

Exploring the Intersection of TPACK and Professional Competence: A Study on Differentiated Instruction Development within Indonesia's Merdeka Curriculum

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Abstract

Despite the growing emphasis on differentiated instruction in modern education, there remains a noticeable gap in research examining the integration of Technological, Pedagogical, and Content Knowledge (TPACK) with professional competence, particularly within the context of Indonesia's Merdeka Curriculum. This study aims to assess teachers' levels of TPACK and professional competence in developing differentiated instruction in Yogyakarta, Indonesia, while exploring the correlation between these two variables. Adopting a quantitative correlational research design, the study employed stratified random sampling to select a sample of 84 teachers from eight elementary schools currently implementing the Merdeka Curriculum (Independent Learning Curriculum). Descriptive statistics and hypothesis testing, using the Spearman-Brown formula, were utilized for data analysis. The findings indicate that the participating teachers exhibit moderate levels of both TPACK and professional competence in developing differentiated instruction. Moreover, hypothesis testing revealed a strong and significant correlation between teachers' TPACK and their professional competence in designing differentiated instruction. This research highlights the importance for teacher training institutions to prioritize the development of TPACK, enabling educators to effectively adapt to evolving educational policies.

Keywords: competency-based education, educational innovation, educational technology, differentiated instruction, *merdeka curriculum*, professional competence, technology integration, TPACK

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1. Introduction

A curriculum is a comprehensive framework that outlines the learning objectives, content, and materials necessary for organizing educational activities with the aim of achieving specific educational goals (Stojadinovic et al., 2021). Curriculum development is an ongoing process, driven by advancements in science, information, and technology, and must align with the evolving

needs of society. The Merdeka Curriculum exemplifies this adaptive approach, emphasizing competency-based education that aligns educational practices with the demands of the modern world (Julaeha et al., 2021). The adoption of the Merdeka Curriculum marks a significant shift towards competency-based education, prioritizing the alignment of educational practices with soci-

etal demands and learner needs (Thummaphan et al., 2022).

The Merdeka Curriculum aims to enhance education delivery in Indonesia by prioritizing an environment that fosters comfort, independence, active participation, meaningful learning, character development, and self-directed learning (Asfiati, 2023; Fikri et al., 2022). It offers sustainable learning materials relevant to students' needs, allowing for adaptability to advancements in science and technology (Sormin et al., 2023). Additionally, the Merdeka Curriculum promotes the cultivation of essential 21st-century skills, including critical thinking, creativity, communication, collaboration, and digital literacy (Mulabbiyah et al., 2024). These skills are crucial in preparing students to confront future challenges (Damayanti & Muhroji, 2022). Moreover, the Merdeka Curriculum empowers teachers to select the learning content that best meets the specific needs of their students (Poerwanti et al., 2023). This autonomy is further enhanced by an improvement in teachers' proficiency and ability to create customized educational resources (Fitriyah & Wardani, 2022).

While the Merdeka Curriculum offers increased flexibility in the learning process, its implementation requires overcoming several challenges (Damayanti & Muhroji, 2022). These challenges are encountered both in terms of content and technological aspects (Mulabbiyah et al., 2024). For instance, teachers, as the primary implementers of the Independent Learning program, are required to step out of their comfort zones and transform traditional teaching methods into innovative instructional approaches (Witraguna et al., 2024). These challenges arise not only from students but also from teachers who employ outdated or unsuitable learning methodologies in the classroom (Citra et al., 2023). For example, research

indicates that when teachers fail to adapt their teaching strategies to incorporate active learning techniques, such as collaborative projects or technology integration, student engagement and comprehension significantly decline, ultimately hindering the overall effectiveness of the Merdeka Curriculum (Fitriyah & Wardani, 2022). Furthermore, many teachers do not fully utilize available educational resources, resulting in a mundane learning experience (Nurulaeni & Rahma, 2022). Teachers are often provided with a limited number of instructional resources by the institution (Admiraal & Ijonse, 2022; Annand, 2015). Additionally, teachers may lack the necessary expertise to design instruction within the context of the Merdeka Curriculum. The scarcity of adequate references poses a challenge for teachers in developing instructional strategies, which leads to the continued reliance on traditional teaching methods, such as monotonous lectures (Ramdhani et al., 2024).

