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Capturing Teacher Readiness for Adapting Playful Virtual Reality in The Learning Process

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Abstract: Technological Content Knowledge (TCK) is a concept that describes the three main components of knowledge teachers must possess: content, pedagogy, and technology. TCK explains how technology and content influence each other, requiring teachers to integrate technology to present lesson concepts effectively through appropriate learning media. However, a common problem is that some teachers are not proficient in creating technology-based learning content, even though they are already familiar with using technology in everyday life. Therefore, it is necessary to map teachers' abilities in using technology and developing content so that training programs can be designed according to their instructional needs. In response to this issue, we conducted mixed-method research (qualitative and quantitative) aimed at identifying the level of teachers' technological skills and content creation abilities in Indonesia. The participants were 20 Motivating Teachers from several elementary schools in Surakarta. This study serves as preliminary research within an ongoing Virtual Reality development project. Data were collected through questionnaires and documentation. The analysis results show that 80.75% of teachers are able to use ICT, 79.67% can apply ICT in learning activities, and only 30% are capable of managing or creating learning content. The next phase of this research will involve training teachers to develop subject-matter content using playful technology, particularly virtual reality content related to animal care topics. This study provides recommendations for teachers and local governments that improving classroom learning quality can begin with strengthening teachers' technological literacy, followed by training in creating engaging technology-assisted learning content for students.

Keywords: TCK, Learning Media, Virtual Reality

Abstrak: Technological Content Knowledge (TCK) adalah sebuah konsep yang menggambarkan tiga komponen utama pengetahuan yang harus dimiliki seorang guru seperti konten, pedagogi, dan teknologi. TCK adalah sebuah konsep tentang bagaimana teknologi dan konten saling memengaruhi. Guru perlu menggunakan teknologi dan menjelaskan konsep pelajaran dalam bentuk konten pembelajaran dengan bantuan teknologi tertentu. Namun, permasalahannya adalah bahwa beberapa guru tidak mahir dalam membuat konten pembelajaran menggunakan teknologi, meskipun mereka sudah mahir menggunakan teknologi dalam kehidupan sehari-hari. Maka perlu untuk memetakan kemampuan guru dalam menggunakan teknologi dan membuat konten sehingga kegiatan pelatihan dapat direncanakan untuk melengkapi kebutuhan mengajar mereka. Menanggapi masalah ini, kami melakukan penelitian metode campuran (metode kualitatif dan kuantitatif) yang bertujuan untuk menangkap tingkat teknologi dan keterampilan membuat konten guru di Indonesia. Kami melibatkan 20 Guru Motivasi dari beberapa sekolah dasar di

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Surakarta. Penelitian ini adalah penelitian pendahuluan sebagai bagian dari proyek pengembangan Realitas Virtual kami yang sedang berlangsung. Data dikumpulkan dari kuesioner dan dokumentasi. Berdasarkan analisis data, 80,75% guru dapat menggunakan TIK, 79,67% guru dapat menerapkan TIK dalam pembelajaran, dan hanya 30% yang dapat mengelola konten. Tahap selanjutnya dari penelitian ini akan melatih para guru untuk membuat konten materi pelajaran menggunakan teknologi yang menyenangkan, termasuk membuat konten tentang perawatan hewan menggunakan teknologi realitas virtual. Studi ini memberikan rekomendasi kepada guru dan pemerintah daerah bahwa upaya peningkatan kualitas pembelajaran di kelas dapat dimulai dengan meningkatkan literasi teknologi guru terlebih dahulu, kemudian melatih mereka untuk membuat konten pembelajaran berbantuan teknologi yang menarik bagi siswa.

