PRIMARYEDU

**Primaryedu: Journal of Elementary Education**
Volume 9, Number 1, February 2025

P-ISSN: 2580-9326 | E-ISSN: 2580-7714

# Technology Integration Strategies for Teaching the Water Cycle: A Case Study in Fifth-Grade Science Learning

**Ai Hayati Rahayu[1*], Ari Widodo[2], Udin Syaefudin Saud[3], Muslim[4]**
[1,2,3,4] Universitas Pendidikan Indonesia. Indonesia

**Article Info**

***Article history:***

Received Jan 30th, 2025
Revised Feb 15th, 2025
Accepted Feb 27th, 2025

***Keywords:***

21st-century skills
Case study
Educational technology
Teacher strategies
Water cycle

**Abstract**

This study aims to analyze teachers' strategies in integrating technology into the teaching of the water cycle material to enhance students' understanding and support 21st-century competencies, such as critical thinking, creativity, and collaboration. Using a qualitative case study approach, the research involved four teachers teaching 5th-grade elementary school students in Sumedang Regency. The teachers had previously received TPACK training using a collaborative, practical, and reflective approach. Data were collected through observations, in-depth interviews with teachers, and analysis of instructional documents.The findings reveal that teachers utilized various technological media, such as animated videos, digital simulations, and interactive PowerPoint presentations, to explain the water cycle concepts in a more engaging and comprehensible manner. Additionally, online learning platforms were employed to facilitate group discussions and student collaboration. These strategies not only improved students' understanding of the water cycle but also fostered 21st-century skills, such as collaboration, problem-solving, and creativity. However, challenges such as limited access to technology and students' digital literacy need to be addressed. This study recommends the principles of collaboration, practice, and reflection in conducting intensive training for teachers to enhance their ability to effectively utilize technology in the learning process.

Keywords: Teacher Strategies, Educational Technology, Water Cycle, 21st-Century Skills, Case Study



***Corresponding Author:***

Name Author: Ai Hayati Rahayu
Universitas Pendidikan Indonesia, Bandung Indonesia
Email Author: ummiai75@upi.edu

## INTRODUCTION

Rapid technological developments have brought significant changes in various sectors, including education. In this digital era, the application of technology in learning is the key to increasing effectiveness and attracting student interest. Technology-based learning not only facilitates knowledge transfer, but also develops 21st century skills, such as critical thinking,

creativity, communication, and collaboration (Ertmer et al., 2012). Therefore, it is important for teachers to improve their professional competence regarding integrating technology effectively in learning to prepare students to face global challenges (Bandung et al., 2010).

The framework that teachers can use to integrate technology is Technological Pedagogical Content Knowledge (TPACK). TPACK is a theoretical framework that can provide direction for teachers to solve the problem of technology integration in classroom learning (Chai et al., 2011). The TPACK framework as proposed by Koehler et al., (2013) describes how teachers' understanding of technology, pedagogy and content are connected and integrated. TPACK combines three main types of knowledge, namely content, pedagogy and technology. Mastery of these three aspects allows teachers to create relevant and contextual learning experiences for students, by utilizing technology as a tool that supports deeper understanding ( Wang et al., 2018).

The TPACK framework also helps teachers overcome challenges that arise from the use of technology. For example, in teaching water cycle material. The water cycle is an important topic in science learning that involves abstract concepts, such as evaporation, condensation, and precipitation. Teaching the water cycle to students often faces challenges in visualizing this process, which is dynamic and cannot be directly observed in everyday life. Therefore, technology can be used to (Wang, 2019).

The TPACK framework consists of three main types of knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK), as well as the intersections of these three components that interact with each other (Cherner & Smith, 2017). In teaching the water cycle, a teacher with content knowledge can identify and explain the essential concepts that must be delivered, such as evaporation, condensation, precipitation, and infiltration, in a comprehensive manner. With pedagogical knowledge, the teacher can apply appropriate teaching strategies, such as experiments, discussions, inquiry-based approaches, or project-based learning, to help students understand these concepts more concretely. Meanwhile, technological knowledge enables the teacher to utilize technology, such as interactive simulations, animated videos, or educational applications, to present the water cycle process more dynamically and engagingly. Ultimately, the teacher can integrate concepts with appropriate teaching models or methods and utilize relevant technology effectively.