The Merdeka Curriculum is renowned for its ability to cater to students' individual learning needs and characteristics. The curriculum is designed to offer targeted instruction that addresses the specific needs and attributes of each student. One effective approach to facilitating both broad and focused learning activities is differentiated instruction (Valcke, 2016). Differentiated instruction is a pedagogical approach that tailors teaching to meet the diverse needs of students, thereby facilitating their ability to select, acquire, organize, and retain knowledge, which ultimately impacts their learning outcomes. This approach fosters inclusive learning by providing all students with equitable opportunities to enhance their self-confidence and motivation throughout the learning process. Teachers address students' needs by offering a diverse range of learning materials that align with their individual characteristics,

such as books, films, and photographs (Nurulaeni & Rahma, 2022). In sum, differentiated instruction can enhance students' understanding of a topic and facilitate more enduring retention of learned content.

The teacher plays a crucial role in differentiated instruction, as they are required to address students' diverse learning needs, such as by providing a variety of learning resources. Tadesse and Melese (2016) assert that instructors face challenges in designing instruction due to the rigid and structured time schedules of traditional curricula, which restrict their ability to adapt instructional materials to meet the individual needs of students. In such contexts, educators struggle to accommodate the individual differences and learning preferences of all pupils. Implementing differentiated instruction demands considerable effort and thorough preparation from teachers, which can be challenging in the busy environment of schools.

To effectively implement differentiated instruction, teachers must possess specific skills, including proficiency in the use of information technology. This set of skills is referred to as TPACK, which stands for Technological Pedagogical Content Knowledge. TPACK is a conceptual framework that helps to understand the integration of instructional resources, pedagogical expertise, and technological knowledge to create appropriate and effective learning experiences (Sembiring, 2022). Teachers need to cultivate their professional competencies by combining various forms of information and technology to design engaging and effective learning experiences for students (Rahmadi, 2019). Teachers with a high level of TPACK are adept at selecting and organizing educational resources effectively. TPACK plays a significant role in the learning process, as it is intrinsically linked to the ability to develop

educational resources. There is a strong correlation between TPACK and the pedagogical competencies of educators, which include the ability to design, implement, and assess instructional practices while also understanding the individual characteristics of students. Integrating TPACK into the learning process has the potential to improve the quality of education and equip students with the necessary skills to address future challenges (Sholihah et al., 2016).

Educational institutions and educators should collaborate to provide effective and engaging 21st-century learning experiences. According to Suyamto (2020), teachers at certain institutions face difficulties in fully comprehending instructional resources and exhibit limited technological proficiency. These teachers often have an insufficient understanding of how to integrate technology into the classroom, despite the fact that technological literacy can enhance the achievement of essential educational goals (Yurinda & Widiasari, 2022). The low level of technological literacy among teachers can be attributed to limited time and resources for developing their TPACK. Teachers also struggle to find the time and resources needed to cultivate their TPACK in daily teaching.

Incorporating TPACK into the classroom involves the careful selection and use of technology that aligns with the learning content and the characteristics of students. The connection between TPACK and differentiated instruction is closely intertwined, as TPACK provides the appropriate framework for integrating technology effectively into differentiated instruction. Teachers, as the facilitators of ongoing learning activities, must possess the ability to create a learning environment that aligns with the distinctive needs of 21st-century students (Ajizah & Huda, 2020). Teachers who are proficient in

TPACK are better able to choose appropriate technologies that match students' unique needs, allowing them to learn at their own pace, cater to their preferred learning styles, and ultimately have meaningful and enjoyable learning experiences.

Based on the above, it can be inferred that incorporating TPACK into differentiated instruction offers numerous benefits for elementary school teachers. According to [Amelia \(2023\)](#), the use of Technological Pedagogical Content Knowledge (TPACK) by elementary school teachers positively impacted student learning outcomes. Additionally, a study by [Ananda and Rani \(2022\)](#) found that implementing TPACK in primary schools in Salo District improved teacher professionalism and enhanced student learning outcomes. However, previous research has focused primarily on the impact of TPACK on student achievement. No studies have yet examined the influence of TPACK on teachers' ability to facilitate differentiated instruction. Therefore, this research is essential to fill this gap.