Kata Kunci: TCK, Media Pembelajaran, Virtual Reality

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1. PENDAHULUAN

The use of technology has penetrated into various aspects of human life. Technology can help humans in various activities, including education. Teachers must have knowledge of how to integrate technology into the learning process. The technology used includes a variety of software and hardware, such as devices used in learning (augmented reality, virtual reality, PowerPoint, video) or commonly used hardware (laptops, LCDs, virtual whiteboards). Problems in the use of technology in education are felt to be very urgent. Therefore the use of technology is an option and a demand to improve efficiency and quality of education (Tanak, 2020). The challenge for teachers today is to develop technology for learning to integrate new technologies into the learning process (Tømte, Enochsson, Buskqvist, & Kårstein, 2015).

The teaching and learning process that elementary school teachers in Indonesia have carried out so far is thematic learning. Thematic learning is a teaching and learning approach that involves several subjects (civics, science, social studies, Indonesian language, arts and culture) in one theme to provide a meaningful experience for students. The meaning of significant experience is that students understand the concepts they have learned through direct experience and relate them to other concepts they already understand. Science is one of the contents of the lesson, which consists of many concepts, so, even though it is taught thematically, the teacher must master the concepts of the material in science without any misconceptions (Swallow & Olofson, 2017).

It is necessary to know the TPACK of primary school teachers in Indonesia in teaching science content in the 21st Century because TPACK can help determine the effect of an intervention or professional development program or to characterize descriptively the development of teacher knowledge (Suyamto, Masykuri, & Sarwanto, 2020). This shows that TPACK is an essential factor that can be used to improve the quality of education. By looking at the TPACK of teachers, the government can determine the policies that will be set to develop teacher professionalism. The Technological Pedagogical Content Knowledge (TPCK) framework is a theoretical framework needed by teachers to integrate technology into learning. Currently, developing technology can be used as a cognitive tool in education (Prawitasari & Suharto, 2020). For example, with internet-based technology, students can learn to gain knowledge constructively by creating content on Youtube. Similarly, when teachers use technology in the learning process, it also stimulates the process of

cognition within the teachers themselves. Cognition processes occur before, during, and after the use of technology in learning activities (Sahin, 2011). The cognitive process before learning occurs when the teacher represents the material using technology, which is a form of technology content knowledge (TCK). TCK is knowledge of how to represent material using technology(Sugiyarta SL, Ardhi Prabowo, Tsabit A. Ahmad, & Aji Purwinarko M.B. S, 2020).

Technological Content Knowledge (TCK) is knowledge about how technology can create a new picture in certain materials (Listiawan, Purwanto, As'Ari, & Muksar, 2018). Technological Content Knowledge (TCK) describes the knowledge of the interrelationship between technology and content (material). Teachers can create new ways and understand concepts in content with the help of specific technologies. Domain Technological Content Knowledge (TCK) is knowledge about the ways in which technology and content influence and limit each other (Billett, Troth, & Yan, 2023).

The choice of technology gives and limits what content (material) can be taught according to the technology used. Teachers need to understand deeply which technology is most suitable to be used in delivering content (material) and how content determines or may even change which technology should be used or vice versa. However, the problem in the field is that some teachers are not yet proficient in creating learning content using technology, even though teachers are already accustomed to using technology in everyday life. Most teachers integrate the material into technology in a simple context, such as making PowerPoint media. In fact, according to the characteristics of generation Z students, they need media with the latest technology so that learning becomes more meaningful. Science subjects integrated with thematic subjects are quite complex and abstract subjects. By developing content technology, it is hoped that information can be conveyed properly and learning becomes more concrete. In accordance with the cone theory of Edgar Dale's experience, which states that the more concrete students learn the lesson material, the message or information obtained will be conveyed properly (Shakirova, Al Said, & Konyushenko, 2020). This theory is in accordance with the latest technological developments, such as virtual reality media, that concrete media are able to stimulate thoughts, feelings, concerns and interests(Im, Gu, Bae, & Lee, 2025) . Based on this analysis, it is necessary to map the ability of teachers to use technology and create content so that training activities can be planned to complement their teaching needs.