A teacher with TPACK can facilitate students in developing their 21st-century competencies. By using appropriate technology, students can enhance critical thinking through analyzing the impact of water cycle changes on the environment, as well as foster creativity by creating models or visual projects related to the water cycle or generating ideas to solve problems within the water cycle. Technology-based learning also encourages collaboration, such as through group discussions in exploring weather data or digital simulations. Additionally, students are trained in communication, whether in presenting their analysis using digital media or actively participating in discussions within a technology-based learning environment(Kafyulilo et al., 2015).

The integration of technology in learning water cycle material can increase students' understanding in a more in-depth and interactive way. By using media such as animated videos, digital simulations, or online-based learning applications, students can observe the water cycle process more realistically and in depth. In addition, technology also allows students to engage in collaborative activities and problem solving online, which supports the development of 21st century skills (Agyei & Voogt, 2012).

However, the application of technology in learning does not always run smoothly. Some of the challenges faced by teachers, especially in elementary schools, include limited access to technology, varying levels of digital literacy among students, and a lack of adequate training for teachers. However, with the right strategy, technology can be optimized to support a more effective and enjoyable learning process (Ertmer et al., 2012).

This research aims to examine how teachers integrate technology in learning water cycle material in fifth grade elementary schools, as well as analyzing its impact on increasing students' 21st century competencies. This case study will provide an overview of the steps taken by teachers in designing and implementing technology-based learning as well as the challenges faced in the process.

## METHOD

The research method used is qualitative case study. This research approach aims to explore in depth a particular phenomenon, event or case in a real life context. This method is used to understand the complexity and uniqueness of a situation, individual, group or organization with a holistic approach. In this research, the researcher acts as the main instrument, supported by several additional instruments such as interview guidelines, observation guidelines, relevant documents, CoRes tables, and reflective journals. Data is collected through various techniques, such as in-depth interviews to explore participants' perspectives, direct observation to record activities or behavior, analysis of written and digital documents, and focus group discussions to gain collective views. The data analysis process was carried out in depth and iteratively, starting with data organization, coding to identify themes or patterns, thematic analysis to understand the relationships between aspects, and data triangulation to increase the validity and trustworthiness of the findings. The research results are prepared in the form of a narrative that describes the findings and interpretations comprehensively.

The participants consisted of four individuals who took part in TPACK training with a collaborative, practice-based, and reflective approach. These four participants were elementary school teachers teaching fifth grade in Sumedang Regency. After completing the TPACK training, they designed the same lesson material, which was the water cycle. This uniformity in lesson material was the primary reason they were selected as participants in this case study. Additionally, their full involvement in every stage of the training served as another justification for their selection. The instruments used in the study were developed based on previous research and included interview guidelines, lesson plan assessment sheets, classroom observation sheets, and reflective journals.

## RESULTS AND DISCUSSION

### A. Learning Planing

The participants were four teachers as TPACK training participants with a collaborative, practical and reflective approach, designing and implementing learning with water cycle material. The design was carried out collaboratively between colleagues. The teacher's initial understanding of the concept of material is still lacking. The results of the interviews concluded that teachers still did not pay attention to the concepts they were going to teach. There are even teachers who are confused about what important concepts to teach. The next stage, the four teachers design, assisted by the CoRes table. The results of the Cores table show that understanding of important concepts that must be taught to students has experienced significant changes from the initial interview results. The results of the interview with Teacher 1 stated that an important concept that must be conveyed regarding the water cycle material is the concept of how the water cycle occurs on earth. This teacher did not mention important concepts in detail. However, after the training, Teacher 1 explained the important concept of the water cycle in more detail, including the definition of the water cycle, the water cycle process, the importance of the water cycle in life, human activities that have an impact on the water cycle.

The learning plan is then analyzed using an analysis sheet that has been developed previously. The RPP analysis sheet is based on seven components, namely learning objectives,

relationship between technology and content, use of technology as media, use of learning models, and assessment. These six components are summarized in Table 1.