This study aims to examine the levels of TPACK and professional competence of teachers in developing differentiated instruction in Yogyakarta, and to explore the correlation between these two variables.

Research questions

- RQ 1 : What is the profile of teachers' TPACK in Yogyakarta?
- RQ 2 : How competent are teachers in developing differentiated instruction?

Hypothesis

- H₀: There is no significant correlation between teachers' TPACK and their professional competence in designing differentiated instruction;
- H₁: There is a significant correlation between teachers' TPACK and their pro-

fessional competence in designing differentiated instruction.

The development of these hypotheses stems from identifying a research gap concerning the impact of teachers' TPACK on their ability to design differentiated instruction. This gap is framed within educational theories and supported by a review of existing literature. The null hypothesis (H₀) assumes no relationship between TPACK and professional competence, while the alternative hypothesis (H₁) suggests a significant relationship exists. Testing these hypotheses will involve empirical research to provide data-driven insights into the connection between these variables.

2. Method

The present study employed a quantitative correlational research design to examine the relationship between two or more variables within a specific population or sample. This research design was selected based on the study's objective of testing the relationship between two variables. Data was collected on key factors of interest, including TPACK and teacher professional competence in fostering differentiated instruction. The data was subsequently analyzed to determine the correlation between these variables, whether positive or negative (inverse) ([Ibrahim et al., 2018](#)).

The sample for this study consisted of 151 public and private elementary schools in the city of Yogyakarta that had adopted the Independent Learning Curriculum (Merdeka Curriculum). The schools were categorized into five distinct groups: independent learning, independent change, independent sharing, PSP 2, and PSP 3. Stratified random sampling was used to select the research sample, which involved dividing the study population into subgroups and then randomly selecting samples from each subgroup ([Fir-](#)

[mansyah & Dede, 2022](#)). The research sample included Lempuyangan I Elementary School, Gedongkuning Elementary School, Ngupasan Yogyakarta Elementary School, Muhammadiyah Pakel Elementary School, Muhammadiyah Suronatan Elementary School, Intis Elementary School Yogyakarta, Karangkajen II Elementary School, and Muhammadiyah Notoprajan Elementary School.

Data was collected through a survey. The Technological Pedagogical Content Knowledge (TPACK) framework was assessed using various instruments designed to evaluate teachers' competencies in integrating technology into their teaching practices. For instance, [Wilujeng et al. \(2020\)](#) developed a TPACK instrument based on the Indonesian curriculum to enhance teachers' professionalism by integrating curriculum, learning scenarios, and technology selection to improve pedagogical competence in science teaching. Similarly, [Chai et al. \(2018\)](#) focused on modeling teachers' design beliefs

and efficacy related to TPACK, emphasizing the intersection of technology, pedagogy, and content knowledge as essential for quality learning in the 21st century. Teachers' TPACK and professional competence in developing differentiated instruction were measured using a semantic differential scale, with "very positive" positioned on the right side of the scale and "very negative" on the left side ([Sugiyono, 2016](#)).

Data analysis was conducted using descriptive statistics. The results were used to describe the TPACK levels and competence in differentiated instruction among elementary teachers. Descriptive analysis was followed by assumption tests, including tests for normality and homogeneity. The assumption tests indicated that the data did not meet the requirements for parametric testing. Consequently, the correlation between the research variables was assessed using the Spearman-Brown formula ([Trimawartinah, 2020](#)).