METODE PENELITIAN

This research employs a mixed-method design (combining qualitative and quantitative approaches) because it allows for a more comprehensive understanding of the phenomenon by integrating numerical data with contextual interpretation. According to Creswell and Plano Clark (2018), mixed-method research provides a stronger foundation for exploring complex educational constructs by merging the strengths of both approaches. The quantitative component helps measure the level of teachers' Technological Content Knowledge (TCK) objectively, while the qualitative component provides deeper insights into teachers' experiences and practices in integrating technology into instruction. This methodological combination is justified because TCK, as a construct, involves both measurable competencies and complex contextual dimensions that cannot be fully captured by quantitative or qualitative methods alone (Tondeur et al., 2017).

The research sample consisted of 20 "Motivating Teachers" from primary schools in Surakarta, Indonesia. A purposive sampling technique was employed because this group possesses specific characteristics relevant to the research objectives. "Motivating Teachers" are educators who have passed a national selection process and completed a nine-month professional development program organized by the Ministry of Education of the Republic of Indonesia. They are expected to act as instructional leaders who promote innovation and improve the quality of learning in their schools. This sampling strategy is appropriate and justified because these teachers represent a critical subgroup with advanced

pedagogical and technological engagement, making them suitable for examining the readiness and application of TCK (Patton, 2015).

The data collection process consisted of three main stages: observation, questionnaire administration, and documentation review. Two primary instruments were used in this study. The first instrument was an observation guideline, developed to capture teachers' actual classroom practices related to technology integration in content delivery. The second instrument was a questionnaire designed to assess teachers' self-perceived mastery of TCK dimensions. The questionnaire and observation items were adapted from previous studies using the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006), specifically focusing on the intersection of technological and content knowledge.

The questionnaire consisted of 25 items covering three main dimensions: technological knowledge, content knowledge, and their integration (TCK). Each item used a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The observation instrument included 10 indicators designed to evaluate how teachers utilized digital tools to support content delivery, problem-solving, and student engagement. Both instruments were validated through expert judgment by three educational technology specialists and tested for reliability (Cronbach's alpha = 0.86).

The data analysis process involved both quantitative and qualitative techniques. Quantitative data from the questionnaire were analyzed using descriptive statistics—means, percentages, and standard deviations—to identify the overall level of teachers' TCK competencies. Qualitative data obtained from observations and documentation were analyzed using thematic analysis (Braun & Clarke, 2006). This involved coding the field notes, identifying recurring patterns, and categorizing them into themes that reflect teachers' technology integration practices.

Finally, both datasets were integrated using a convergent mixed-method approach (Creswell & Plano Clark, 2018), where quantitative and qualitative findings were compared and interpreted together to provide a richer and more valid understanding of the teachers' TCK profiles. This integration helped validate the results by confirming patterns observed in numerical data with the qualitative insights from classroom contexts (Vidal-Balea et al., 2020).

Table 1. Indicators Used to Develop Research Instruments

Aspect	Indicator	Code
Use of ICT	Hardware used during teaching	TCK1
	Knowledge of applications/media for learning	TCK 2
	App/media selection accuracy	TCK 3
	Application/media selection.	TCK 4
Application of ICT in learning	Frequency of using technology in class	TCK 5
	Technological developments in teaching approaches	TCK 6
	Application of applications that are in accordance with current technological developments	TCK 7
Ability to manage content	Load content with the help of technology	TCK 8
	The teacher's ability to develop multimedia (Virtual Reality)	TCK 9
	Multimedia development (Virtual reality) in schools	TCK 10

HASIL DAN PEMBAHASAN

Based on the research that has been done, the results obtained about the content technology capabilities of elementary school teachers in the city of Surakarta as driving teachers include aspects of using ICT, aspects of implementing ICT in learning and aspects of managing learning content. The presentation of research results on each aspect studied in this study is described as follows.