Table 1. Description of RPP Observation Results

| Component | Teacher1 | Teacher2 | Teacher3 | Teacher4 |
|---|---|---|---|---|
| Learning objective | All objectives are formulated in complete sentences, leading to the achievement of creative competence, communication and collaboration (using operational words explain, present, create poster work | All objectives are formulated in complete sentences, leading to the achievement of critical, creative and communicative competencies (using operational words to explain, analyze and generate various ideas) | All objectives are formulated in complete sentences, leading to the achievement of 21st century creativity competencies (operational words that identify, explain and create campaigns to maintain the water cycle). | All objectives are formulated in complete sentences, leading to the achievement of critical competencies (operational words used to examine, understand, assess, explain). |
| Concept | Water Cycle material with important concepts including the definition of the water cycle, stages of the water cycle process, impacts of the water cycle | Water Cycle material with important concepts includes the definition of the water cycle, stages of the water cycle process, the process of changes in state in the water cycle, and the impact of the water cycle | Water Cycle Material with important concepts of the definition of the water cycle, stages of the water cycle process, the process of changes in state in the water cycle, the impact of the water cycle and human actions that have an impact on water conditions. | Water cycle material and human actions in protecting and preserving the environment |
| Media | Using a cooperative model PPT assisted by LKPD to create posters about the | Using PPT, LKPD and students are asked to create products in the form of concept maps or mind | Utilizing learning videos assisted by LKPD that is in accordance with the Project Based Learning | Using animated videos about the water cycle. |

| | | | | |
|---|---|---|---|---|
| | impact of the water cycle | mapping but they are not yet relevant. | model, Google slides and teaching materials presented in the form of modules via plifbook | |
| Model and | Using the TPS (think, pair, share) type cooperative model. Ending with evaluation and reflection. | The activity stages are designed using a scientific approach, the PPT is presented during the let's observe step and is finally closed with evaluation and reflection. | Using a project-based learning model where students are asked to produce ways to campaign on how to maintain sustainable water conditions. | Using a scientific approach depicted in the learning steps. |
| Assasment | The assessment is well planned especially for communication and collaboration competencies in the form of observation sheets and questionnaires. There are no guidelines for assessing creativity. | The assessment focuses on assessing creative thinking skills (there are creative thinking indicators) and product assessment | Assessment follows Bloom's taxonomy, using quizizz for knowledge assessment. | follows Bloom's taxonomy, using educaplay for knowledge assessment. |

Table 1. states that teachers have utilized various technologies in their learning process on the water cycle material. Learning objectives have been directed towards achieving 21st century competencies. Planning appropriate learning objectives is very necessary because learning objectives will guide teachers to achieve what is expected after the learning process is carried out. The learning objectives designed should be specific, measurable, relevant and of course in accordance with basic competencies or learning outcomes. In the 21st century TPACK instrument, the objectives planned by teachers are also expected to direct and facilitate students in achieving 21st century competencies (critical thinking and problem solving, creative and innovative, communicative and collaborative).

Learning objectives can direct teachers to design various activities that can achieve these 21st century competencies. In this case, teachers have been able to design objectives that are expected to facilitate students' 21st century abilities. One of them is indicated by the operational words used by teachers in learning objectives. The results of initial interviews showed that many

teachers still explained their objectives only as explaining or describing, but in this case, after the teachers took the training, the operational words were more complex, such as analyzing, presenting, generating ideas, campaigning, and assessing. Some of the difficulties teachers found in compiling objectives were understanding 21st century abilities, especially the indicators to evaluate them. Another difficulty is the lack of teacher processes in analyzing competencies that already exist in the curriculum (Putri et al., 2020).

Integrating content in planning is connecting various important concepts systematically, according to the order of concepts from easy to complex. From concrete concepts to abstract concepts so that students can understand the topic of the material. The design of teaching materials (content) in learning planning is adjusted to the scope of learning objectives and the technology used. Some weaknesses found in designing content for Elementary School teachers are the unclear basic concepts that will be delivered in the learning process. This is reinforced by interview data at the end of the training. When teachers were asked what concepts were related to the material that would be delivered during learning, the teachers had not explained it correctly. For example, S1's answer when asked about the concept of the water cycle that would be taught was, "The concept of how the water cycle occurs on the earth's surface".

