RESEARCH ARTICLE

TPACK profile of biology teachers in the industrial revolution 4.0 era

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Abstract: Technological Pedagogical and Content Knowledge (TPACK) is very important in the process of developing professional teacher competencies in the era of the Industrial Revolution 4.0. The purpose of this study was to determine the profile of biology teachers TPACK on the classification of living things. This research is a descriptive study using a qualitative approach. Data collection techniques were carried out using questionnaires, CoRe&TPaP-eRs, and interviews. The sample was compiled using a saturated sampling technique with a total of ten respondents. The results indicated that biology teachers' TPACK skills must be improved. The results of the questionnaire consisting of 7 TPACK components, reaching 70.11% were categorized as good. The TK, PK, CK, and PCK components are in the excellent category, while the TCK, TPK, and TPACK components are still in the good category. The results of the CoRe & TPaP-eRs instrument covering 5 aspects show that the average of teacher's TPACK reached 41%, in the Growing-TPACK category. The TPACK of biology teachers based on teaching experience is not so different. The results show that the length of teaching experience is not directly proportional to the growth of TPACK skills.

Keywords: Biology teachers; CoRe & TPaP-eRs; growing TPACK; maturing TPACK; pre-TPACK

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Introduction

In the era of the Industrial Revolution 4.0, technological advances are increasingly significant in all areas of life (Li et al., 2017; Yahaya et al., 2021), including in education sector (Elayyan, 2021; Ilori & Ajagunna, 2020; Tri et al., 2021; Valeyeva et al., 2020). The education sector needs to adopt technology by integrating it into the learning system (Koumiti et al., 2024; Ranbir, 2024). Therefore, technology must be utilized as much as possible in every learning process to encourage the Industrial Revolution 4.0, as is currently being promoted by the Indonesian government. The integration of technology in learning environments has the potential to cultivate a more active, creative, and innovative generation (Kara, 2023; Stefan et al., 2020).

Technological Pedagogical Content Knowledge (TPACK), formerly known as TPCK, is knowledge about the appropriate use of technology and pedagogy in various subjects to facilitate learners' understanding and assist teachers in thinking creatively (Cavanagh & Koehler, 2013; Schmid et al., 2021). TPACK is the process of advancing PCK with the addition of technological elements. TPACK brings together knowledge derived from Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK), with an emphasis on how technology can be aligned with a deep understanding of the needs of educators to teach relevant material in a particular context (Adnan & Yunisari, 2023; Colón et al., 2023). TPACK is an important tool to refer to the era of the Industrial Revolution 4.0, especially the 21st Century Education sector (Limbong, 2016; Mutiani et al., 2021; Suyanto et al., 2019). TPACK will encourage teachers to become more professional and bring new perspectives so that technology in education becomes more advanced (Adipat et al., 2023; Colón et al., 2023). A professional teacher must master adequate TPACK competencies because developing teacher

competencies with the TPACK framework is an important step to ensure that teaching is in line with current demands and changes.

Teachers are professional educators, so in carrying out their duties teachers must be able to carry out effectively in all fields including teaching, educating, directing, guiding, training, evaluating, and assessing (Dirsa et al., 2022; Ramdiah et al., 2019; Riadi et al., 2022). Along with the advancement of knowledge and technology in a global society, teachers must respond with professionalism that leads to professionalism (Suryawati et al., 2017).

TPACK is inseparable from learning content. This study focuses on the classification of living things because the classification of living things is the basic topic in biology (Dias-da-Silva, 2019; Williams, 2024) that biology teachers need to understand. In understanding biodiversity, the basic aspect of learning is the identification of species (classification of living things) and their history. In addition, it covers concepts that are difficult to visualize. Understanding the classification of living things is a challenging topic for students due to its complexity and the misconceptions that often arise (Manishimwe et al., 2021).

