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Enhancing TPACK for Excellent Vocational Teachers: The Role of Teacher Engagement in Implementing the Merdeka Curriculum

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Abstract

Therefore, this paper aims to investigate the effect of teacher competency, school and teacher commitment on the effectiveness of the implementation of the Merdeka Curriculum. Employing a mixed methodologies design, this research investigates the impact of Teacher Pedagogical Competence (TPC), Technological Competence (TC), Content Competence (CC), School Infrastructure Support (SIS), and Teacher Professional Training (TPT) on curriculum encouraging. Moreover, the study examines mediation effects for Teacher Involvement in Learning Process (TILP) in the curriculum effectiveness relationship, as well as the moderating effects of Teacher Motivation (TM). The data is taken from 500 teachers randomly selected from five regions in Indonesia. The data were collected using a few online surveys, interviews and classroom observations. It shows that TPC and TC contribute significantly to the effectiveness of the Merdeka Curriculum with teacher involvement being the main mediator. Proper infrastructure and professional development also play considerable roles in ensuring effective implementation. These findings emphasize the need for continuous professional teacher development, technological integration, and infrastructure improvement to support the implementation of the Merdeka Curriculum. The findings offer helpful information for policymakers and educational leaders when optimizing curriculum delivery to enhance educational achievement in Indonesia.

Keywords: *Merdeka Curriculum, Teacher Competencies, Technological Competence, Teacher Involvement, School Infrastructure.*

Introduction

Introducing Merdeka Curriculum in Indonesia itself is a big leap and progress towards creating more flexible, innovative, adaptable learning by students (Lantu et al., 2022). As this type of curriculum will now be introduced, it has a huge relevance for vocational education, where technology integrated with pedagogical strategies and subject content is crucial to provide students with industry relevant skills (Barakabitze et al., 2019; Cattaneo et al., 2022). Previous research has shown the importance of teachers integrating these three domains (pedagogical, technological, and content knowledge) for effective implementation of the curriculum (Evens et al., 2018; Lachner et al., 2021; Scherer et al., 2018). Vocational schools have placed a greater emphasis on skill-based learning that is aligned with the needs of industry and therefore require instructors to incorporate new methods, digital equipment, and content within their subjects as demands of the curriculum (Haleem et al., 2022; Núñez-Canal et al., 2022; Uerz et al., 2018). The need for strengthening teachers' competencies to implement technology and pedagogy and effective teacher engagement in the implementation of Merdeka Curriculum (Nelson et al., 2019; Runge et al., 2023; Wilson et al., 2020), are becoming salient items as Indonesia is going through this educational transformation.

If we look closely, there is indeed a lot of potential in the merdeka curriculum to transform our education landscape into a better one (Beni et al., 2022; Kučerová et al., 2020). However, all these good things are sadly not without challenges that need to be addressed whenever possible. As we have seen in previous studies, teachers especially those who teach at vocational education programs may experience challenges in balancing conventional teaching approaches with enhanced digital literacy and advanced pedagogical practices advocated through the new curriculum (Hennessy et al., 2022; L. Mishra et al., 2020; Thornby et al., 2023). The situation is even worst since there are no well-done professional development programs that

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increase teachers' costly skills in both technology and pedagogy so they could be better equipped to engage fully with the curriculum (AlAjmi, 2022; Meyer, 2023). In addition, the installation of adequate technological infrastructure in schools is still lacking to support efforts to optimize the integration of digital tools into teaching, so that the impact of the Merdeka Curriculum cannot be maximized (AlAjmi, 2022). What this issue highlights, however, is the need for more exploration of the forces behind both how and why teachers engage with and develop competencies at times, as well as how involvement in the learning process itself remains a key role for teachers (Nguyen & Dao, 2019; Postholm, 2018). Overcoming these barriers will be vital in ensuring that the Merdeka Curriculum delivers on its promises and can ultimately improve educational outcomes for all learners in Indonesia (Goger et al., 2022).

This study is based on the TPACK framework, which focuses on integrating three basic areas of knowledge: pedagogy, technology and content. Teaching is an emergent phenomenon in which the connections between key domains content, pedagogy and technology are fluid Fawns, (2022), Henriksen et al., (2021), in ways that make instruction at once relevant to and engaging for learners. Recent studies prove the implementation of TPACK in vocational education, which subject matter depend on rich knowledge needed but teachers also have to a great deal of understanding technology use and using productive teaching suitable with current demands (George & Sanders, 2017; Harris et al., 2009). This knowledge areas integration is beginners important in the frame of Merdeka Curriculum where teachers have to flexible and innovative for learning process (Al-khresheh, 2024; Hidayat et al., 2024). Research has proven that teachers with strong TPACK are more capable of facing the challenges associated with curriculum implementation and improving student outcomes (Giannakos et al., 2015; Ling Koh et al., 2014; Tømte et al., 2015).

As the educational landscape is evolving fast, especially in terms of technology integrated within both vocational education and teacher training sphere where, this is essential for students to gain necessary labour market relevant skill sets (Béduwé & Giret, 2011; Harvey, 2000). Numerous studies provide evidence of the impact of professional development on teachers' knowledge and use of technology, pedagogy and content in their classrooms; however, the effectiveness of these programs differs substantially within contexts (Goldschmidt & Phelps, 2010; Sancar et al., 2021; Voogt et al., 2013). However, other studies that have attempted pre- and post-tests of teachers before and after being given training programs to improve their knowledge in technology resources or teaching strategies found positive results (EL-Deghaidy & Nouby, 2008; Ng, 2018; Shieh, 2012). Yet other studies have noted the difficulty of translating learned knowledge into action, and mention factors like poor infrastructure at schools, limited follow-up assistance, and teachers' reluctance to change (Ertmer et al., 2012; Glewwe & Muralidharan, 2016). This difference in research outcomes indicates the newness of this study to articulate how teacher engagement, teacher involvement in learning activities and motivation become mediators and moderators for a successful implementation of Merdeka Curriculum (Herani & Pranandari, 2024; Pusparini et al., 2024; Solih et al., 2024). Through exploring these relationships, this research seeks to add further understanding into the ways that knowing how to combine technology type of instruction and subject matter can be developed and utilized in vocational education, offering some practical recommendations for improvement in implementation and solutions found through earlier research.

The objective of this research that we will present is to better understand the action of improving integrated knowledge and know-how essential for vocational curriculum implementation affected by educator engagement in vocational settings. This research will seek to demonstrate how competencies in pedagogy, use of technology and content knowledge affect the enactment of curriculum along with mediating effect of educator involvement in learning. In addition, this study will explore the role of teacher motivation as a moderator and provide a comprehensive understanding of essential components behind successful educational reforms. Results from this study will provide a better understanding of how to support educators via professional development, resources and incentives needed for successful implementation of curricular change.

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Literature Review

Theory Research

The association of Technological Pedagogical Content Knowledge (TPACK) theory with research on the effectiveness of merdeka curriculum implementation within Indonesia serves as foundation forthis study (Graham, 2011). Whetten, (1989), TPACK is a framework that incorporates three main categories of knowledge essential for effective teaching technology, pedagogy, and content. Archambault & Barnett, (2010), that successful teaching cannot occur without a harmonious integration of these three area of knowledge. TPACK is particularly salient in vocational education, where practitioners must combine specialists' content knowledge with pedagogical reasoning and technology-specific educational tools. The relationship between technology, pedagogy and content feeds into the teaching and learning process (Jimoyiannis, 2010; Reyes et al., 2017; Wright & Akgunduz, 2018). As the rise of new digital tools permeated into classrooms, the role of technology in education has become ever more significant, and so have their effective integration into content delivery and pedagogical practices (McLay & Reyes Jr, 2024; Muschaweck, 2023; Sanusi et al., 2022). Pedagogical knowledge refers to knowing how to teach students Jang, (2010), including strategies for engaging and motivating students, as well as managing a classroom effectively. Content knowledge knowledge of the particular subject being taught is also essential, so students receive correct and applicable information (Santos & Castro, 2021; Yeh et al., 2014). Aligning these three domains is essential to the challenges of learning goals through a flexible and creative learning approach, as called for in the Merdeka Curriculum (Mouza et al., 2014; Olofson et al., 2016). The framework posits that when teachers can integrate these three domains, the curriculum implemented as intended is enhanced; thus enriching the educational experience (Calcagni & Lago, 2018; Voogt et al., 2015). Hence, the TPACK framework could provide a useful theoretical lens to explore how teacher competencies are pivotal to systemically implement the Merdeka Curriculum (Shao et al., 2024; Yeh et al., 2021).