The unclear concept to be delivered has an impact on the design of the technology used. First, the concept is not delivered systematically. Second, the concept is only given as something informative. The results of the RPP analysis related to the ability to design content strengthen the results of the TPACK survey which is still at the developing level or moderate category (Nofrion et al., 2012). In addition to the ability to analyze important concepts that are still moderate, teachers are also less able to determine the breadth and depth of the material. This is obtained from the teacher's response when answering other concepts related to material that does not need to be taught. In addition, teachers are also still less able to identify student misconceptions so that they are not anticipated from the start (Putri et al., 2020). Teachers' understanding of student misconceptions will be one of the considerations for technology that will be used as anticipation material.

Integration is not just about including it in the planning, but how teachers are involved in utilizing the technology. One factor that determines the use of technology by teachers is the availability of resources. Applications such as videos, web-based games and online test applications are widely used by teachers (Lee & Kim, 2014). The limitations that must be improved in the integration of technology and content are making the presentation of content not only informative, but contextual by aligning it with everyday life so that it can present problems that can be used as a way for students to learn to think critically and creatively. This is a challenge for practitioners to integrate content in interesting learning videos that can achieve or facilitate 21st century skills. So that its availability helps teachers in organizing learning that utilizes video as its media.

The results of the analysis also show that there is still a need to improve teachers' abilities in designing assessments. One of the reasons for the lack of teachers' abilities in designing assessments is the unclear learning objectives. Teachers are also not used to making assessment grids. The use of technology in the assessment process is also still underutilized. The cause is the lack of teachers' technological abilities, the use of online tests and digital data processing. As expressed by a training participant, namely Teacher 2, "I don't know about technology applications for conducting online assessments, even if I know about Quiziz, I can't make it yet."

### B. Implementation of Learning

At this stage, participating teachers are observed while implementing learning using the previously designed RPP. The results of learning observations are described based on the observation sheet that has been prepared based on the TPACK framework. The results are

categorized based on the categories that have been prepared with descriptions of the results of observations and interviews after the implementation of learning

Table 2. Learning Observation Results

| Partisipant | Description |
|---|---|
| Teacher 1 | Teachers teach according to the planned stages. The objectives are conveyed well. The learning process is carried out according to the model used, namely think pair and share. The use of PPT technology received appreciation from some students because there were still students who were not focused on the process being carried out. The questionnaire assessment process has not been optimally carried out. Teachers still need to divide their time for the assessment process using questionnaires or observation sheets. |
| Teacher 2 | The teacher teaches according to the planned stages. The objectives are conveyed but are still not optimal. The learning process uses PPT and students are asked to create products in the form of concept maps or mind mapping but are not yet relevant to the objectives to be achieved, namely analyzing and generating various ideas. The LKPD used is also not relevant enough. The use of PPT technology received appreciation from some students because there were still students who were not focused on the process being carried out. The assessment focused on creativity, namely creating mind mapping, but was not creative enough to generate various ideas related to water problems. |
| Teacher 3 | Teachers teach according to the planned stages. The objectives are conveyed to students and learning activities are in accordance with the objectives to be achieved. Teachers utilize various technologies that can facilitate student activities such as learning videos, teaching materials as learning resources in the form of plifbooks, utilizing canva so that students can create campaign materials about maintaining water conditions. Students are quite enthusiastic about the learning process. The assessment process is still not optimal. The use of Quiziz is only to assess students' cognitive or understanding of the water cycle content. |
| Teacher 4 | The teacher teaches according to the planned stages. The objectives are conveyed to the students. The learning process runs smoothly according to the steps of the activity from the beginning to the assessment. The use of animation technology for water cycle material is enough to make students concentrate and focus. However, there are still students who have not followed the learning properly. The assessment process has not used the critical thinking ability indicators to be achieved. The assessment uses technology but the assessment content is not yet appropriate. |

Based on table 2. information is obtained that teachers have implemented the learning process according to the planning they have made. The existence of a discussion forum in planning helps teachers understand what they should do in implementing the learning process. The planning process carried out collaboratively allows teachers to frequently review the RPP design. In addition, discussions and feedback from both colleagues and facilitators have been proven to help teachers in designing and implementing it in the field. The feedback provided is useful for improving the design.