Studies exploring the TPACK profile among biology teachers are essential to understand how they integrate technology into their teaching. Several studies analyzed the improvement of TPACK of teachers during training programs (Hidayat et al., 2024). Other study analyzed TPACK in pre-service teachers (Hidayat et al., 2024). Other studies analyzed the application of TPACK in distance learning (Elvianasti et al., 2023) and the impact of TPACK on student competence (Sonsupap et al., 2024). However, studies that focus on analyzing the TPACK of biology teachers related to the material of classification of living things are still difficult to find. Therefore, the purpose of this study is to determine the profile of biology teachers TPACK on the classification of living things

Method

The type of research used is descriptive research with a qualitative approach. This study aims to describe the ability of Technological Pedagogical and Content Knowledge (TPACK) of Class X Biology Teachers on the Classification of Living Things of SMA Negeri Ilir Barat 1 Sub-District.

The sample in this study was all X grade Biology teachers in public high schools in Ilir Barat 1 sub-district from 4 different schools. The sample was taken using the Saturated Sampling technique with a total of 10 teacher respondents. According to Sugiyono (2021), Saturated sampling is a sample collection technique in which each member of the population is determined as a sample. Based on the length of teaching from a total of 10 teachers, namely 8 experienced teachers and 2 novice teachers. The details of overall respondents are showed in the Table 1.

Table 1. Population of biology teachers involved in the study

SMA	Accreditation	Biology Teachers
SMA Negeri 1 Kota Palembang	A	2
SMA Negeri 2 Kota Palembang	A	2
SMA Negeri 10 Kota Palembang	A	4
SMA Negeri 11 Kota Palembang	A	2
Total		10

Some of the instruments used as data collection tools in this study are questionnaires, CoRe and TPaP-eRs sheets, and interview guidelines related to CoRe and TPaP-eRs. The questionnaire used focuses on the ability of Technological Pedagogical and Content Knowledge (TPACK) in the classification of living things which contains statements containing 7 components, including TK, PK, CK, TPK, TCK, PCK, and TPACK. The questionnaire instrument that will be used in this study is prepared based on the adaptation of questionnaire items that have been used in the research of (Kiray, 2016). The CoRe & TPaP-eRs instrument used in this study was prepared based on the adaptation of the CoRe & TPaP-eRs instrument by Anwar (2014) which was then adjusted by adding and lifting technological aspects so that it became the CoRe & TPaP-eRs instrument. The interview guidelines are based on the results of CoRe & TPaP-eRs produced by teachers.

In this study, the authors used descriptive data analysis techniques. The data to be collected is qualitative data described by words or sentences according to categories to obtain conclusions. Analysis of questionnaire data was carried out by asking questions that represented the TPACK component using a Likert scale where there were only 4 answers, namely very suitable (SS), suitable (S), not suitable (TS), and very unsuitable (STS) (Sugiyono, 2021). Then data analysis of the CoRe & TPaP-eRs sheet will be carried out with scoring and categorization rubrics. The scoring given for each answer to each question described by the teacher is between 0-3. Then based on the CoRe & TPaP-eRs answers, the TPACK category of each teacher can be analyzed using the PCK categorization rubric adapted and modified from Anwar (2014) into a CoRe & TPaP-eRs rubric. Furthermore, to support the results of the CoRe & TPaP-eRs analysis, researchers used the help of QSR software Nvivo 12 for Windows to

visualize the results of the CoRe & TPaP-eRs data analysis. Data obtained from interviews were analyzed descriptively, to expand the research findings on Biology teachers' TPACK abilities based on the answers to the CoRe & TPaP-eRs instrument.

Results and Discussion

A recapitulation of the results of the analysis of questionnaire data consisting of 47 statement items that must be answered by teachers, which have been analyzed based on 7 components. Based on the results of the questionnaire analysis in Table 2, teachers' TK, PK, CK, and PCK skills are in the excellent category. The PCK component has entered the excellent category with a percentage of 81.88%, although it only slightly exceeds the good category. PCK is an integration between PK and CK. This illustrates that teachers can appropriately teach certain materials to improve students' understanding (Kestiani et al., 2018). The components of TK, PK, and CK are separate or not integrated knowledge. This illustrates that Biology teachers of Class X SMA Negeri Ilir Barat 1 District understand technology, pedagogy, and content separately. This situation arises because teachers are still unfamiliar with the terms associated with the TPACK framework. Even so, they have an understanding of the components that make up the TPACK framework, such as the TK component. Teachers have knowledge of technologies that can be integrated in curriculum and learning and are skilled in using them.