Effectiveness of Implementing the Merdeka Curriculum (EIMC)

The implementation of the Merdeka Curriculum (EIMC) is a crucial topic for educational research in Indonesia. The core philosophy of the Merdeka Curriculum is flexibility in teaching and learning, enabling students to be given options for their learning pathways while teachers are recommended to play a more student-centred role (Sakhiyya & Rahmawati, 2021; Vásquez et al., 2019). Previous studies addressing the effectiveness of the curriculum only mentioned that its implementation enhances students participation and academic performance when applied appropriately (Akyuz, 2018; Jen et al., 2016; Su et al., 2022). But, the success of this curriculum depending on many things teachers preparedness, infrastructure supporting and their conformity with national education standard (M'mboga Akala, 2021), Researchers also found that, even at a nationwide scale, teachers' efforts to adapt new curriculum approaches especially in pedagogical skills and technological tools have been critical to the success of reforms (Caena & Redecker, 2019; Urban et al., 2018). Therefore, the Merdeka Curriculum will only be successful if teachers have had the skills, competencies, and appropriate support systems to transition to an evolving education landscape (Baylor & Ritchie, 2002; Resnick & Resnick, 1992; Yusuf et al., 2018). Chu et al., (2017), such measures encompass professional development programs aimed at enhancing technological, pedagogical and content knowledge as well as provision of adequate infrastructure that would reinforce innovative teaching-learning approaches.

Teacher Pedagogical Competence (TPC) on the Effectiveness of Implementing Merdeka Curriculum (EIMC)

An example of TPC in supporting the implementation of Merdeka Curriculum. Pedagogical competence simply describes the capacity of a teacher to organize and manage the learning process, utilize teaching techniques, and respond to different kinds of learners (Nousiainen et al., 2018; Susanto et al., 2020). Teachers who have high-level pedagogical competencies research made elaborated a few studies that is consistantly show how effective teacher implementing curricula including the Merdeka Curriculum in practical context with many expectation to be flexibly adapted (Indrawati & Kuncoro, 2021). Pedagogically competent teachers are also capable of establishing friendly learning environments and raising critical

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thinking (Brew & Saunders, 2020; Fung, 2017; Wang et al., 2016). Curriculum merdeka calls for a student-centered approach, and the teachers' skills in using active learning methods, problem-solving activities and adapting their teaching practices are crucial to supporting the successful implementation of the curriculum (Sianturi et al., 2023; Sihombing et al., 2021).

H1: Teacher Pedagogical Competence (TPC) Influence on the Effectiveness of Implementing the Merdeka Curriculum *(EIMC)*

Technological Competence (TC) on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

The other crucial factor that affects the establishment of Merdeka Curriculum well is Technological competence (TC). TC represents a teacher's capacity to integrate digital tools and technologies into their teaching practices (Antonietti et al., 2022; Cattaneo et al., 2022). As the education world enters a phase of increasing use of technology, teachers need to be proficient in implementing their skills so that it can create conducive learning process according to the innovative and dynamic character provided by Merdeka Curriculum (Hong & Chai, 2017; Yao et al., 2023). Research indicates that teachers who are competent in integrating technology into their lessons can offer students more stimulating, interactive learning opportunities (Bereczki & Kárpáti, 2021; Ifinedo et al., 2020). In addition, technological adeptness allows teachers to access numerous online materials and teaching resources that support individualized learning, one of the characteristics of the Merdeka Curriculum (Hairida et al., 2023). Falloon, (2020), Hennessy et al., (2022), TC lays the foundation for how effectively teachers can combine technology with pedagogical methods to achieve more efficient learning outcomes, which lends further significance to this issue under relevance of goodimplementing the Merdeka Curriculum.

H2: Technological Competence (TC) Influence on the Effectiveness of Implementing the Merdeka Curriculum

Content Competence (CC) on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

The second factor is the content competence (CC), which is the amount of knowledge teachers have in their subject area: it plays an important role in assessing the success of Merdeka Curriculum implementation (Chan et al., 2017). It has been found that teachers who possess deep content knowledge are able to create meaningful learning opportunities for students that link with their curriculum objectives (Mukti et al., 2021). Especially in vocational education, where actual knowledge about the industry surrounding a lot of what is taught can be embedded in the curriculum itself Büth et al., (2017), Hasanefendic et al., (2016), content competence may well matter. According to research, teachers who are experts in their subject areas can offer students a better understanding of the content which improves the process and learning outcomes (van Dijk et al., 2020). In addition to this, content competence helps the teacher to implement and refresh the knowledge with new one in line with changing industry standards so that Merdeka Curriculum stays current (Dirgantoro & Soesanto, 2023). Thus, nurturing teachers' content competence is essential to the effective implementation of the curriculum (Cheng & Chan, 2021). Has been discussed in several studies (Aktoprak & Hursen, 2022; Dallinger et al., 2016; Elfeky et al., 2020).

H3: Content Competence (CC) Influence on the Effectiveness of Merdeka Curriculum Implementation

School Infrastructure Support (SIS) on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

Another important factor in the success of implementing Merdeka Curriculum is school infrastructure support (SIS) (Gil-Flores et al., 2017). Innovative classroom and learning process require sufficient infrastructure, such as technology access, learning spaces, and resources (Lestari et al., 2020). Research shows that schools with better infrastructure have higher rates of successful implementation of flexible and student-centered curricula (e.g. Merdeka Curriculum) (Nugroho et al., 2022; Haris et al., 2021). In vocational education, for example, infrastructure support is something of the utmost importance as students need hands-on experience on industry-specific tools and equipment. This means that bad facilities can make better learning aligned with the objectives of the Merdeka Curriculum, as researched Al-Samarraie & Saeed,

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(2018), making schools that have equiped facilities can deliver more effective learning experience. In addition, digital technologies and online learning platforms must be available to facilitate the implementation of the technology integration component in the curriculum (Bereczki & Kárpáti, 2021). And that is the role of SIS to make sure teachers and students have a smooth experience in administering the Merdeka Curriculum, thanks to their reliance on technology. (Gaffney et al., 2019; Iglesias-Pradas et al., 2021).

H4: School Infrastructure Support (SIS) Influence on the Effectiveness of Merdeka Curriculum Implementation

Teacher Professional Training (TPT) on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

Teacher professional training (TPT) is one of the essential elements to support the successful implementation of the Merdeka Curriculum. According to Sutrisno et al. (2021); Aisyah et al. (2022), professional development programs are established in order to equip teachers with the abilities and experiences that they need towards the new method of teaching or breakthrough curriculum. Research demonstrates that effective teacher training produces better pedagogical practices, increases technology competence, and ensures that instructors remain current in their fields of study (Sukmawati & Subianto, 2023). Professional training supports teachers to adopt innovative teaching practices in line with the Mandate Curriculum, integrating technology and managing flexible learning spaces, while student centred pedagogy embeds learning processes and assessment. Studies by Daryanto et al. (2022) reminds that continuous professional development to inspire teachers is important, as it enables teachers to deliver high-quality education in line with the objectives of the curriculum. This means there needs to be an investment in teacher professional development because the Merdeka Curriculum that replaces previous content standards cannot be run effectively if teachers are not trained to implement it.

H5: Teacher Professional Training (TPT) Influence on the Effectiveness of Merdeka Curriculum Implementation

Development of Intervening Hypothesis Teacher Involvement in Learning Process (TILP)

Teacher Involvement in Learning Process (TILP) is the most important mediator between teacher competencies and Teacher Effectiveness of Implementation of Merdeka Curriculum (EIMC). In this section, the mediating effect of TILP is demonstrated for four key teacher-related factors: Teacher Pedagogical Competence (TPC), Technological Competence (TC), Content Competence (CC) and School Infrastructure Support (SIS).

Teacher Pedagogical Competence (TPC) specifically is one of the significant factors affecting quality implementation of curriculum, including in Merdeka Curriculum which requires more flexible and student-centered learning. TILP, or a teacher engaging with students while they learn, is important when putting pedagogical content knowledge into practice. Studies have shown that teachers who are involved during the learning process can engage students, adapt teaching strategies and implement innovative pedagogical techniques (Kurniawati et al., 2021; Suhendi et al., 2022). The analysis of the mediation role of TILP has proofed TILP being responsible for the influence of TPC towards curriculum implementation results, both in relation to student engagement (Fathia & Rahardjo, 2022) and student outcome (Fathia & Rahardjo, 2021). The Merdeka Curriculum will be more effective if teachers can pour their pedagogical knowledge fully to involve students in the learning process to create a better learning environment (Andriani et al., 2021). This corroborate the findings of Kusumawati and Astuti (2020) that teachers who are involved can maintain a good relationship between teacher and students so that curriculum implementation will be successful.

