi.org/10.29333/iji.2020.1323a

Lachner, A., Jarodzka, H., and Nückles, M. (2021). Development and Application of a Domain-Specific TPACK Questionnaire-Findings from a Longitudinal Study on Teaching Human Biology Using Digital Tools. *Journal of Science Education and Technology*, 30(3), 406-420. https://doi.org/10.1007/s10956-024-10108-w

Lin, Y., and Yu, Z. A. (2023) Meta-analysis Evaluating the Effectiveness of Instructional Video Technologies. *Tech Know Learn*, 28(2), 123-145. https://doi.org/10.1007/s10758-023-09669-3

Listiawan, T., & Baskoro, W. W. (2015). Analisis Technological Content Knowledge (TCK) Calon Guru Matematika Dalam Menggunakan Perangkat Lunak

Geometri Dinamis. In Prosiding Seminar Nasional Matematika Dan Pendidikan Matematika UNY. pp. 827-834.

Mishra, P. and Koehler, Matthew J. (2008). *Introducing Technological Pedagogical Content Knowledge*. Annual Meeting of The American Educational Research Association: New York City.

Nofiani, M., and Julianto, T. (2018). Efektivitas Pelaksanaan Program Magang Pembelajaran terhadap Kemampuan TPACK (*Technological Pedagogical Content Knowledge*) Mahasiswa Calon Guru Biologi FKIP Universitas Muhammadiyah Purwokerto. Proceeding Biology Education Conference, 15(1), 577-582.

NSTA (2012). Standards for Science Teacher Preparation. National Science Teachers Association in Collaboration with The Association for The Education of Teachers in Science.

Nuruzzakiah, N., Hasanuddin, H., Artika, W., Supriatno, S., & Rahmatan, H. (2022). Competency Analysis of Technological Pedagogical and Content Knowledge (TPACK) Biology Teachers. *Jurnal Penelitian Pendidikan IPA*, 8(1), 325-335. https://doi.org/10.29303/jppipa.v8i1.1166

Pramana, K. A. B., and Putra, D. (2019). *Merancang Penilaian Autentik*. Jembrana-Bali: CV Media Educations.

Pratiwiningrum, F. M., Hairida, H., Sartika, R. P., Masriani, M., & Rasmawan, R. (2023). Deskripsi Kemampuan Guru dalam Merancang Kegiatan Pembelajaran Aktif dengan Model Pembelajaran Discovery Learning dan Problem Based Learning. *Edukatif: Jurnal Ilmu Pendidikan*, 4(6), 8096-8105. https://doi.org/10.31004/edukatif.v4i6.3675

Rosyid, A. (2016). *Technological Pedagogical Content Knowledge*: Sebuah Kerangka Pengetahuan Bagi Guru Indonesia di Era MEA. Prosiding Seminar Nasional Inovasi Pendidikan. 446-454.

Schmidt, D. A., Baran, E., Thompson, A., Punya Mishra, Matthew J. Koehler, & Tae S. Shin. (2009). Technological Pedagogical Content Knowledge (TPACK): 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

Setyoningsih, Anggie Iim, and Hariyatmi. (2024). Pedagogical Content Knowledge (PCK) Guru Biologi SMA Se-Kartasura dalam Menyusun Modul Ajar. *Didaktika: Jurnal Kependidikan*, 13(2), 1819-1832. https://doi.org/10.58230/27454312.643

Shofiyah, N., and Budi Sartika, S. (2018). *Asesmen pembelajaran*. Sidoarjo: UMSIDA PRESS.

Sukaesih, S., Ridlo, S., and Saptono, S. (2017). Analisis Kemampuan *Technological Pedagogical and Content Knowledge* (TPACK) Calon Guru pada Mata Kuliah PP Bio. Prosiding Seminar Nasional Pendidikan Sains (SNPS). Universitas Sebelas Maret Surakarta. 58-64.

Suyamto, J., Masykuri, M., and Sarwanto. (2020). Analisis Kemampuan TPACK (*Technolgical, Pedagogical, And Content, Knowledge*) Guru Biologi SMA dalam Menyusun Perangkat Pembelajaran Materi Sistem Peredaran Darah. *INKUIRI: Jurnal Pendidikan IPA,* 9(1), 44-53. https://doi.org/10.20961/inkuiri.v9i1.41381

Utami, A. D., Harahap, G. and Khoiriyah, A. N. (2024). Developing Technological, Pedagogical, And Content Knowledge (TPACK) Booklet in Biology Subject to Provide the TPACK Materials for Prospective Biology Teachers at UIN Sunan Kalijaga Yogyakarta. *Assimilation: Indonesian Journal of Biology Education*, 7(1), 1-35. https://doi.org/10.17509/aijbe.v7i1.66063

Valtonen, T., Eriksson, M., Kärkkäinen, S., Tahvanainen, V., Turunen, A., Vartiainen, H., Kukkonen, J., & Sointu, E. (2022). Emerging Imbalance in The Development of TPACK-A Challenge for Teacher Training. *Education and Information Technologies*, 28(5), 5363-5383. https://doi.org/10.1007/s10639-022-11426-5

Walan, S. (2020). Embracing Digital Technology in Science Classrooms-Secondary School Teachers' Enacted Teaching and Reflections on Practice. *Journal of Science Education and Technology*, 29(3), 367-383. https://doi.org/10.1007/s10956-020-09828-6

How To Cite This Article, with *APA style* :
Tobing, P.U.A.L., Djulia, E., & Sipahutar, H. (2024). Analysis of Pedagogical Technology and Content Knowledge and Authentic Assessment of Biology Preservice Teachers in Implementing School Field Introduction (ISFI). *Jurnal Pembelajaran dan Biologi Nukleus*, *10*(3), 820-830. https://doi.org/10.36987/jpbn.v10i3.5936

Conflict of interest The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author contributions All authors contributed to the study's conception and design. Material preparation, data collection and analysis were performed by all authors. The first draft of the manuscript was submited by [**Priskila Uli Arta Lumban Tobing**]. All authors contributed on previous version and revisions process of the manuscript. All authors read and approved the final manuscript.