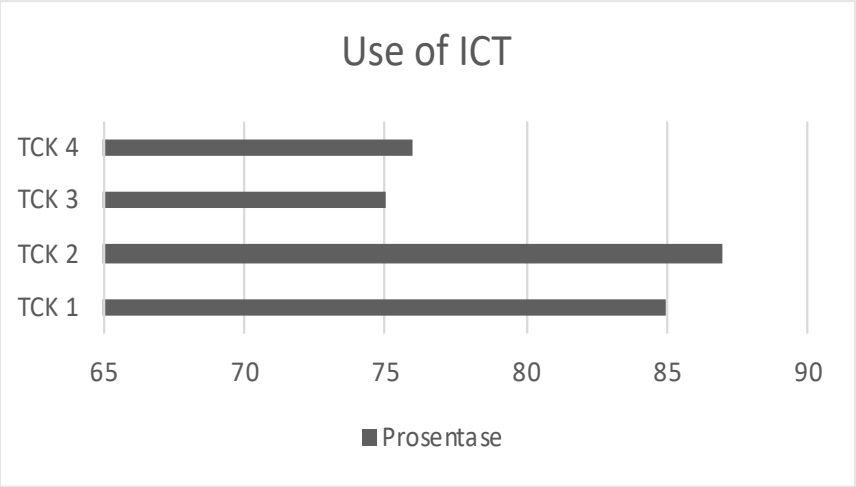

Figure 1. Aspects of Using ICT

There are four indicators in aspects of ICT use hardware used during teaching, knowledge of applications/media for learning, the accuracy of the selection of applications/media, and the choice of applications/media. From the data analysis, it is known that 80.75% of teachers are able to use ICT. For more details related to aspects of ICT use based on Figure 1, on the indicator of Hardware used during teaching (TCK1), it was found that 85 % of driving teachers in elementary schools had used hardware in the form of smartphones and laptops/PCs in science learning which was integrated into learning thematic. In addition, learning support facilities in the form of technological tools provided by the school are well available. The next indicator is Knowledge of applications/media for learning (TCK 2). In the TCK 2 indicator, 87% of the driving teachers have understood the media or applications used in science learning which are integrated into thematic learning. Applications and media that are often used in science learning, such as PowerPoint media and interactive videos. Indicator Accuracy in the selection of applications/media (TCK 3) in accordance with the science material is 76%. Most teachers are right in choosing interactive media for science material. Selection of applications/media (TCK 4) in science learning 76% of teachers choose to use PowerPoint and youtube applications as science learning media. The teacher chooses the application based on the consideration of the ease that will be obtained and the convenience obtained by the user (student). To overcome the technical difficulties experienced by the teacher, he made an application tutorial.