3. Results and Discussion

a. The Profile of Teachers' TPACK in Yogyakarta

Table 1. The Distribution of TPACK Scores Among Participants

Aspect	Number of Teachers			Percentage		
	High	Medium	Low	High	Medium	Low
CK	16	56	12	19.05%	66.67%	14.29%
TK	14	56	14	16.67%	66.67%	16.67%
PK	11	59	14	13.10%	70.24%	16.67%
PCK	13	58	13	15.48%	69.05%	15.48%
TCK	8	61	15	9.52%	72.62%	17.86%
TPK	12	59	13	14.29%	70.24%	15.48%

Table 1 presents the distribution of scores achieved by teachers across the various TPACK components, along with a comparison of scores in different TPACK categories. The data reveals that 19.05% of teachers attained high scores in Content Knowledge (CK), while 17.86% of teachers scored low in Technological Content

Knowledge (TCK). These findings suggest that the majority of elementary school teachers in Yogyakarta exhibited moderate levels of Technological Pedagogical Content Knowledge (TPACK).

Approximately two-thirds (66.67%) of teachers in Yogyakarta achieved moderate scores in Content Knowledge (CK). This

indicates that most teachers were proficient in the subject matter they were teaching but faced challenges in grasping more complex concepts. While they could effectively enhance students' understanding through relevant examples, they often relied on a relatively straightforward approach (Suyamto et al., 2020). Content Knowledge (CK) is a crucial determinant of teacher readiness and professionalism (Tripalupi et al., 2019). It plays an essential role in improving instructional effectiveness and fostering teacher professionalism.

In Yogyakarta, 66.67% of teachers demonstrated an adequate level of Technological Knowledge (TK), enabling them to use technology appropriately based on students' comprehension levels. However, these teachers occasionally faced difficulties when attempting to implement more complex teaching methods. They were proficient in using technology to engage students but struggled to adopt the latest technological advancements (Zulhazlinda et al., 2023). This finding underscores the importance of continual professional development in technology, as teachers must remain up to date with rapidly evolving technological tools that can be applied in the classroom (Sintawati & Indriani, 2019). Technological Knowledge (TK) is crucial for enhancing instructional quality and providing opportunities for professional growth while also supporting teachers in managing administrative tasks.

Approximately 70.24% of teachers in Yogyakarta exhibited a moderate level of Pedagogical Knowledge (PK). This suggests that these teachers were capable of fostering student-centered learning while employing traditional methods for teaching complex subject matter. Although they had the ability to use a variety of instructional strategies, their implementation was hindered by time constraints. These teachers were also profi-

cient in classroom management but struggled to engage all students in the learning process (Lestari & Rahayu, 2023). As such, it is essential for teachers to stay informed about contemporary pedagogical strategies and, when appropriate, develop instructional methods tailored to the specific needs of their students (Julia et al., 2020). According to Minister of National Education Regulation No. 16 of 2007, pedagogical competence is a mandatory requirement for teacher professionalism. Pedagogical Knowledge (PK) is vital for improving teaching effectiveness, strengthening professional skills, and deepening the understanding of effective teaching practices.

In Yogyakarta City, 69.05% of teachers demonstrated sufficient Pedagogical Content Knowledge (PCK). This suggests that the teachers were able to implement learning strategies and approaches appropriate for the subject matter. However, they faced difficulties when attempting to apply these strategies to particularly complex and challenging content. While the teachers were capable of assessing student comprehension through questioning, they occasionally overlooked variations in student learning styles and failed to fully involve students in the evaluation process (Makaraka et al., 2021). Pedagogical Content Knowledge encompasses two essential components: the teacher's ability to represent the subject matter effectively and their understanding of students' perceptions or challenges encountered during learning (Rakhmah et al., 2024). To design meaningful and effective learning experiences, educators must possess a robust understanding of PCK (Ambaryanti et al., 2020). In conclusion, PCK is vital for educators, as it enables them to build strong rapport with students and foster productive learning environments.

The findings of this research also indicated that 72.62% of teachers in Yogyakarta

demonstrated adequate Technological Content Knowledge (TCK). While these teachers were able to use technology relevant to their teaching, they occasionally faced challenges in adapting to the latest technological advancements. Additionally, although they could understand the technology relevant to their subjects, they struggled to design media that could accommodate the diverse needs and readiness levels of students (Suyamto et al., 2020). According to the Minister of National Education Regulation No. 16 of 2007, professional competence is a critical attribute for educators. This competence includes the ability to utilize technology effectively. Technological Content Knowledge (TCK) is therefore an indispensable tool for professional teachers, as it enhances teaching effectiveness and contributes to the advancement of teachers' careers and professional development.