Table 2. Recapitulation of total results of questionnaire data analysis of all participants

Component	Percentage (%)	Category
Technological Knowledge (TK)	82.50	Very good
Pedagogical Knowledge (PK)	84.00	Very good
Content Knowledge (CK)	82.08	Very good
Pedagogical Content Knowledge (PCK)	81.88	Very good
Technological Content Knowledge (TCK)	74.38	Good
Technological Pedagogical Knowledge (TPK)	79.58	Good
Technological Pedagogical and Content Knowledge (TPACK)	76.43	Good

The focus of TPACK is not only on the use of technology but also on how technology can be used effectively in the learning process. As for the results of the questionnaire analysis in Table 2, the TPK, TCK, and TPACK components of the teacher are in a good category. This illustrates that Biology teachers of Class X SMA Negeri Ilir Barat 1 District have good knowledge about the integration of technology in content and pedagogy. Teachers have been able to properly integrate technology into the learning process by considering learning materials and strategies that are by the characteristics of students. However, if a comparison is made between the results obtained when the components are still separate or not integrated with components that have been integrated with technology, it can be said that integrating technology in content and pedagogy is still a challenge for teachers. The challenges faced by teachers in integrating content knowledge and pedagogy with technology into learning can be caused by the inability of teachers to explore the characteristics of the material and technology to be used. Aligning technology in the learning process is still a dilemma for teachers, involving various aspects such as the selection of technological devices, the use of technology to present subject matter, designing innovations to facilitate student learning, technology operation skills, and the availability of supporting facilities and infrastructure. Therefore, teachers' in-depth knowledge of learning models that emphasize the interaction between technology, pedagogy, and content is a must (Harris et al., 2010).

Table 3 shows a description of the TPACK Ability of Biology Teachers based on the results of the CoRe & TPaP-eRs data. The data taken is further divided into five aspects namely Purpose, Concept, Pedagogy, Technology, and Evaluation.

In general, the TPACK ability of Biology teachers in class X SMA Negeri Ilir Barat I Sub-District in teaching the classification of living things is included in the Growing-TPACK category. The aspects of goals, technology, and evaluation are in the Growing-TPACK category while the concept and pedagogy aspects are still in the Pre-TPACK category. This shows that teachers already know of various technologies that can be applied in learning or assessment, but adjusting the technology used with different concepts is still an obstacle, teachers tend to use the same technology for each different concept.

Then each teacher is grouped based on the TPACK development category presented in Figure 1. Based on Figure 1, the number of teachers based on the TPACK development category for each aspect can be seen. On average, in the goal aspect, the dominant teachers fall into the Growing-TPACK category, while on average in the concept, pedagogy, technology, and evaluation aspects, the dominant teachers fall into the Pre-TPACK category.

Table 3. Recapitulation of the total results of the CoRe & TPaP-eRs analysis of the five aspects of TPACK

Teachers	TPACK Aspects					Average Score
	Objective	Concept	Pedagogy	Technology	Evaluation	
A	2.00	1.25	1.27	3.00	3.00	1.82
B	2.17	1.00	1.00	1.58	1.00	1.31
C	1.80	0.95	1.73	1.00	1.00	1.30
D	1.75	0.75	0.58	1.38	1.25	1.00
E	1.00	0.50	0.53	1.00	1.00	0.73
F	1.00	0.92	0.89	1.00	1.00	0.94
G	1.60	1.00	1.00	1.70	1.40	1.28
H	1.25	1.13	2.00	0.50	0.00	1.00
I	1.00	0.33	0.33	1.00	1.67	0.71
J	1.25	0.38	0.75	1.00	1.25	0.81
Percentage of Achievement	52%	27%	32%	47%	45%	41%
TPACK development	Growing-TPACK	Pre-TPACK	Pre-TPACK	Growing-TPACK	Growing-TPACK	Growing-TPACK