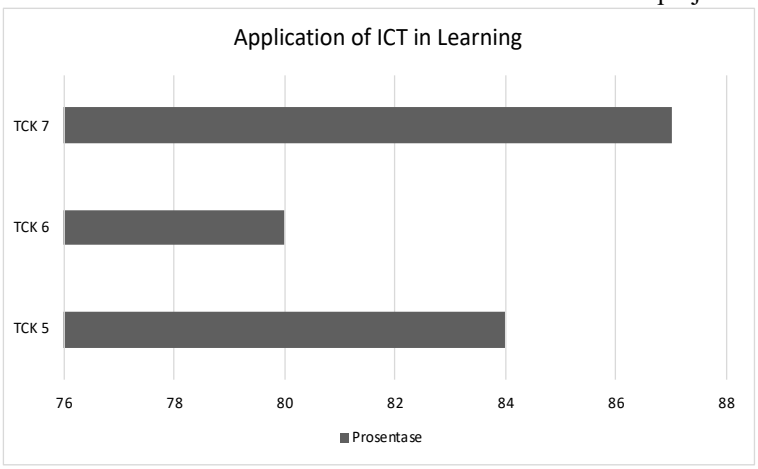

Figure 2. Aspects of ICT Application in Learning

From the data analysis, it is known that 79.67% of teachers are able to apply ICT in learning. Based on the aspects of the application of ICT in learning, there are three indicators discussed, namely the frequency of using technology in the classroom (TCK 5), the development of technology into the teaching approach (TCK 6) and the application of applications that are in accordance with current technological developments (TCK 7). In the TCK 5 indicator, 85% of teachers use technology in science learning. The application of ICT-based learning depends on the teacher in each school. In thematic subjects, especially on the theme of science learning, utilizing technology devices that have been provided at school or from teachers. In the indicator of the development of technology in the teaching approach (TCK 6), 80% of students are introduced to many media that can support learning. Students in the current era are considered easier and faster to understand when operating new applications that are known along with technological developments. On the indicator of application in accordance with current technological developments (TCK 7), 87% of teachers have implemented applications or media in accordance with technological developments. Based on interviews, the application often used besides PowerPoint is social media for science learning. Technological developments make teachers have demands to know more about new applications that can support learning.

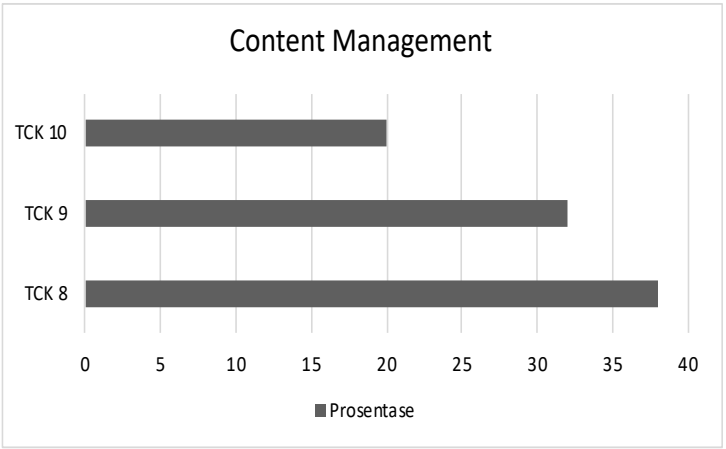

Figure 3: Aspects of Ability to Manage Content

From the data analysis in Figure 3, it is known that only 30% of teachers are able to manage content. In the aspect of the ability of teachers to manage content, one indicator of content with the help of technology (TCK 8) is that 38% of teachers have not been able to create content with the use of technology. In addition, the ability of teachers and schools to develop multimedia (Virtual Reality) is still

relatively low. Of the 20 driving teachers, only 32% of teachers can use Virtual reality (TCK 9). The results show that only 20% of teachers can develop Virtual reality applications (TCK 10), and the remaining 80% of teachers have not been able to create Virtual reality applications. This is because many teachers do not know about Virtual Reality applications or learning media. TCK is proven to be able to help teachers understand how to plan and implement learning by integrating technology in the classroom (Burkhardt et al., 2025). In science subjects integrated into thematic learning, in elementary schools, several materials teach content technology knowledge to students, namely the theme Caring for Living Creatures.

TCK is not only an understanding of how technology can be used to describe the content but also how technology can change or even produce content. In the sense that technology can open or explain content that was previously not clearly understood. Science subjects are oriented towards the self-actualization of students to understand knowledge, ideas and concepts about the natural environment that are obtained from a series of experiences. Several aspects that were highlighted during the development of multimedia in the form of virtual reality in this science subject were the analysis of learning objectives, basic competencies and indicators, analysis of the initial conditions of learning, and analysis of student characteristics and needs (Neher et al., 2025). The supporting factor for the success of learning by integrating technology into learning is the ability to use ICT optimally from qualified teachers and facilities. In addition, learning that utilizes technology can increase the effectiveness of students' learning time, creativity, and critical thinking (Capitani et al., 2025).

Habituation of learning activities using technology in the classroom is found in science subjects which are integrated into thematic subjects. Class teachers take advantage of technology such as laptops, LCDs and internet networks provided in schools. Based on research, there are still many teachers who have not been able to recognize or determine the software that can help in learning because of the low frequency of using ICT during learning (Ljungblad, Murphy, & Fonkalsrud, 2025). Therefore, the habit of using technology affects students' ability to use technology. Habituation of ICT activities makes teachers accustomed to using computers, so teachers can get used to recognizing technology and its developments in teaching. In addition to the habituation factor in using technology for classroom learning, the age factor also affects the use of ICT during learning (Plotzker, Harmon, Kanellitsas, & Klein, 2025).