Integration of technology in learning has a significant impact on the teaching and learning process (Delgado et al., 2015). Because the use of technology in the learning process can increase

the efficiency and effectiveness of the learning process (Wuryaningtyas & Setyaningsih, 2020). Integration of technology in learning makes learning more innovative and helps teachers in organizing a more productive learning process. The TPACK framework in this case has an impact on the teacher's teaching process.

Some of the obstacles found in the implementation of the learning process that utilizes technology are the negative attitudes and views of teachers towards technology. A positive view of the importance of using technology will facilitate teachers so that they will start adopting and integrating it into their learning activities (Charles, 2012). Previous research has shown that technological competence and attitudes towards technology integration are positively correlated (Yulisman et al., 2020). Specifically, teacher attitudes are moderating variables in the relationship between technological competence and teacher TPACK. Even teachers' positive attitudes towards technology have a direct effect on teacher TPACK (Karaca et al., 2013).

The results of the analysis of the four teachers have begun to realize the importance of using technology, but because technological capabilities still need to be trained, teachers need to collaborate or only use existing technology such as videos taken from YouTube. The use of technology in learning carried out by teachers is only limited to adaptation. Teachers have realized the importance of using technology but still lack practical experience. So it takes continuous practice that has an impact on becoming a meaningful experience. Because TPACK will mature along with continuous practice and teaching experience (Angeli & Valanides, 2015). The relevance of technology to the objectives, content and models used requires a lot of continuous practice. Some things found during learning practice are that teachers design lesson plans centered on students, but in practice many still return to being teacher-centered in class (Angeli & Valanides, 2009). Lack of experience in communicating ideas that have been outlined in the lesson plan is another factor in the lack of teacher TPACK in implementing learning in class (Voogt et al., 2013). This was found when teachers conveyed learning objectives. Teachers conveyed objectives textually as written in the lesson plan, giving the impression of being rigid and difficult for students to understand.

The presentation of important contextual concepts can be done through student worksheets. The creation and use of student worksheets also need to be improved by paying attention to the activities that will be carried out. Many questions in the worksheet still ask students to answer questions that can actually be found in books. The discussion process that occurs ultimately only discusses the answers to the questions. This proves that the process of integrating learning with technology, in addition to requiring technical skills in using technology, also requires a comprehensive understanding of specific content, student needs, pedagogy, representation and availability of tools (Yeh et al., 2015). Teachers are not only required to understand pedagogy, content and technology separately because basic pedagogical knowledge is only a basis for knowledge in integrating effective technology (Wang, 2019). This transformation is a challenge for teachers (Angeli & Valanides, 2009).

Teachers' TPACK knowledge in learning practices is proven by how skilled teachers are in managing classes with technology. Because classroom management is also the key to success in implementing learning with technology. The technology used is not just presenting content but can also involve students, for example technology as a learning resource. As experts say that science learning is guiding and facilitating students to explore nature, conduct investigations. While technology can be used to stimulate, and represent and become a medium for these activities. Classroom management by utilizing this technology can only be developed with practice in real classes(Baran & Uygun, 2016).

Teachers use a combination of evaluation methods, namely interactive quizzes based on the Quiziz application and student-made project assessments. The evaluation results show that students are more enthusiastic and understand the material better with a technology-based approach. The results of the study showed that the integration of technology in water cycle

learning has a positive impact on the student learning process. The use of media such as animated videos and digital simulations has been proven effective in helping students understand the complex concept of the water cycle. This is in line with the theory of multimedia learning which states that interactive visualization can improve students' understanding of abstract material. This study also found several obstacles, such as limited access to technology for some students who do not have personal devices. Although the school has provided facilities, their use still needs to be optimized to ensure that all students get an equal learning experience. Therefore, collaborative efforts are needed between teachers, schools, and parents to ensure the availability of devices and support in the technology-based learning process. With the right strategy, technology integration can improve the effectiveness of learning while preparing students to face future challenges. This study provides recommendations to develop more training for teachers on the use of technology in learning, so that the potential of technology can be utilized optimally.