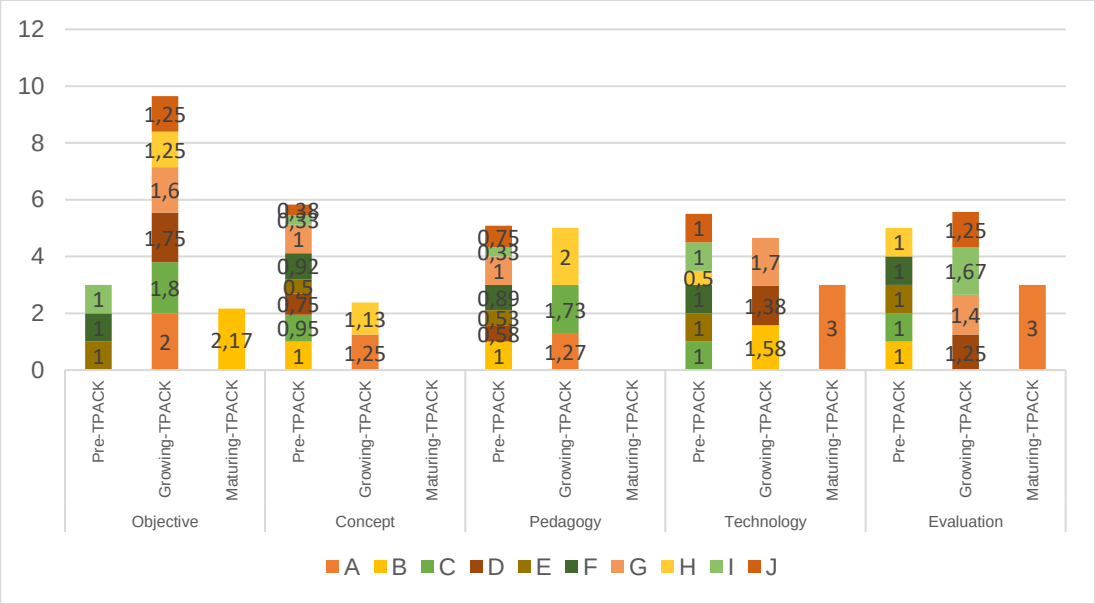

Figure 1. Recapitulation of teachers' TPACK development categories on 5 aspects

After the results of the CoRe & TPaP-eRs teacher answers are analyzed by scoring, the CoRe & TPaP-eRs data are described descriptively following the CoRe & TPaP-eRs categorization rubric. The results of the analysis can be seen in Table 4.

Table 4. Descriptive recapitulation of CoRe & TPaP-eRs

Respondents	Aspects	Indicator	Average Score	TPACK Development
A	**Objective**	Objective identification Formulation of objectives Important concept	2	Growing-TPACK
	Concept	Breadth and depth of material Identification of misconceptions	1.25	Growing-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	1.27	Growing-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of	3	Maturing-TPACK

Respondents	Aspects	Indicator	Average Score	TPACK Development
		technology		
	Evaluation	Evaluation	3	Maturing-TPACK
	Average		**1.82**	**Growing-TPACK**
B	**Objective**	Objective identification Formulation of objectives	2.17	Growing-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	1	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	1	Pre-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1.58	Growing-TPACK
	Evaluation	Evaluation	1	Pre-TPACK
	Average		**1.31**	**Growing-TPACK**
C	**Objective**	Objective identification Formulation of objectives	1.8	Growing-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	0.95	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	1.73	Growing-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1	Pre-TPACK
	Evaluation	Evaluation	1	Pre-TPACK
	Average		**1.30**	**Growing-TPACK**
D	**Objective**	Objective identification Formulation of objectives	1.75	Growing-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	0.75	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	0.58	Pre-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1.38	Growing-TPACK
	Evaluation	Evaluation	1.25	Growing-TPACK
	Average		**1**	**Pre-TPACK**
E	**Objective**	Objective identification Formulation of objectives	1	Pre-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	0.5	Pre-TPACK
	Pedagogy	Teaching considerations	0.53	Pre-TPACK