Over half (70.24%) of the teacher participants in Yogyakarta City exhibited a commendable level of Technological Pedagogical Knowledge (TPK). This finding suggests that these teachers were capable of selecting

technology that aligned with their teaching methods and strategies. They effectively employed technology to communicate with students, such as collecting assignments, and integrated it into their teaching practices to enhance student learning activities. However, there were instances where teachers did not provide adequate guidance or instruction for students in using the technology. While the teachers were able to utilize technology to engage students during the learning process, they encountered limitations in using diverse technical tools and applications that could offer a broader range of learning opportunities for students (Suryawati et al., 2014). As stipulated by the Minister of National Education Regulation No. 16 of 2007, a professional teacher must be capable of effectively employing information and communication technologies for educational purposes. Therefore, it can be inferred that Technological Pedagogical Knowledge (TPK) serves to enhance teaching expertise and the effectiveness of learning, while also positively influencing teachers' professional development.

b. Teacher Competence in Developing Differentiated Instruction

Table 2. Teacher Competence in Developing Differentiated Instruction

ASPECT	Number of Teachers			Percentage		
	High	Medium	Low	High	Medium	Low
The ability to develop a diagnostic assessment	13	55	16	15.48%	65.48%	19.05%
The ability to develop lesson plans	10	60	14	11.90%	71.43%	16.67%
The ability to conduct the learning process	13	62	9	15.48%	73.81%	10.71%
The ability to perform reflection and evaluation	12	58	14	14.29%	69.05%	16.67%
The ability to develop differentiated instruction	10	61	13	11.90%	72.62%	15.48%

Table 2 displays the distribution of scores achieved by teachers for each indicator of differentiated instruction development.

A small proportion (15.48%) of teachers received high scores on the indicator of "developing a diagnostic assessment," while

19.05% scored low. The analysis reveals that teachers' ability to develop differentiated instruction generally falls within the moderate range.

The findings of this study indicated that teachers in Yogyakarta exhibited a modest level of proficiency in developing differentiated instruction. Data revealed that 65.48% of teachers demonstrated competence in constructing diagnostic assessments to identify students' learning strengths and weaknesses. However, these educators occasionally failed to consider students' diverse learning styles when designing the assessment tools. Furthermore, the teachers lacked the skills to interpret diagnostic test results and were unable to provide adequate feedback or effective solutions to address identified issues (Maut, 2022). Diagnostic assessments simplify the process of identifying and analyzing students' learning needs, enabling teachers to tailor educational resources to students' abilities (Kemendikbud, 2020). Teachers must conduct both cognitive and non-cognitive diagnostic evaluations before instruction to categorize students based on their readiness levels and learning requirements (Insani et al., 2023). Therefore, the ability to develop diagnostic assessments is crucial for teachers to enhance their professionalism in managing the learning process.

More than half (71.43%) of the participants demonstrated the ability to design lesson plans tailored to the specific needs and characteristics of their students. However, they faced challenges when adapting to changes in class dynamics or the progress of individual students. The research indicated that teachers were capable of designing diverse instructional strategies to meet learning objectives but struggled with limited resources in the student learning environment (Sufiati & Afifah, 2019). An unclear or inadequate lesson plan can hinder students' abil-

ity to achieve specific learning outcomes, impair their understanding of the material, and lead to ineffective instructional delivery (Putrianingsih et al., 2021). Teachers need to refine their ability to develop lesson plans as this directly impacts their teaching performance, which can be evaluated based on their proficiency in designing and evaluating the learning process (Rokhmawati et al., 2023). The ability to create effective lesson plans is a key indicator of teacher professionalism and contributes to the overall quality of teaching.