The strategies planned and implemented by teachers in teaching the water cycle have impacted students' learning outcomes. Observations show an increase in students' average understanding scores as a result of cognitive assessments conducted by Teachers 3 and 4. Students' communication and collaboration skills also improved, as seen from the questionnaire results and observation sheets (Teacher 1). Meanwhile, Teachers 2 and 3 focused more on enhancing students' creativity by assessing their work, including visualizing the water cycle through mind mapping and conducting campaigns on how to preserve water conditions.

## CONCLUSION

This study aims to explore teacher strategies in integrating technology in learning water cycle material in fifth grade of elementary school. The results of the study indicate that technology integration has a positive impact on the learning process and outcomes. Teachers have successfully implemented effective strategies, starting from planning that includes the selection of interactive media, implementing technology-based learning with a student-centered learning approach, to evaluation using digital tools such as Quiziz and educaplay. This strategy is able to improve students' understanding of the material, strengthen their involvement in learning, and develop relevant technology skills.

However, there are challenges in the form of limited access to technological devices for some students, which need to be overcome through school and parental support. Overall, this study concludes that the use of planned and directed technology can be an effective solution in teaching abstract concepts such as the water cycle, while preparing students to face the demands of 21st century learning.

The results of this study also recommend continuous professional development for teachers, including conducting TPACK training using a collaborative, practice-based, and reflective approach to enhance teachers' competence in integrating technology into the learning process. School learning communities serve as one of the platforms for this continuous training process.

## ACKNOWLEDGMENTS (OPTIONAL)

Thanks are due to the participants who contributed to the training, especially those organized in the Teacher Working Group Forum (FKKG) in Sumedang district.

## REFERENCES

Agyei, D. D., & Voogt, J. (2012). Developing Technological Pedagogical Content Knowledge In Pre-Service Mathematics Teachers Through Collaborative Design. *Australasian Journal of*

*Educational Technology*, *28*(4), 547–564. https://doi.org/10.14742/ajet.827

Angeli, C., & Valanides, N. (2009). Epistemological And Methodological Issues For The Conceptualization, Development, And Assessment Of ICT-TPCK: Advances In Technological Pedagogical Content Knowledge (TPCK). *Computers and Education*, *52*(1), 154–168. https://doi.org/10.1016/j.compedu.2008.07.006

Angeli, C., & Valanides, N. (2015). Technological Pedagogical Content Knowledge: Exploring, Developing, And Assessing Tpck. *Technological Pedagogical Content Knowledge: Exploring, Developing, and Assessing TPCK*, 1–331. https://doi.org/10.1007/978-1-4899-8080-9

Bandung, Y., Nugraha, A. A., Yonathan, B., Langi, A. Z. R., Saptawati, G. A. P., W., D. H., Fany, A., & Liliasari. (2010). Perancangan Sistem Produk-Layanan Komunitas Guru Belajar Untuk Sekolah Dasar Di Pedesaan. *E-Indonesia Initiative 2010*, *2010*(May), 5–8. https://www.researchgate.net/publication/261439197_Perancangan_Sistem_Produk-Layanan_Komunitas_Guru_Belajar_untuk_Sekolah_Dasar_di_Pedesaan

Baran, E., & Uygun, E. (2016). Putting Technological, Pedagogical, And Content Knowledge (TPACK) In Action: An Integrated TPACK-Design-Based Learning (DBL) Approach Teachedmobile View Project Open Pedagogy: Empowering Learners In The Co-Creation Of Course Content View Project. *Article in Australasian Journal of Educational Technology*, *32*(2), 47–63. https://www.researchgate.net/publication/299594534

Chai, C. S., Ling Koh, J. H., Tsai, C. C., & Lee Wee Tan, L. (2011). Modeling Primary School Pre-Service Teachers' Technological Pedagogical Content Knowledge (TPACK) For Meaningful Learning With Information And Communication Technology (ICT). *Computers and Education*, *57*(1), 1184–1193. https://doi.org/10.1016/j.compedu.2011.01.007

Charles, B. (2012). Factors Influencing Teachers ' Adoption And Integration Of Information And Communication Technology Into Teaching : A Review Of The Literature. *International Journal of Education and Development Using Information and Communication Technology*, *8*(1), 136–155.