Respondents	Aspects	Indicator	Average Score	TPACK Development
F	Technology	Teaching strategy Order of presentation of material Technology utilization Purpose of using technology Getting around the lack of technology	1	Pre-TPACK
	Evaluation	Evaluation	1	Pre-TPACK
	Average		**0.73**	**Pre-TPACK**
	Objective	Objective identification Formulation of objectives	1	Pre-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	0.92	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	0.89	Pre-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1	Pre-TPACK
	Evaluation	Evaluation	1	Pre-TPACK
	Average		**0.94**	**Pre-TPACK**
G	**Objective**	Objective identification Formulation of objectives	1.6	Growing-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	1	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	1	Pre-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1.7	Growing-TPACK
	Evaluation	Evaluation	1.4	Growing-TPACK
	Average		**1.28**	**Growing-TPACK**
H	**Objective**	Objective identification Formulation of objectives	1.25	Growing-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	1	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	2	Growing-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	0.5	Pre-TPACK
	Evaluation	Evaluation	0	Pre-TPACK
	Average		**1**	**Pre-TPACK**
I	**Objective**	Objective identification Formulation of objectives	1	Pre-TPACK

Respondents	Aspects	Indicator	Average Score	TPACK Development
J	**Concept**	Important concept Breadth and depth of material Identification of misconceptions	0.33	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	0.33	Pre-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1	Pre-TPACK
	Evaluation	Evaluation	1.67	Growing-TPACK
	Average		**0.71**	**Pre-TPACK**
	Objective	Objective identification Formulation of objectives	1.25	Growing-TPACK
	Concept	Important concept Breadth and depth of material Identification of misconceptions	0.38	Pre-TPACK
	Pedagogy	Teaching considerations Teaching strategy Order of presentation of material	0.75	Pre-TPACK
	Technology	Technology utilization Purpose of using technology Getting around the lack of technology	1.13	Pre-TPACK
	Evaluation	Evaluation	1.25	Growing-TPACK
	Average		0.81	Pre TPACK

Furthermore, as supporting data, the analysis used QSR NVivo 12 software with the Word Frequency Query feature of the CoRe & TPaP-eRs data to identify the main keywords that appear most frequently in the data. The results of the NVivo analysis for the objective aspect can be seen in Figure 2. The three main words that often appear are classification, creature, and life. The results obtained show that the classification of living things is the main purpose of every important concept in the classification of living things.

Figure 2. Objective aspect

The results of the NVivo analysis for concept aspects can be seen in Figure 3. The three main words that often appear are classification, creatures, and life. The results obtained are the same as the objective aspect, this shows that the classification of living things is the basic concept for every important concept in the classification of living things that the teacher raises.

Figure 3. Concept aspects

The results of the NVivo analysis for the pedagogy aspect can be seen in Figure 4. The three main words that often appear are students, learning, and learning. The results obtained from the analysis include indicators on pedagogical aspects which include teacher considerations in teaching which not only refer to the material but also to students such as student conditions and characteristics. Then other factors that influence the way teachers teach such as learning styles and learning resources. Furthermore, the word learning, which comes from Discovery Learning or Problem-Based Learning, refers to the learning model chosen by the teacher as a strategy for teaching the material of classification of living things.

Figure 4. Pedagogy aspects

The results of the NVivo analysis for technology aspects can be seen in Figure 5. The three main words that often appear are PPT, LKPD (student worksheet), and reflection. The results obtained show the technology used by teachers to teach and assess each important concept in the classification of living things that the teacher raises.

Figure 5. Technology aspects

The results of the NVivo analysis for the evaluation aspect can be seen in Figure 6. The three main words that often appear are reflection, LKPD, and posttest. The results obtained show ways for teachers to find out the understanding of students.