In Yogyakarta, 73.81% of teachers possessed the ability to employ adaptable instructional strategies tailored to students' individual needs. However, they encountered difficulties when implementing these strategies in complex and challenging subjects. Teachers demonstrated the capacity to present content in a clear and organized manner, but occasionally struggled to engage all students in the learning process. Although they were able to provide diverse instructional materials to meet students' needs, they faced difficulties when trying to teach intricate subjects within a limited timeframe. The role of educators in facilitating the achievement of learning objectives is crucial. Teachers' proficiency in managing the learning process and employing diverse instructional strategies is vital for the effective implementation of education (Mulyawati & Purnomo, 2021). According to Law No. 14/2005 concerning Teachers and Lecturers (Chapter IV, Article 10, Paragraph 1), teachers are required to possess pedagogical competence, which reflects their teaching ability. A professional teacher is defined as one who can perform their duties and responsibilities in a manner that is both effective and conducive to the learning environment (Badelah, 2021). Teachers' pedagogical competence is characterized by their ability to teach efficiently,

effectively, and professionally (Wahyulestari, 2018). In summary, it is essential for teachers to have the ability to develop learning experiences that provide positive learning outcomes for students. By adopting this approach, teachers' reputations and professional expertise can be enhanced.

As indicated in Table 2, 69.05% of teachers demonstrated the ability to assess student understanding through reflective and evaluative exercises related to the subject matter. However, these teachers occasionally failed to provide adequate feedback to students. They also exhibited the ability to analyze the results of learning assessments using basic technologies, though at a slower pace. These educators could use reflection and evaluation results to plan future learning, although their scope was often limited to basic educational content (Purba et al., 2021).

Professional teachers must be able to assess their students' progress. Reflection and evaluation are essential tools for teachers to measure student achievement (Saputri et al., 2023). Teachers are responsible for continuously improving their teaching methods and assessing them to determine the necessary adjustments for instructional improvement. Lack of expertise in student evaluation can negatively impact teacher effectiveness and

professional integrity (Magdalena et al., 2023). The ability to engage in reflection and evaluation is critical for professional development, as it allows teachers to refine their teaching practices and enhance classroom instruction.

c. The Correlation between Teachers' TPACK and Competence in Developing Differentiated Instruction

The novelty of the research presented in this document lies in its focus on examining the integration of Technological Pedagogical Content Knowledge (TPACK) with professional competence in developing differentiated instruction among elementary school teachers within the context of the Merdeka Curriculum in Yogyakarta, Indonesia. This study addresses a research gap by exploring the correlation between teachers' TPACK and their ability to develop differentiated instruction, a topic that has been underexplored in relation to this specific curriculum. While previous studies have primarily focused on enhancing student learning outcomes through TPACK, this research is unique in investigating the impact of TPACK on teacher competence in designing differentiated instruction, thereby providing new insights for teacher training institutions and policy development.

Table 3. Results of the Non-Parametric Test on Teachers' TPACK and Competence in Developing Differentiated Instruction

Independent Variable	R_{table}	$R_{calculated}$	Conclusion
CK	0.2146	0.797	Correlated
TK	0.2146	0.907	Correlated
PK	0.2146	0.882	Correlated
PCK	0.2146	0.908	Correlated
TCK	0.2146	0.902	Correlated
TPK	0.2146	0.900	Correlated

According to Table 3, a strong ($R = 0.60-0.799$) and positive ($0.80-1.00$) correlation exists between each indicator of TPACK

and teachers' competence in developing differentiated instruction, as evidenced by $R_{calculated} > R_{table}$. This finding suggests that

changes in one variable are closely related to changes in the others. In other words, an increase in a teacher's TPACK is associated with an enhanced ability to implement differentiated instruction. Conversely, a decrease in TPACK corresponds with a diminished capacity to provide differentiated learning experiences.

Content Knowledge (CK) is the foundational element of teaching. Government Regulation No. 74 of 2008 highlights that content knowledge is a critical component of a teacher's professional competence. It involves a comprehensive understanding of the subject matter in line with the program's content standards for educational units, subjects, and groups of subjects to be taught. The content knowledge that teachers must acquire varies by educational level. Teachers must possess a high degree of expertise in the subjects they teach to deliver effective instruction (Rosyid, 2016). Content knowledge represents a unique framework for thinking about a discipline, and educators must have a deep understanding of the subject they are responsible for teaching (Akhwani, 2020). The correlation analysis revealed a positive relationship between teachers' content knowledge and their ability to develop differentiated instruction. Specifically, an increase in a teacher's content knowledge is associated with a corresponding improvement in their capacity to design differentiated learning approaches.