The Merdeka Curriculum indeed encourages this notion by expecting technology integrated in the teaching, hence Technological Competence (TC) must be one of important competences. TILP is a mediator between TC and the impact of curriculum. More knowledgeable teachers regarding to technology will best utilize digital tools and resources to meaningfully engage students (Koh, 2019; Ling Koh et al., 2014).

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TPACK and TILP facilitates teachers to implement technology into learning, so the students can learn better and increase their outcomes (Yeh et al., 2021). Research suggested that if teacher involved in the learning process along with technology skills mastery, it will surely impact the students in terms of motivation and achievement (Suryadi & Rahayu, 2020). TILP assists teachers in adapting technology to meet a wide range of dynamic learning needs of students, making classes become more interactive and individualized, in line with who adopts the Merdeka Curriculum which promotes innovation and gives students freedom (Thomas et al., 2019). Selvaraj et al., (2021), states that whether teaching is executed effectively with maximum technology involvement in the learning process depends on teacher involvement in the entire scheme of things as well. Therefore, ensuring tech-saturated curriculum implementation would completely rely upon how efficiently teachers take care of every activity involved inside and outside classroom context.

Finally, Content Competence (CC), which is the comprehensive knowledge of a teacher regarding the subject matter, retains its fundamental place among effective teaching attributes (Caena & Redecker, 2019). Findings suggest that TILP is an essential bridge between content competence and curriculum enactment outcomes. It is important to highlight that when teachers understand the content process, they will present complex content better, clarify concepts and make the material more accessible (Santos & Castro, 2021). Evidence indicates that teacher involvement contributes to the students' understanding of subject content and favorable learning outcomes (Fauth et al., 2019; Raes & Schellens, 2016). The TILP does not only conveys content but also facilitates an interactive communication where the teachers can adjust their teaching strategies according to what students perform and require (Alam & Mohanty, 2023; Saeed & Al Qunayeer, 2022). Moreover, studies show that active teacher involvement enhances critical thinking and problem-solving skills in students which are the fundamental skills needed to apply knowledge from Merdeka Curriculum (Xu et al., 2023). Therefore, TILP becomes the intermediary between content competence and curriculum effectiveness by promoting advanced learning experience or such type of learning that is more experiential (Shawer, 2017).

The implementation of Merdeka Curriculum is highly influenced by School Infrastructure Support (SIS), such as availability of learning facilities, technology and resources. But the class engagement will also determine how effective these resources are providing RMI because teachers need to play an active role in the learning (Du Plessis, 2019, 2020; Whippy, 2021). Previous studies have proven that even if the school has a well-prepared curriculum changing infrastructure, it will not be able to successfully implement without teachers being able to use the existing resources properly (L. Mishra et al., 2020). TILP bridges this divide by emphasizing that teachers should utilize existing infrastructure to create a meaningful learning process (Singh et al., 2022). When teachers are actively implementing school resources, curriculum implementation will be more effective Marco-Bujosa et al., (2017), from digital tools to laboratories and learning spaces. Besides, teacher involvement creates a collaborative atmosphere of teaching and learning, in which the students take part in utilizing those resources attended by using the media given and it helps the learning outcomes (Hanaysha et al., 2023). Dirgantoro & Soesanto, (2023), the direct implementation of Merdeka Curriculum, maximizing school infrastructure is determined by teacher involvement during learning process.

H6: The role of Teacher Involvement in the Learning Process (TILP) as mediating the effect of TPC to EIMC

H7: The role of Teacher Involvement in the Learning Process (TILP) as mediating the effect of TC to EIMC

H8: The role of Teacher Involvement in the Learning Process (TILP) as mediating the effect of CC to EIMC

H9: The role of Teacher Involvement in the Learning Process (TILP) as a mediating influence of SIS to EIMC

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Development of Moderating Teacher's Motivation (M)

The implementation of the Merdeka Curriculum (EIMC) depends not only on teachers but also their motivation to support it as a crucial component. In fact, motivation affects the way teachers adapt their pedagogical practice and interactions with students, as well as how they use the resources available. This section discusses the moderation effect of teacher motivation on the relationship of Pedagogical Competence, Technological Competence, and Content Competence, School Infrastructure Support, towards Merdeka Curriculum implemented.

Base of TPC implementation is essential to the success if delivery of operational curriculum (Merdeka Curriculum), through developing learners who are centered in learning and active teachers model within teaching character. Yet, the influence of TPC on the effectiveness of curriculum can be significantly attenuated by teacher motivation (Slemp et al., 2020). When teachers are motivated, in addition to being more open to innovative teaching methods and creating meaningful interactions with students, they will also be able to find the approach that suits their students best (Sivarajah et al., 2019). Since a sense of motivation in their role as educators is proven to strengthen the effect between Teacher Professional Communities or TPC and success in carrying out curriculum implementation (Prenger et al., 2017; Vangrieken et al., 2017). Furthermore, motivated teachers with great pedagogy will create a quality learning environment that contributes to good learning (Kangas et al., 2017; Shoshani & Eldor, 2016). Motivation is a driving energy that directs and moves teachers to improve their pedagogical practice continuously, thereby strengthening the impact of their pedagogical competence in the Merdeka Curriculum (Hasanah et al., 2020). Whitaker & Valtierra, (2018), teacher motivation acts as an intervening variable in the association between TPC and curriculum effectiveness, encouraging richer enthusiasm, commitment, and creativity among teachers to effectively deliver lessons.

In the context of the Merdeka Curriculum, Technological Competence (TC) becomes a very crucial part to integrate technology in teaching and learning process (Almerich et al., 2016). But then the impact of TC on teachers for how effectively a curriculum is implemented depends upon teacher motivation. Teachers who are motivated to teach will be more open-minded about the technological tools that exist, and continuously look for new opportunities to use these tools in their lessons (Grimus, 2020). Grimus, (2020), Hanaysha et al., (2023), teacher motivation moderates the effect of TC on effective curriculum implementation, because it drives teachers to adopt new technology eagerly. Motivated teachers will use creativity in improving the learning process by utilizing technology to increase student engagement (Kurniawati et al., 2020). Li et al., (2021), confirmed this by finding that digital-based innovation in learning will maximize the effective Merdeka Curriculum if the teacher has high motivation and expert technology. Further motivation can also come from teachers who continuously adapt and upskill their technological knowledge so that they are expanding the dynamic presentation of content in an interactive classroom.

Content Competence (CC) is the teacher's knowledge of content. CC is necessary for effective curriculum administration, but the extent to which it impacts the success of the Merdeka Curriculum is mitigated by teacher motivation (Blank et al., 2016). As for teachers, excellent content knowledge coupled with motivation and teaching strategies to help students learn creates a better environment for student engagement, critical thought, and learning responsiveness (Baier et al., 2019). Motivation increases the teacher's devotion to keep making improvements on how well he or she can know about the topic or presented in an interesting way (Chilingaryan & Zvereva, 2017). Motivated teachers also tend to have a better grasp of various relevant developments within their specialization, which aids them in applying the curriculum (Bradley, 2019). Well-motivated teachers are also more flexible in delivering the content according to various learners' needs, thus providing an opportunity for a deeper and more meaningful learning (Chakraborty & Biswas, 2020). Liou et al., (2019), reveal that motivation among teachers is an important mediatory tool allowing CC to achieve its potential advantages of a successful implememtation of the curriculum with signs of having positively influenced student engagement and learning outcomes.