Figure 6. Evaluation aspect

Semi-structured interviews in this study aim to add information on the CoRe & TPaP-eRs that teachers have produced. The findings can be seen in Table 5.

The TPACK ability of Biology teachers in Class X of SMA Negeri Ilir Barat 1 Subdistrict as a whole is in the Growing-TPACK category. TPACK is important knowledge and must be possessed by a teacher. As for describing the TPACK profile of Class X Biology teachers of SMA Negeri Ilir Barat 1 Subdistrict, researchers dsescribe based on the teacher's teaching experience. According to Noh et al., (2020), a teacher can be said to be experienced in their field if they have five or more years of teaching experience. Therefore, from the entire research population, it can be seen that with a total of 10 teachers, 8 teachers are experienced while 2 teachers are novice teachers. The results of the CoRe analysis of TPaP-eRs in terms of 5 aspects of TPACK. In the aspect of objectives, it shows that there is not much difference in the ability of novice and experienced teachers in identifying and formulating learning objectives. There is one experienced teacher who is in the same category as novice teachers in the goal aspect. In the concept aspect, it shows that there is no difference in the ability of novice and experienced teachers to determine important concepts, breadth, and depth of material, and identifying misconceptions. Based on

the overall biology teachers, 6 out of 8 experienced teachers were in the same category as 2 novice teachers. This shows that experienced and novice teachers are not so different in describing important ideas/concepts, besides that knowledge about concepts that have not yet been learned by students, almost all teachers have not determined which can be an illustration of how the breadth and depth of the material to be delivered and reflect the teacher's ability to recognize the core value of a material content based on the basic competencies to be achieved (Putri et al., 2020).

Table 5. Teacher interview results

Respondents	Considerations in adapting materials to strategies and technology	Strategy	Technology
A	Characteristics of learners' learning styles and interests	Discovery Learning Model	LCD projector, PPT media using Canva, videos from YouTube or current/contextual news from the internet, Wordwall/Quizizz, Padlet/Mentimeter
B	The form of the material (the concept), The learning objectives we design, The conditions and environment of the learners	Discovery Learning Model	Internet video
C	Learner ability, class time, learner interest	Problem-based learning model	Canva, Plantnet
D	Learner condition, class time, learner interest	Discussion Method	PPT
E	The level of difficulty of the material, the learning style of the learners, and the learning objectives to be achieved	Discovery Learning Model	PPT
F	Lesson hours, learner conditions	Lecture Method	PPT, YouTube video, Googleform
G	Lesson hours	Problem-based learning model	PPT, YouTube video
H	Lesson hours	Discovery Learning Model	Plantnet, Information from the internet
I	Consideration of time, infrastructure, learners' abilities	Problem-based learning model	Googleform

Furthermore, the teacher's ability to identify misconceptions is usually related to the teacher's knowledge of the material and the teacher's experience in teaching the topic (Antink-Meyer & Meyer, 2016). In the pedagogical aspect, it shows that there is not much difference in the ability of novice and experienced teachers to determine teaching considerations, teaching strategies, and the order of presentation of material. Based on all biology teachers, 5 of the 8 experienced teachers were in the same category as novice teachers, except that 2 novice teachers had the lowest average score. One of the obstacles faced by teachers in the pedagogical aspect is the inadequate number of teachers. The number of teachers is not proportional to the number of students seen in some schools, as stated by novice teacher E in the answer to CoRe & TPaP-eRs regarding the number of students as a factor that affects teaching methods. This is an obstacle for teachers in mastering the learning characteristics of students because there are too many students and various learning characteristics that must be adjusted (Lestari & Mulianingsih, 2020). In the aspect of technology, it shows that there is not much difference in the ability of novice teachers and experienced teachers to utilize technology, determine the purpose of using technology, and get around the absence of technology. Based on all biology teachers, 5 of the 8 experienced teachers were in the same category as 2 novice teachers, but 1 experienced teacher had the lowest score.