Cherner, T., & Smith, D. (2017). Reconceptualizing TPACK To Meet The Needs Of Twenty-First-Century Education. *New Educator*, *13*(4), 329–349. https://doi.org/10.1080/1547688X.2015.1063744

Delgado, A. J., Wardlow, L., McKnight, K., & O'Malley, K. (2015). Educational Technology: A Review Of The Integration, Resources, And Effectiveness Of Technology In K-12 Classrooms. *Journal of Information Technology Education: Research*, *14*(2015), 397–416. https://doi.org/10.28945/2298

Ertmer, P. A., Ottenbreit-Leftwich, A. T., Sadik, O., Sendurur, E., & Sendurur, P. (2012). Teacher Beliefs And Technology Integration Practices: A Critical Relationship. *Computers and Education*, *59*(2), 423–435. https://doi.org/10.1016/j.compedu.2012.02.001

Kafyulilo, A., Fisser, P., Pieters, J., & Voogt, J. (2015). ICT Use In Science And Mathematics Teacher Education In Tanzania: Developing Technological Pedagogical Content Knowledge. *Australasian Journal of Educational Technology*, *31*(4), 381–399.

https://doi.org/10.14742/ajet.1240

Karaca, F., Can, G., & Yildirim, S. (2013). A Path Model For Technology Integration Into Elementary School Settings In Turkey. *Computers and Education*, *68*, 353–365. https://doi.org/10.1016/j.compedu.2013.05.017

Koehler, J. M., Mishra, P., & Cain, W. (2013). What Is Technological Pedagogical Content Knowledge ( TPACK )? *Journal of Education*, *193*(3), 13–19.

Lee, C. J., & Kim, C. M. (2014). An Implementation Study Of A TPACK-Based Instructional Design Model In A Technology Integration Course. *Educational Technology Research and Development*, *62*(4), 437–460. https://doi.org/10.1007/s11423-014-9335-8

Nofrion, Wijayanto, B., Wilis, R., & Novio, R. (2012). Analisis Technological Pedagogical and Content. *Jurnal Geografi*, *10*(2), 105–116.

Putri, A. R. A., Hidayat, T., & Purwianingsih, W. (2020). Analysis Of Technological Pedagogical Content Knowledge (TPACK) Of Biology Teachers In Classification Of Living Things Learning. *Journal of Physics: Conference Series*, *1521*(4). https://doi.org/10.1088/1742-6596/1521/4/042033

Voogt, J., Fisser, P., Pareja Roblin, N., Tondeur, J., & van Braak, J. (2013). Technological Pedagogical Content Knowledge - A Review Of The Literature. *Journal of Computer Assisted Learning*, *29*(2), 109–121. https://doi.org/10.1111/j.1365-2729.2012.00487.x

Wang, C.-J. (2019). Facilitating The Emotional Intelligence Development Of Students: Use Of Technological Pedagogical Content Knowledge (TPACK). *Journal of Hospitality, Leisure, Sport & Tourism Education*, *25*, 100198. https://doi.org/https://doi.org/10.1016/j.jhlste.2019.100198

Wang, W., Schmidt-Crawford, D., & Jin, Y. (2018). Preservice Teachers' TPACK Development: A Review of Literature. *Journal of Digital Learning in Teacher Education*, *34*(4), 234–258. https://doi.org/10.1080/21532974.2018.1498039

Wuryaningtyas, E. T., & Setyaningsih, Y. (2020). Urgensi Pengembangan TPACK Bagi Guru Bahasa Indonesia. *Bahastra*, *40*(2), 134. https://doi.org/10.26555/bahastra.v40i2.16898

Yeh, Y. F., Lin, T. C., Hsu, Y. S., Wu, H. K., & Hwang, F. K. (2015). Science Teachers' Proficiency Levels and Patterns of TPACK in a Practical Context. *Journal of Science Education and Technology*, *24*(1), 78–90. https://doi.org/10.1007/s10956-014-9523-7

Yulisman, H., Widodo, A., Riandi, R., & Nurina, C. I. E. (2020). The Contribution Of Content, Pedagogy, And Technology On The Formation Of Science Teachers' TPACK Ability. *Edusains*, *11*(2), 173–185. https://doi.org/10.15408/es.v11i2.10700