Curriculum Implementation: School Infrastructure Support (SIS) such as the availability of teaching resources, technology and learning environments are closely linked to curriculum effectiveness. But, motivation of the teacher highly affects SIS–Curriculum Merdeka effectiveness. Teachers with a high level

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of motivation are more likely to make the most of existing infrastructure and resources in order to create a good learning environment (Yuniati & Fitria, 2022). Additionally, teacher motivation reinforces the beneficial effects of SIS by inducing teachers to make use of as well as optimize existing opportunities for pedagogy (Wibowo et al., 2021). Studies indicate that highly driven educators are not only able to compensate for deficiencies within the framework of infrastructure but they also successfully adapt their working capabilities from resources that would promote a positive learning process (Hidayati & Yusuf, 2021). Studies by Suhendi et al. As (2022) Discovery-Utilization of School Infrastructure: Teachers ARE Motivated, But To What End? In addition, higher levels of teacher motivation creates a culture that thrives for self-improvement leading to the motivation of teachers looking for different resources and using it which will definitely enrich curriculum implementation (Rizal et al., 2020)

H10 Teacher's Motivation (TM) Moderates the Effect of TPC on EIMC

H11: Teacher's Motivation (TM) Moderates the Effect of TC to EIMC

H12: Teacher's Motivation (TM) Moderates the Effect of CC on EIMC

H13: Teacher's Motivation (TM) Moderates the Effect of SIS on EIMC

Internevening and Moderating Development Research Framework Model

The intervening and moderating development research framework model is based on theoretical exposure or explanation of what an intervening variable is, it has as well been developed from the concept of a moderating variable which is significant when undertaking any educational study (Liamputtong & Ezzy, 2005) An intervening variable is a variable that provides the mechanism whereby an independent variable affects or leads to a dependent variable (Baron, Reuben M. Kenny, 1986). Conversely, a moderating variable, as noted by (Cohen & Baruch, 2022), affects the strength and/or direction of such relationships. In educational research these are very important as they help to understand the role of context where external variables such as teacher engagement, motivation, and support systems behaviour (intention) will have implications for the actual mind set/outcome which in this case is behaviour in implementing school reforms such as the Merdeka Curriculum. As an example, the association between curriculum innovation and student performance might be moderated by teacher motivation, whereas the impact of curricular implementation on teaching effectiveness could be mediated by teacher engagement (Gunness et al., 2023). Using these perspectives highlights the importance of considering intervening and moderating variables in our understanding of effective models for programme success, and therefore contributes to an improvement in the implementation of curriculum reforms through their recognition.

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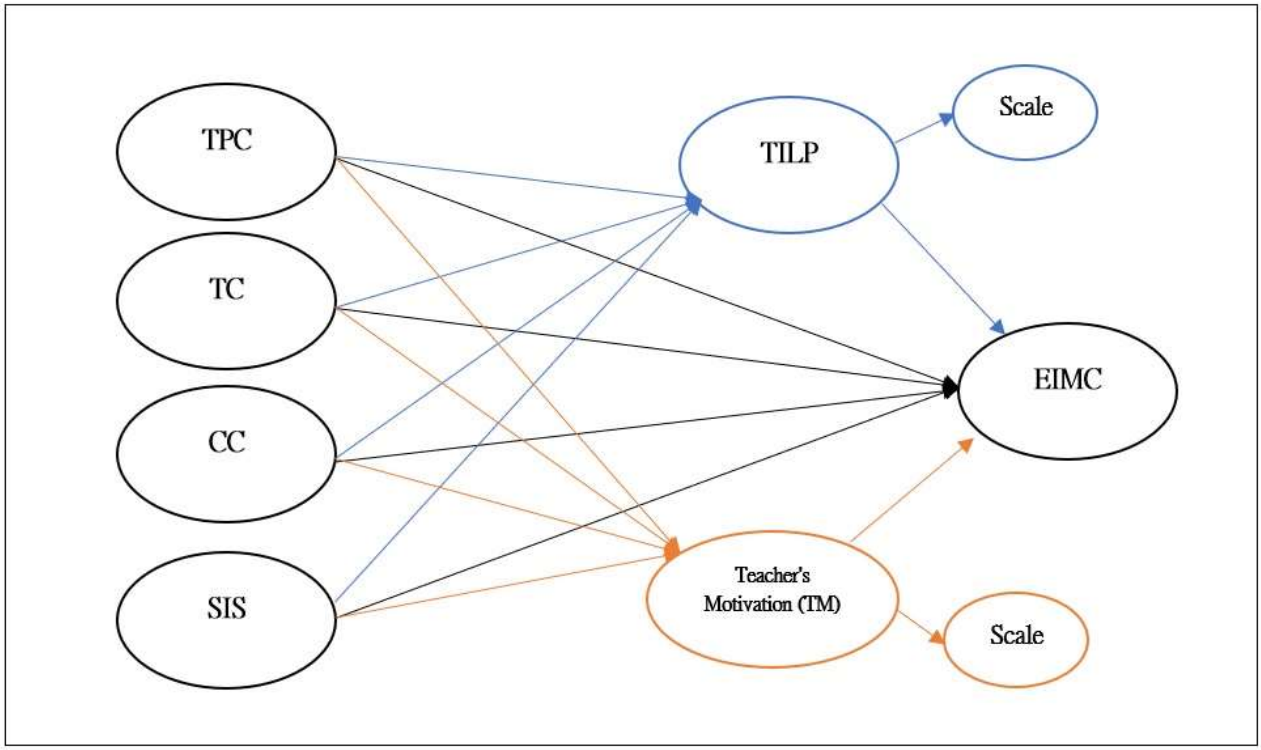

Figure 1. Model Riserach EIMC

H1: Teacher Pedagogical Competence (TPC) Influence on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

H2: Technological Competence (TC) Influence on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

H3: Content Competence (CC) Influence on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

H4: School Infrastructure Support (SIS) Influence on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

H5: Teacher Professional Training (TPT) Influence on the Effectiveness of Implementing the Merdeka Curriculum (EIMC)

H6: The role of Teacher Involvement in the Learning Process (TILP) as mediating the effect of TPC to EIMC

H7: The role of Teacher Involvement in the Learning Process (TILP) as mediating the effect of TC to EIMC

H8: The role of Teacher Involvement in the Learning Process (TILP) as mediating the effect of CC to EIMC

H9: The role of Teacher Involvement in the Learning Process (TILP) as a mediating influence of SIS to EIMC

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H10 Teacher's Motivation (TM) Moderates the Effect of TPC on EIMC

H11: Teacher's Motivation (TM) Moderates the Effect of TC to EIMC

H12: Teacher's Motivation (TM) Moderates the Effect of CC on EIMC

H13: Teacher's Motivation (TM) Moderates the Effect of SIS on EIMC

Methodology Research

Research Object

This study used a mixed-methods design to investigate the effectiveness of the Implementation of Merdeka Curriculum (EIMC) in Indonesian Vocational High School (SMK) 2024, based on Andi Kusumawati, (2018), Creswell et al., (2014), suggested that mixed-method is an approach to inquiry involving collecting both quantitative and qualitative data, integrating it, and then interpreting the meaning. Represents our research objects are vocational high school that has implemented Merdeka Curriculum, which the schools pick one by purposive sampling method based on the measurement of readiness and willingness to join. This population consist of teachers, administrators, and students that use the curriculum. Surveys, interviews, and classroom observations are the primary tools: The survey focuses on teacher competencies, student engagement, and curriculum outcomes; whereas interviews and observations provide richer data to understand both challenges and successes of the curriculum. The argument behind developing the instruments is informed by TPACK framework Harris et al., (2009), P. Mishra & Koehler, (2006), Curriculum Implementation gets validity and reliability. Quantitative data will be analysed through descriptive statistics and regression analysis, and qualitative data will go through thematic analysis, as per (Braun & Clarke, 2006, 2023). Method Ethical considerations with regards to informed consent and confidentiality, will be followed according to the American Psychological Association (APA, 2020) research ethics guidelines.

Population and Sampling

The population for this study involves teachers from Vocational High Schools throughout Indonesia, providing a comprehensive view of the country's heterogeneous education system. Given the critical role that SMKs have to play in vocational education and the practical implementation of the Merdeka Curriculum, by selecting the teachers to participate in the study from a range of regions, the researchers ensured capturing the broadest possible array of the views and challenges addressed in various local contexts. As a result, 500 teachers were randomly sampled in five major areas Jakarta, Surabaya, Bandung, Medan, and Semarang. In this instance, the use of random sampling is appropriate because it eliminates the possibility of selection bias and guarantees that every teacher has an equal chance of being selected, therefore making the sample more standard and easily generalizable. This approach is customary in educational research, particularly using random sampling to ensure increased external validity of the study's results, which could then plausibly be applied to the broader population of vocational education teachers in Indonesia. Additionally, the 500 respondents in the sample fit the SEM recommended for an appropriate sample size, according to guidelines, which states that SEM studies should involve a sample of between 200 and 500 respondents to guarantee reliability and validity. Such a sample size would provide significant data power to determine relations and mediating and moderating effects such as teacher motivation and motivation enhancement. Moreover, regional representatively was balanced, including major urban centers like Jakarta and Surabaya and smaller regional cities such as Semarang. This methodology guarantees that the study would be widerekachable ultimately.