Some of the facts that affect the teacher's TCK ability are the number of learning experiences such as participation in training that are obtained with the aim of improving the quality of teachers (Abbas et al., 2025). So the length of teaching experience is not directly proportional to the increase in TCK ability. This is influenced by many factors, including the busyness faced by teachers and also the age factor. This causes senior teachers not to be able to take the time to learn new things, especially technological advances in supporting the teaching process in the classroom. Therefore, most senior teachers still apply conventional learning.

The results of the recapitulation of TCK data for primary school teachers for science subjects that were integrated into thematic subjects in Surakarta City showed an average percentage of 52%, which was included in the sufficient category. In terms of the use of ICT, almost all driving teachers use technology in their daily lives. In addition, the driving teacher uses existing technological facilities during the learning process. However, in developing materials with the help of new technology, only a small number of teachers have technological facilities such as the virtual reality that are used to deliver teaching materials. The factor that causes the percentage gain in the aspect of the ability to manage content is not good because there are still many teachers who have not been able to integrate content (material) with technology. This is in accordance with the findings, which stated that all aspects of TCK affect the success of the integration between content and technology in learning (Sukmawati, Santosa, & Rejekiningsih, 2023). TCK is essential for the ability to compose learning tools; teachers can use technology well in

learning activities if teachers can integrate knowledge into the learning tools they have prepared (Lopez et al., 2021).

The findings of this study indicate that most primary school teachers integrate ICT into their teaching primarily through conventional tools such as PowerPoint presentations and online multimedia resources, reflecting practices situated largely at the substitution and augmentation levels within the SAMR model. While this demonstrates an increasing awareness of technology's pedagogical potential, the integration remains largely instrumental rather than transformative. The use of digital devices such as laptops, smartphones, and LCD projectors—particularly when combined with immersive media like virtual reality (VR)—offers significant opportunities to enhance students' conceptual understanding through experiential and interactive learning environments (Parong & Mayer, 2021; Radianti et al., 2020). This finding aligns with the Technological Pedagogical Content Knowledge (TPACK) framework, emphasizing that effective technology integration arises from a dynamic interplay among content, pedagogy, and technology. The principal strength of this study lies in its empirical contribution to understanding early-stage VR adoption among primary school teachers in developing contexts, thereby expanding the discourse on Technological Content Knowledge (TCK) development and teacher digital readiness. Nevertheless, the study is limited by its small sample size, reliance on self-reported and observational data, and unequal access to advanced technological infrastructure, which may restrict broader generalization. Theoretically, these findings underscore that TCK development is a context-sensitive and evolving process influenced by teachers' exposure to and confidence with digital tools. Practically, they highlight the urgent need for sustained professional development, institutional support, and equitable access to educational technologies. Consequently, policymakers and teacher education institutions should collaborate to design scalable, resource-sensitive frameworks that facilitate meaningful and sustainable technology integration in primary education.

KESIMPULAN DAN SARAN

From the research that has been carried out that 80.75% of teachers can use ICT, 79.67 teachers are able to apply technology in learning, and only 30% of teachers are able to manage content, so it can be concluded that teacher readiness in developing and utilizing Virtual Reality media technology is seen from the aspect of the teacher's ability to use technology it is good, and the aspect of using ICT in learning is also quite good, but there are still shortcomings in managing content/materials that will be loaded in applications such as virtual reality. In science subjects that are integrated into thematic subjects in elementary schools, teachers should be able to manage content with the latest technology, such as virtual reality, to make it easier for teachers to deliver material optimally. The next stage of this research will train these teachers to create subject matter content using playful technology, in this case creating content about caring for living things using virtual reality technology. This study provides recommendations to teachers and local governments that efforts to improve the quality of classroom learning can be started by improving teacher literacy technology first and then training them to create interesting technology-assisted learning content for students.

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