Teachers who possess extensive content knowledge are better equipped to adapt educational resources in ways that cater to the diverse needs, learning styles, and comprehension levels of their students. This deep understanding of subject matter not only allows teachers to modify instructional materials effectively but also empowers them to design and implement teaching strategies that are both innovative and impactful (Anggarini et al., 2023). A strong foundation in content

knowledge is essential for developing differentiated instruction, as it enables educators to make informed decisions about how to present content, assess student progress, and provide targeted support. By leveraging their expertise, teachers can create a flexible and inclusive learning environment that accommodates the varying abilities and backgrounds of students, thereby enhancing the overall quality and effectiveness of the educational experience (Sulistyanto et al., 2022). In this way, content knowledge (CK) serves as the cornerstone of successful teaching practices, supporting the creation of differentiated learning experiences that promote engagement, understanding, and academic growth for all students.

Technological Knowledge (TK) refers to an understanding of how to utilize both basic and advanced technologies. It encompasses the ability to install, operate, and troubleshoot various technological tools (Kim, 2018). The use of technology should align with the demands of the modern era (Hanik et al., 2022). In this context, knowledge of educational technology, including relevant software or applications, enables teachers to create personalized learning experiences that address the specific needs of their students (Janah, 2022). The findings of this study indicated that an increase in a teacher's TK directly correlates with an improvement in their ability to develop differentiated instruction. Teachers with extensive TK can select and integrate software or applications that are suited to their students' needs. Additionally, teachers with sufficient TK can create diverse and engaging educational experiences using technology, fostering a learning environment that is adaptable to students' individual needs and differences.

Pedagogical Knowledge (PK) encompasses the understanding of teaching methods and procedures, including classroom man-

agement, task allocation, curriculum design, and the cognitive development of students (Ambaryanti et al., 2020). According to Government Regulation No. 74 of 2008, pedagogical knowledge refers to the ability to manage learning effectively. This entails a fundamental understanding of educational principles, an awareness of students' needs, the application of interactive teaching methods, and the promotion of students' potential. For teachers to achieve pedagogical competence, it is essential to grasp students' cognitive, emotional, and social needs, as well as to understand learning theories and their practical applications in the classroom. Pedagogical Knowledge covers an understanding of students' cognitive, affective, and psychomotor capacities (Arisandy et al., 2022) and is fundamental for attaining professional status as a teacher (Dudung, 2018).

According to the correlation test results, an increase in a teacher's Pedagogical Knowledge (PK) correlates with a corresponding rise in their skills in developing differentiated instruction. Teachers with advanced PK can effectively construct differentiated learning strategies because they are better able to comprehend the needs and learning preferences of a diverse student population. Teachers with sufficient PK can also provide tailored educational experiences that align with students' unique comprehension levels and interests. Implementing flexible instructional approaches in the classroom is essential for fostering growth in all learners. By embracing this approach, teachers can create an inclusive educational environment that supports each student's progress according to their individual capacities.

Pedagogical Content Knowledge (PCK) combines content knowledge (CK) and pedagogical knowledge (PK), enabling teachers to organize, represent, and adapt material to meet students' varied interests and abilities

(Sarkim, 2015). Proficiency in teaching a topic extends beyond mastery of the subject matter; it also involves a deep understanding of students, both individually and as a group. PCK supports pedagogical approaches aligned with students' cognitive abilities (Nur'aini & Pagiling, 2020). Teachers must possess not only pedagogical skills but also a solid grasp of the subject content (Awaluddin & Sarwah, 2019). Pedagogical Content Knowledge (PCK) is what sets apart a teacher's specialized understanding of instructional content (Bahari, 2020).