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Table 1. Population and Sample Detail

Region	Number of SMKs	Number of Respondents (Sample Size)	Sampling Method	Age Range (%)	Education Level (%)
Jakarta	150	100	Random Sampling	25-30 (20%)	Bachelor's Degree (70%)
				31-40 (35%)	Master's Degree (20%)
				41+ (45%)	Diploma (10%)
Surabaya	100	75	Random Sampling	25-30 (25%)	Bachelor's Degree (80%)
				31-40 (40%)	Master's Degree (15%)
				41+ (35%)	Diploma (5%)
Bandung	80	60	Random Sampling	25-30 (15%)	Bachelor's Degree (75%)
				31-40 (45%)	Master's Degree (20%)
				41+ (40%)	Diploma (5%)
Medan	50	35	Random Sampling	25-30 (30%)	Bachelor's Degree (60%)
				31-40 (40%)	Master's Degree (30%)
				41+ (30%)	Diploma (10%)
Semarang	40	30	Random Sampling	25-30 (20%)	Bachelor's Degree (60%)
				31-40 (50%)	Master's Degree (30%)
				41+ (30%)	Diploma (10%)
Total	500	500	Random Sampling	25-30 (22%)	Bachelor's Degree (71%)
				31-40 (40%)	Master's Degree (18%)
				41+ (38%)	Diploma (11%)

Source data; Researcher observation 2024

Data Collection Process

Data collection for this research will use the online survey method through Google Forms because it is considered to be effective, easy to access, and can reach far-ranging places in Indonesia. This survey will be conducted to 500 teachers belonged in many kind of Vocational High Schools (SMK) across Indonesia. The survey questionnaire will be constructed on the basis of a Likert-scale, which is one of the most frequently used instrument in educational research that measures attitudes, perceptions and behaviours. The aforementioned survey will assess several study related variables such as teacher characteristics, professional development, school infrastructure support, teacher motivation and engagement, and effectiveness of Merdeka Curriculum implementation.

Selected teachers will receive a survey through a web link with instructions on how to properly answer it. Google Forms will be used for data collection in real-time, responses will get stored automatically and organized, ensuring less human error while entering the data. Then the data will be analysed statistically to find out whether or not correlations exist between teacher competencies, infrastructure and teacher motivation and curriculum effectiveness??.

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The following table outlines the key variables measured in the survey, along with the corresponding items and scales.

Table 2. Data Collection Variables and Measurement Scales

Variable	Definition	Measurement Scale	Example Item
Teacher Pedagogical Competence (TPC)	Teachers' ability to apply teaching methods that are effective for student learning.	Likert Scale (1-5)	"I feel confident in adapting my teaching methods to meet students' needs."
Teacher Content Competence (TC)	Teachers' knowledge and understanding of the subject matter they teach.	Likert Scale (1-5)	"I possess in-depth knowledge of the subject I teach."
Teacher Technological Competence (CC)	Teachers' ability to integrate technology into the teaching process.	Likert Scale (1-5)	"I effectively use technology to support student learning in my classroom."
Teacher Professional Training (TPT)	The extent and quality of professional development programs that teachers have undergone.	Likert Scale (1-5)	"I have participated in professional development programs that helped me improve my teaching."
School Infrastructure Support (SIS)	The availability and quality of resources and facilities to support teaching and learning.	Likert Scale (1-5)	"My school has sufficient resources (e.g., digital tools, classrooms) for effective teaching."
Teacher Motivation (TM)	Teachers' intrinsic and extrinsic motivation to perform their teaching duties.	Likert Scale (1-5)	"I am motivated to improve my teaching to help students succeed."
Teacher Involvement in Learning Process (TILP)	The degree to which teachers actively engage students in the learning process.	Likert Scale (1-5)	"I regularly involve students in decision-making regarding their learning."
Effectiveness of Merdeka Curriculum Implementation (EIMC)	The perceived success of the Merdeka Curriculum in fostering flexible, student-centered learning.	Likert Scale (1-5)	"The Merdeka Curriculum has positively impacted student engagement in my class."

Source data; Researcher observation 2024

Instrumentation for Data: Questionnaires

There will be multiple items in the questionnaire for each of the key variables of interest. Items are derived from known scales within the literature that are both reliable and valid. Questions will develop on a Likert-type scale (1 = Strongly Disagree; 5 = Strongly Agree) in which the participants rate their level of agreement to statements concerning the variables.

Table 3. Instrumentation for Variables

Variable	Definition	Measurement	Scale
Teacher Pedagogical Competence (TPC)	Teacher's ability to effectively manage the learning process and	10 items measuring teaching strategies, student engagement, and lesson delivery	Likert Scale (1-5)

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Variable	Definition	Measurement	Scale
	engage students in meaningful learning experiences.		
Technological Competence (TC)	Teacher's proficiency in using technology to enhance learning.	8 items measuring the use of educational technology and online tools	Likert Scale (1-5)
Content Competence (CC)	Teacher's mastery of subject matter and content knowledge.	9 items measuring knowledge of curriculum content and subject expertise	Likert Scale (1-5)
School Infrastructure Support (SIS)	The availability and quality of school resources and facilities that support learning.	7 items measuring school resources, classroom conditions, and digital tools	Likert Scale (1-5)
Teacher Professional Training (TPT)	The formal training teachers receive to enhance their teaching practices.	8 items measuring participation in professional development activities	Likert Scale (1-5)
Teacher Motivation (TM)	The degree of enthusiasm and commitment teachers have towards their profession and students.	10 items measuring intrinsic and extrinsic motivation factors	Likert Scale (1-5)
Teacher Involvement in the Learning Process (TILP)	The extent to which teachers actively engage in the learning process beyond teaching duties.	8 items measuring teacher-student interaction, feedback, and involvement in student activities	Likert Scale (1-5)
Effectiveness of Implementing the Merdeka Curriculum (EIMC)	The success and impact of the Merdeka Curriculum in enhancing student learning and achievement.	12 items measuring student outcomes, curriculum delivery, and teacher feedback	Likert Scale (1-5)

Source data; Researcher observation 2024

Data Analysis Method

In this study, the data analysis process leverages SmartPLS software, a powerful tool for performing Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM is widely recognized for its flexibility in handling complex models with multiple variables and for providing robust results even when data does not meet strict normality assumptions. It is also highly suitable for exploratory research and models with both formative and reflective constructs, making it ideal for examining intricate relationships among the variables of teacher competencies, professional training, school infrastructure support, teacher involvement, and motivation as they relate to curriculum implementation (Lam et al., 2010).

The outer model deals with the evaluation of its respective validity and reliability. In this research, each variable including teacher competencies (TPC, TC, TTC), and school infrastructure support (SIS) as well the motivation of teacher (TM) on effectiveness of Merdeka Curriculum implementation (EIMC), have a direct scores in form of indicators. In the analysis, assessment of indicator reliability (i.e., factor loadings), internal consistency reliability (Cronbach's alpha and composite reliability), convergent validity (average variance extracted, or AVE) and discriminant validity (Fornell-Larcker criterion and cross-loadings) will be carried out. Achieving satisfactory results for both reliability and validity means that a measurement model is able to reflect the underlying constructs well.

After confirming the outer model, we then confirm reliability and validity followed by analysis of inner model or structural model. This is a model that tests the hypothesized relationships between constructs while looking at direct and indirect effects. The aim of this study, therefore, is going to test the direct influence of teacher abilities, professional development and institutional support for effective curriculum implementation through SmartPLS. It will also assess the moderating role of teacher motivation and mediating role of student-teacher engagement in these associations. Fit indices R^2 (explained variance), Q^2

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(predictive relevance) and T-values (significance of path coefficients) will be utilized to assess model quality, as well as the strength of each proposed path. A high R^2 value suggest that the model explains a large share of variance in the dependent variable, and Q^2 values reflect the predictive validity of the model (Liengaard et al., 2021). T-values (derived from bootstrapping) are representative of the strength of significance in our hypotheses comparisons. Thus, the integrated evaluation of outer and inner models would illustrate the entire picture of how teacher competencies, infrastructure, motivation and involvement drive effective implementation curriculum. This allows for trustworthiness and credibility in the study along with practical relevance to enhance effectiveness of curriculum reform initiatives.