The obstacles faced by teachers in the technology aspect are caused by the ability of human resources. This is related to teachers' ability to utilize Information and Communication Technology (ICT). In addition

to the fact that teachers are dominated by senior teachers who are less able to master and keep up with technological developments, it is also due to unsupportive school facilities. High schools in Ilir Barat 1 Sub-district, do not all have adequate facilities such as LCD projectors in each class with an adequate number, as stated teacher J during the interview that the school does not support the use of technology because there is no focus in each class. This also illustrates that schools with A accreditation do not guarantee to have sufficient facilities to support learning. In the evaluation aspect, it shows that there is no difference in the ability of novice teachers and experienced teachers to measure students' understanding. Based on the overall biology teachers both experienced and novice teachers are both in the Growing-TPACK and Pre-TPACK categories. Teachers not only use written tests as an assessment instrument but have begun to use technology in their evaluation techniques and consider concepts. Meanwhile, some teachers use evaluation tools still limited to written tests and have not considered the characteristics of the important concepts raised. Based on the results of the CoRe & TPaP-eRs analysis of the length of teaching experience, no difference was found between experienced and novice teachers, so it can be concluded that the length of teaching experience is not directly proportional to the growth of TPACK skills. This contradicts the results of research by Anwar (2014) due to differences in components, in TPACK there is one component that is different from PCK, namely technology so the results obtained are not the same. The difference in research findings with previous research is that there are differences between experienced and inexperienced biology teachers in making documents CoRe & TPaP-eRs.

This study has limitations in identifying biology teachers' TPACK through questionnaire instruments and CoRe & TPaP-eRs because the data obtained is based on self-assessment of questionnaires and CoRe & TPaP-eRs produced by teachers. Therefore, further similar research can be conducted by combining more objective measurements such as direct observation during the ongoing learning process in order to get better and more accurate results and information. In measuring teachers' TPACK, it is still a challenge to understand how teachers' knowledge affects actual teaching practices as well as the overall challenge of the efficiency, reliability and validity of the measurement method to be accurate (Riyanti & Anwar, 2023).

Conclusion

TPACK profile research on biology teachers through questionnaires obtained from 7 components. Based on the seven TPACK components, it can be said that teachers are only able to use content, pedagogy, and technology separately; this is evident from the results, which are divided into two categories, namely the TK, PK, CK, and PCK components are in the excellent category, while the TCK, TPK, and TPACK components are still in the good category. The CoRe & TPaP-eRs results show that the TPACK development category of biology teachers is in the Growing-TPACK category with a percentage of 41%, which means it is in the developmental stage. The analysis is divided into five aspects: the goal aspect of 52% with the Growing-TPACK category, the concept aspect of 27% with the Pre-TPACK category, the pedagogy aspect of 32% with the Pre-TPACK category, the technology aspect of 47% with the Growing-TPACK category and the evaluation aspect of 45% with the Growing-TPACK category. This finding is expected to be useful as information and evaluation material for teachers regarding their technology implementation skills in learning and TPACK so that teachers can improve their professional skills.

Based on the results of the research and discussion of TPACK of biology teachers in class X SMA Negeri Ilir Barat 1 District, it can be concluded that the TPACK of biology teachers is in a good category and the category of Growing-TPACK development. Teachers still have difficulty determining which learning model suits certain concepts and what kind of technology should be used. This shows that teachers know about integrating technology, pedagogy, and content in biology learning. Still, they must improve in mastering concepts, pedagogy, and technology to create quality learning. The TPACK of biology teachers based on teaching experience is not so different. The results show that the length of teaching experience is not directly proportional to the growth of TPACK skills. One of the reasons is that many senior teachers still have difficulty using the latest technology. They don't really care about technological advances, so they have difficulty integrating the latest technology into their material content and pedagogy.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author Contributions

Y. Anawar: Composing the first draft in preparation, methodology, data analysis, review paper, editing and approval of the final version of the manuscript, and validation; **S. Riyanti:** Composing the first draft in preparation, methodology, and data analysis; **S. P. Dewi:** Validation

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