The correlation test findings revealed a positive relationship between improvements in a teacher's Pedagogical Content Knowledge (PCK) and their capacity to develop differentiated instruction. Teachers with strong PCK can design tailored learning techniques that address students' specific needs. Additionally, they can assess students' levels of understanding and cognitive preferences. PCK equips teachers to create instructional strategies that are inclusive and comprehensible to all students. Furthermore, possessing a strong and well-developed Pedagogical Content Knowledge (PCK) enables educators to make informed decisions when selecting and adapting instructional materials to meet the diverse needs of students. Educators with sufficient PCK are able to tailor these resources, adjusting their complexity and delivery to align with students' varying levels of understanding and skill. By leveraging their expertise in both content and pedagogy, teachers can create a dynamic and inclusive educational environment that fosters the development of all students, regardless of their individual abilities. This, in turn, contributes to more effective and engaging learning experiences, ensuring that every student has the opportunity to succeed and thrive within the classroom setting (Haiyudi & Art-In, 2021; Ishartono et al., 2022).

Technological Content Knowledge (TCK) encompasses the ability to effectively integrate technology with educational content. Technology plays a crucial role in the development of educational resources; therefore, educators should be able to utilize it to enhance students' understanding of instructional material (Shafira & Minsih, 2022). TCK also includes an awareness of how technology can influence and reshape perspectives on various subjects, as well as an understanding of how technology and content interact to shape and sometimes constrain each other (Fuada et al., 2020). Results from the correlation test indicated a positive relationship between TCK and teachers' proficiency in developing differentiated instruction. Teachers with advanced Technological Content Knowledge (TCK) are able to effectively incorporate technology into the classroom, providing personalized instruction that meets the unique needs of each student. TCK enables educators to utilize a variety of technical tools and resources to deliver content in multiple formats, thereby enhancing students' comprehension of topics. Additionally, TCK supports teachers in designing assignments and projects that can be adapted to students' readiness levels and individual interests.

Technological Pedagogical Knowledge (TPK) represents the combination of Technological Knowledge (TK) and Pedagogical Knowledge (PK). TPK involves understanding how technology can influence the learning process and includes insights into how technology can be effectively used in educational contexts. TPK has the potential to transform instructional methods employed by teachers (Ni'mah et al., 2023). Furthermore, TPK includes knowledge of how the dynamics of learning may shift when specific technologies are integrated with particular teaching approaches (Hidayati et al., 2018). The correlation test findings demonstrated a posi-

tive relationship between teachers' TPK and their competence in developing differentiated instruction. Teachers with strong TPK are equipped to integrate technology into the classroom while adapting instructional strategies to meet diverse student needs and learning preferences. In conclusion, TPK facilitates the creation of varied learning experiences and promotes success for all students in the classroom.

4. Conclusion

The novelty of this research lies in its focus on examining the integration of Technological Pedagogical Content Knowledge (TPACK) with professional competence in developing differentiated instruction. While previous studies have primarily addressed the role of TPACK in enhancing student learning outcomes, this study uniquely investigates the impact of TPACK on teacher competence in designing differentiated instruction, providing valuable insights for teacher training institutions and policy development. The findings revealed that teachers in Yogyakarta demonstrated moderate levels of TPACK as well as moderate proficiency in developing differentiated instruction. A significant, positive correlation was observed between teachers' TPACK and their competence in creating differentiated instruction, with a strong correlation between Content Knowledge and the ability to design differentiated instruction. Furthermore, an even stronger correlation was found between teachers' Technological Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, and Technological Pedagogical Knowledge, and their competence in differentiated instruction design. This suggests that improvements in TPACK are closely linked to enhancements in teachers' ability to develop differentiated instruction. In other words, a substantial increase in

TPACK would likely result in a corresponding improvement in teachers' instructional differentiation skills, while a decrease in TPACK may lead to a decline in this competence. Future research could investigate the effectiveness of immersive technology in strengthening teachers' TPACK and their capacity for differentiated instruction. Additionally, professional development programs that address individual teacher needs and incorporate ongoing support mechanisms may substantially enhance TPACK levels and proficiency in differentiated instruction.

5. References

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