Ethical Considerations

Researches involving human participants cannot be conducted without ethical considerations, as people need protection of their rights and well-being privacy ought to be honored. Abstract: This study is consistent with major ethical principles, at least in terms of informed consent where an explanation is given to the subjects regarding the purpose of the study and their rights including their capacity to withdraw at any time without any consequence. The data will be anonymized, and only the research team will have access to it; confidentiality is safeguarded (Chris et al., 2017), American Psychological Association APA, 2017) through procedures that conform to standards outlined in the Belmont Report (National Commission, 1979). Such measures embody both the principles of beneficence and justice that ethical research must seek to minimalize population harm while being fair to all [7, 8]. Complying with these protocols not only increases the credibility of the study but also maintains ethical integrity while establishing participant trust.

Result and Discusion

Variable Description Using Scoring Techniques

All of the variables within the study were therefore scored on a scale of 1 to 5. The following formula was used to calculate the respondent answer index.

Score Range: Upper Bound = (%F × 5) / 5 = (500 × 5) / 5 = 500(\%F×5)/5=(500×5)/5=500... (1)

The Three-Box Method was used to determine the range of scores.

Score Range: Upper Bound = (%F × 5) / 5 = (500 × 5) / 5 = 500(\%F×5)/5=(500×5)/5=500... (2)

In case you forgot, here is the range again: Lower Bound of the Range of Scores:

(%F×1) 5=(500×1) 5=100(%F \times 1)\backslash5 =(500\times1)\backslash5=100(%F×1)5=(500×1)5=100..... (3)

The maximum index range is 100–500 so the total difference is 400. This total was then broken down into three separate buckets, with a gap of about 133 based on the Three-Box Method. Hence, index scores are categorized as follows:

100–233: Low

234–367: Moderate

368–500: High

Teacher Pedagogical Competence

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Table 4. Teacher Pedagogical Competence

Indicator	Response	Total	Index	Category
	STS	TS	N	S
TPC.1	-	-	63	244
TPC.2	-	-	55	261
TPC.3	-	-	65	232
TPC.4	-	-	69	218
TPC.5	-	-	61	240
TPC.6	-	-	61	242
TPC.7	-	-	63	238
TPC.8	-	-	76	228
TPC.9	-	-	73	215
TPC.10	-	-	78	242

Technological Competence

Table 5. Technological Competence

Indicator	Response	Total	Index	Category
TC.1	-	-	59	236
TC.2	-	-	56	253
TC.3	-	-	66	251
TC.4	-	-	66	243
TC.5	-	-	62	241
TC.6	-	-	70	231
TC.7	-	-	67	238
TC.8	-	-	77	212

Content Competence

Table 6. Content Competence

Indicator	Response	Total	Index	Category
CC.1	-	-	64	245
CC.2	-	-	70	240
CC.3	-	-	68	232
CC.4	-	-	65	228
CC.5	-	-	62	240
CC.6	-	-	74	222
CC.7	-	-	71	234
CC.8	-	-	68	238

School Infrastructure Support

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Table 7. School Infrastructure Support

Indicator	Response	Total	Index	Category
	STS	TS	N	S
SIS.1	-	-	60	247
SIS.2	-	-	55	252
SIS.3	-	-	61	239
SIS.4	-	-	66	237
SIS.5	-	-	72	229
SIS.6	-	-	69	233
SIS.7	-	-	70	222
SIS.8	-	-	76	218

Teacher's Motivation

Table 8. Teacher's Motivation

Indicator	Response	Total	Index	Category
TM.1	-	-	59	246
TM.2	-	-	61	238
TM.3	-	-	65	232
TM.4	-	-	67	230
TM.5	-	-	63	240
TM.6	-	-	62	242
TM.7	-	-	71	234

Teacher Involvement in the Learning Process

Table 9. Teacher Involvement in the Learning Process

Indicator	Response	Total	Index	Category
TILP.1	-	-	55	254
TILP.2	-	-	57	251
TILP.3	-	-	59	245
TILP.4	-	-	66	237
TILP.5	-	-	63	238
TILP.6	-	-	61	240
TILP.7	-	-	68	236
TILP.8	-	-	70	228

The summary of the variables in Table 10 shows that all of the key factors analyzed in the article are rated highly. In particular, six of those sub-variables are Teacher Pedagogical Competence, Teacher Technological Competence, Teacher Content Competence, School Infrastructure Support, Teacher Motivation, and Teacher Involvement in Learning, each of which is in the "High" category, the mean index score of which ranges from 424.9 to 426.4. These scores indicate that the participating teachers exhibit high capabilities in these critical areas. The consistent high ratings of these competencies indicate that they are critical while adding that a holistic approach to the learning process embracing both pedagogical skills, technology competence, contents competence, motivational competence, and learning process active

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capacity are a necessity to bring about the effective foundation of the Merdeka Curriculum (Vivorenzo & Hakim 2023). These findings summarize the critical things that lead to successful of vocational education in Indonesia and also highlight things that can be improved, especially in terms of teacher participation and infrastructure.

Table 10. Summary of Variables

Variable	Mean Index	Category
Teacher Pedagogical Competence	426.2	High
Technological Competence	426.2	High
Content Competence	424.9	High
School Infrastructure Support	425.8	High
Teacher's Motivation	426.4	High
Teacher Involvement in Learning	426.4	High

Data Analysis

The research data analysis used a Structural Equation Model (SEM) with a partial least square (PLS) method approach. PLS aims to complete multiple regression analysis. Testing using PLS requires 2 stages, namely testing the outer model and inner model.

Outer Model Testing

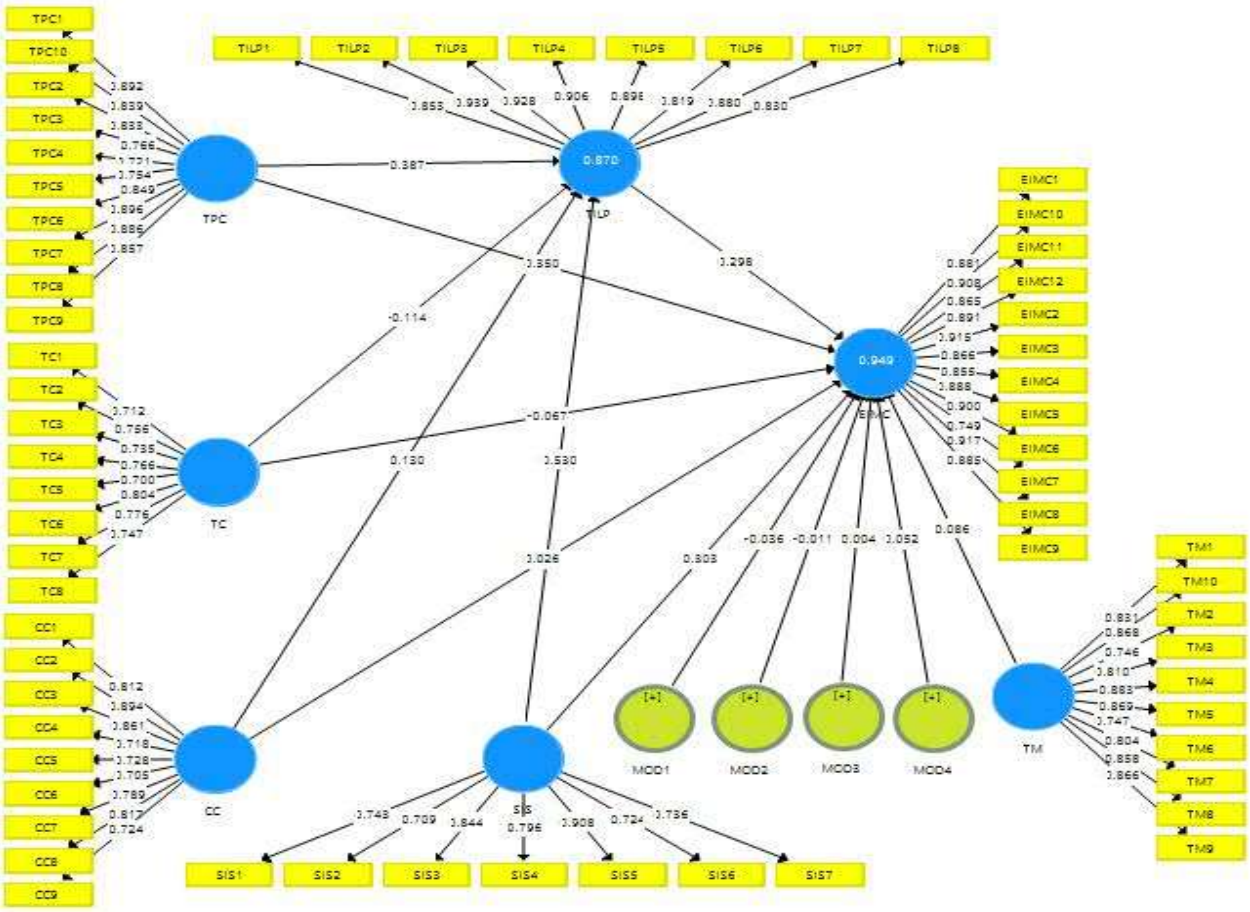

Figure 2. Outer Model Result

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Convergent Validity Test

The results of the test of convergent validity through the outer loading value indicate that all indicators of the research constructs, namely Teacher Pedagogical Competence, Technological Competence, Content Competence, School Infrastructure Support, Teacher's Motivation, Teacher Involvement in the Learning Process, and Effectiveness of Implementing the Merdeka Curriculum have a value> 07. This means that every construct or variable involved in this study is valid and can effectively represent its respective dimension. As an example, the highest (0.894: CC2) and lowest (0.705: CC6) outer loading values for the Content Competence construct indicator showed value of load are greater than 0.708, hence meet the validity criteria. Similarly, the construct variable for the Effectiveness of Implementation of the Merdeka Curriculum has the highest outer loading value at 0.917 in EIMC8 and the lowest value at 0.749 in EIMC7, both of which are declared valid. Based on the above results, we can conclude that all of the research variables have a good validity to be carried on for further test.

Table 11. Outer Model Convergent Validity Test Results Outer Model Convergent Validity Test Results

Construct	Indicator	Outer Loading	Description
Content Competence	CC1	0.812	Valid
	CC2	0.894	Valid
	CC3	0.861	Valid
	CC4	0.718	Valid
	CC5	0.728	Valid
	CC6	0.705	Valid
	CC7	0.789	Valid
	CC8	0.817	Valid
	CC9	0.724	Valid
Effectiveness of Implementing the Merdeka Curriculum	EIMC1	0.881	Valid
	EIMC2	0.915	Valid
	EIMC3	0.866	Valid
	EIMC4	0.855	Valid
	EIMC5	0.888	Valid
	EIMC6	0.900	Valid
	EIMC7	0.749	Valid
	EIMC8	0.917	Valid
	EIMC9	0.885	Valid
	EIMC10	0.908	Valid
	EIMC11	0.865	Valid
	EIMC12	0.891	Valid
School Infrastructure Support	SIS1	0.743	Valid
	SIS2	0.709	Valid
	SIS3	0.844	Valid
	SIS4	0.796	Valid
	SIS5	0.908	Valid
	SIS6	0.724	Valid
	SIS7	0.736	Valid
Technological Competence	TC1	0.712	Valid
	TC2	0.756	Valid

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Construct	Indicator	Outer Loading	Description
	TC3	0.735	Valid
	TC4	0.766	Valid
	TC5	0.700	Valid
	TC6	0.804	Valid
	TC7	0.776	Valid
	TC8	0.747	Valid
Teacher Involvement in the Learning Process	TILP1	0.853	Valid
	TILP2	0.939	Valid
	TILP3	0.928	Valid
	TILP4	0.906	Valid
	TILP5	0.898	Valid
	TILP6	0.819	Valid
	TILP7	0.880	Valid
	TILP8	0.830	Valid
Teacher's Motivation	TM1	0.831	Valid
	TM2	0.746	Valid
	TM3	0.810	Valid
	TM4	0.883	Valid
	TM5	0.869	Valid
	TM6	0.747	Valid
	TM7	0.804	Valid
	TM8	0.858	Valid
	TM9	0.866	Valid
	TM10	0.868	Valid
Teacher Pedagogical Competence	TPC1	0.892	Valid
	TPC2	0.833	Valid
	TPC3	0.766	Valid
	TPC4	0.721	Valid
	TPC5	0.754	Valid
	TPC6	0.849	Valid
	TPC7	0.896	Valid
	TPC8	0.886	Valid
	TPC9	0.857	Valid
	TPC10	0.839	Valid
TPC * TM	TPC * TM	1.372	Valid
TC * TM	TC * TM	1.258	Valid
CC * TM	CC * TM	1.388	Valid
SIS * TM	SIS * TM	1.363	Valid

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Discriminant Validity

Table 12. Cross Loading Result

	CC	EIMC	MOD1	MOD2	MOD3	MOD4	SIS	TC	TILP	TM	TPC
CC1	0.812	0.722	-0.383	-0.242	-0.389	-0.357	0.739	0.577	0.679	0.708	0.690
CC2	0.894	0.738	-0.402	-0.245	-0.378	-0.388	0.765	0.606	0.747	0.739	0.719
CC3	0.861	0.723	-0.408	-0.241	-0.376	-0.401	0.729	0.641	0.706	0.669	0.690
CC4	0.718	0.510	-0.285	-0.194	-0.285	-0.279	0.584	0.625	0.511	0.505	0.525
CC5	0.728	0.531	-0.254	-0.137	-0.257	-0.236	0.611	0.578	0.523	0.509	0.541
CC6	0.705	0.518	-0.269	-0.158	-0.252	-0.283	0.612	0.592	0.519	0.465	0.535
CC7	0.789	0.700	-0.397	-0.230	-0.380	-0.403	0.676	0.478	0.703	0.659	0.681
CC8	0.817	0.700	-0.396	-0.240	-0.381	-0.395	0.666	0.438	0.698	0.693	0.670
CC9	0.724	0.622	-0.423	-0.254	-0.376	-0.415	0.616	0.409	0.614	0.664	0.622
EIMC1	0.732	0.881	-0.410	-0.244	-0.378	-0.392	0.805	0.507	0.822	0.819	0.833
EIMC2	0.707	0.915	-0.422	-0.247	-0.400	-0.369	0.895	0.516	0.835	0.863	0.863
EIMC3	0.743	0.866	-0.421	-0.244	-0.394	-0.384	0.830	0.505	0.839	0.855	0.850
EIMC4	0.763	0.855	-0.505	-0.303	-0.438	-0.468	0.817	0.521	0.795	0.821	0.806
EIMC5	0.777	0.888	-0.424	-0.262	-0.379	-0.409	0.810	0.534	0.848	0.799	0.835
EIMC6	0.732	0.900	-0.416	-0.260	-0.396	-0.395	0.825	0.535	0.818	0.791	0.840
EIMC7	0.563	0.749	-0.377	-0.200	-0.331	-0.341	0.697	0.408	0.678	0.693	0.691
EIMC8	0.710	0.917	-0.423	-0.250	-0.403	-0.371	0.896	0.518	0.837	0.865	0.864
EIMC9	0.748	0.885	-0.434	-0.286	-0.400	-0.418	0.788	0.505	0.833	0.802	0.822
EIMC10	0.754	0.908	-0.450	-0.287	-0.423	-0.435	0.827	0.552	0.879	0.796	0.840
EIMC11	0.717	0.865	-0.366	-0.220	-0.341	-0.342	0.814	0.502	0.851	0.833	0.823
EIMC12	0.733	0.891	-0.529	-0.322	-0.469	-0.496	0.825	0.525	0.871	0.835	0.829
SIS1	0.606	0.630	-0.293	-0.174	-0.287	-0.270	0.743	0.512	0.582	0.588	0.625
SIS2	0.679	0.597	-0.316	-0.258	-0.304	-0.313	0.709	0.756	0.569	0.560	0.602
SIS3	0.738	0.813	-0.442	-0.261	-0.395	-0.399	0.844	0.537	0.845	0.772	0.755
SIS4	0.662	0.710	-0.320	-0.235	-0.320	-0.312	0.796	0.603	0.690	0.680	0.678
SIS5	0.718	0.910	-0.423	-0.249	-0.404	-0.365	0.908	0.508	0.839	0.866	0.858
SIS6	0.694	0.696	-0.340	-0.197	-0.324	-0.343	0.724	0.514	0.674	0.625	0.652
SIS7	0.579	0.709	-0.412	-0.254	-0.381	-0.382	0.736	0.389	0.723	0.766	0.701
TC1	0.521	0.449	-0.275	-0.224	-0.244	-0.279	0.532	0.712	0.423	0.411	0.466
TC2	0.538	0.430	-0.186	-0.167	-0.167	-0.180	0.529	0.756	0.417	0.378	0.469
TC3	0.384	0.315	-0.149	-0.139	-0.124	-0.146	0.422	0.735	0.300	0.292	0.348
TC4	0.638	0.613	-0.307	-0.235	-0.303	-0.280	0.655	0.766	0.609	0.600	0.606
TC5	0.542	0.464	-0.198	-0.182	-0.177	-0.215	0.507	0.700	0.482	0.441	0.462
TC6	0.481	0.375	-0.150	-0.186	-0.136	-0.163	0.451	0.804	0.371	0.320	0.407
TC7	0.421	0.290	-0.129	-0.155	-0.118	-0.132	0.407	0.776	0.292	0.233	0.311
TC8	0.485	0.376	-0.163	-0.180	-0.139	-0.163	0.458	0.747	0.353	0.326	0.403
TILP1	0.687	0.793	-0.445	-0.286	-0.420	-0.431	0.769	0.455	0.853	0.813	0.770
TILP2	0.716	0.872	-0.422	-0.255	-0.386	-0.385	0.848	0.555	0.939	0.819	0.825
TILP3	0.722	0.877	-0.471	-0.287	-0.430	-0.437	0.830	0.530	0.928	0.810	0.822

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	CC	EIMC	MOD1	MOD2	MOD3	MOD4	SIS	TC	TILP	TM	TPC
TILP4	0.720	0.834	-0.429	-0.267	-0.391	-0.396	0.836	0.496	0.906	0.804	0.791
TILP5	0.714	0.849	-0.451	-0.273	-0.417	-0.417	0.813	0.526	0.898	0.810	0.793
TILP6	0.715	0.780	-0.439	-0.269	-0.385	-0.415	0.755	0.499	0.819	0.784	0.760
TILP7	0.747	0.827	-0.432	-0.247	-0.362	-0.402	0.787	0.505	0.880	0.797	0.803
TILP8	0.741	0.814	-0.525	-0.321	-0.477	-0.503	0.778	0.472	0.830	0.800	0.774
TM1	0.638	0.768	-0.436	-0.273	-0.444	-0.408	0.768	0.401	0.738	0.831	0.751
TM2	0.547	0.699	-0.331	-0.115	-0.276	-0.302	0.653	0.328	0.729	0.746	0.707
TM3	0.688	0.757	-0.432	-0.257	-0.391	-0.419	0.721	0.417	0.716	0.810	0.752
TM4	0.724	0.806	-0.457	-0.275	-0.425	-0.435	0.764	0.468	0.793	0.883	0.789
TM5	0.721	0.813	-0.442	-0.267	-0.408	-0.426	0.802	0.546	0.822	0.869	0.803
TM6	0.582	0.668	-0.404	-0.222	-0.387	-0.377	0.638	0.377	0.674	0.747	0.650
TM7	0.607	0.744	-0.437	-0.285	-0.411	-0.409	0.764	0.414	0.751	0.804	0.732
TM8	0.717	0.804	-0.467	-0.287	-0.422	-0.447	0.746	0.476	0.780	0.858	0.812
TM9	0.708	0.777	-0.470	-0.277	-0.430	-0.455	0.746	0.466	0.771	0.866	0.790
TM10	0.713	0.852	-0.454	-0.278	-0.420	-0.412	0.821	0.505	0.778	0.868	0.835
TPC1	0.746	0.881	-0.431	-0.256	-0.396	-0.397	0.840	0.525	0.810	0.876	0.892
TPC2	0.619	0.765	-0.459	-0.290	-0.453	-0.444	0.746	0.421	0.695	0.789	0.833
TPC3	0.611	0.657	-0.359	-0.237	-0.316	-0.334	0.634	0.589	0.625	0.637	0.766
TPC4	0.525	0.641	-0.350	-0.175	-0.313	-0.348	0.611	0.396	0.612	0.625	0.721
TPC5	0.632	0.678	-0.342	-0.232	-0.292	-0.321	0.665	0.636	0.680	0.665	0.754
TPC6	0.680	0.788	-0.424	-0.250	-0.403	-0.408	0.775	0.479	0.741	0.784	0.849
TPC7	0.690	0.823	-0.445	-0.269	-0.427	-0.429	0.792	0.511	0.791	0.799	0.896
TPC8	0.716	0.873	-0.401	-0.250	-0.390	-0.401	0.824	0.509	0.846	0.857	0.886
TPC9	0.710	0.809	-0.454	-0.294	-0.431	-0.456	0.742	0.488	0.795	0.780	0.857
TPC10	0.764	0.854	-0.396	-0.244	-0.357	-0.384	0.782	0.507	0.821	0.797	0.839
TPC * TM	-0.462	-0.492	1.000	0.631	0.869	0.942	-0.470	-0.276	-0.511	-0.523	-0.490
TC * TM	-0.278	-0.297	0.631	1.000	0.721	0.700	-0.298	-0.253	-0.312	-0.308	-0.301
CC * TM	-0.441	-0.452	0.869	0.721	1.000	0.912	-0.445	-0.252	-0.463	-0.485	-0.456
SIS * TM	-0.453	-0.458	0.942	0.700	0.912	1.000	-0.438	-0.275	-0.479	-0.494	-0.473

The test results prove that all of the indicators that measure the construct of Teacher Pedagogical Competence, Technological Competence, Content Competence, School Infrastructure Support, Teacher's Motivation, The role of Teacher Involvement in the Learning Process and Effectiveness of the Implementation of the Merdeka Curriculum have a loading factor value above than the loading value of other latent variables. Thus, these outcomes show good discriminant validity values for all constructs.

Another testing for discriminant validity was conducted with the average variance extracted (AVE) test for each construct. The results of the AVE test can be found in Table 13 AVE test.

Table 13. Discriminant Validity Results

	Average Variance Extracted (AVE)
TPC	0.691
TC	0.563
CC	0.617

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SIS	0.613
EIMC	0.770
TILP	0.779
TM	0.688
MOD1	1.000
MOD2	1.000
MOD3	1.000
MOD4	1.000

The AVE value for Teacher Pedagogical Competence, Technological Competence, Content Competence, School Infrastructure Support, Teacher Work Motivation, the Role of Teacher Involvement in the Learning Process, and the Effectiveness of Implementing the Merdeka Curriculum constructs is > 0. 5, so it can be concluded that good discriminant validity for this study model explained the difference between the overall model.

Discriminant validity testing is also carried out by looking at the FornellLarcker Criterion, which can be seen in the following table:

Table 14. Fornell Larcker Result Criteria

	CC	**EIMC**	**SIS**	**TC**	**TILP**	**TM**	**TPC**	**MOD1**	**MOD2**	**MOD3**	**MOD4**
TPC	0.810	0.941	0.897	0.606	0.898	0.921	0.831	-0.490	-0.301	-0.456	-0.473
TC	0.692	0.583	0.684	0.751				-0.276	-0.253	-0.252	-0.275
CC	0.786										
EIMC	0.825	0.878									
SIS	0.852	0.935	0.783					-0.470	-0.298	-0.445	-0.438
TILP	0.816	0.942	0.910	0.573	0.883			-0.511	-0.312	-0.463	-0.479
TM	0.804	0.929	0.897	0.534	0.912	0.829		-0.523	-0.308	-0.485	-0.494
MOD1	-0.462	-0.492						1.000			
MOD2	-0.278	-0.297						0.631	1.000		
MOD3	-0.441	-0.452						0.869	0.721	1.000	
MOD4	-0.453	-0.458						0.942	0.700	0.912	1.000

Source of Data; Results of Author Observation SmartPLS Method 2024

The test results show that the magnitude of the AVE root value in each construct is greater than the correlation value between the variables. These results conclude that discriminantly, the variables used in the study are said to be valid.

Composite Reliability Test

The test results show that the constructs of Teacher Pedagogical Competence, Technological Competence, Content Competence, School Infrastructure Support, Teacher Motivation, the Role of Teacher Involvement in the Learning Process and the Effectiveness of Implementing the Merdeka Curriculum have a composite reliability value greater than 0.70. Thus the model in this study has met the composite reliability. Thus the model in this study has met the composite reliability.

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Table 15. Composite Reliability Results

Variable	Composite Reliability
TPC	0.957
TC	0.911
CC	0.935
SIS	0.917
EIMC	0.976
TILP	0.966
TM	0.956
MOD1	1.000
MOD2	1.000
MOD3	1.000
MOD4	1.000

Source of Data; Results of Author Observation SmartPLS Method 2024

Cronbach Alpha

Table 16. Cronbach Alpha Result

Var	Cronbach's Alpha
TPC	0.950
TC	0.891
CC	0.922
SIS	0.893
EIMC	0.973
TILP	0.959
TM	0.949
MOD1	1.000
MOD2	1.000
MOD3	1.000
MOD4	1.000

Source of Data; Results of Author Observation SmartPLS Method 2024

The test results show that the constructs of Teacher Pedagogical Competence, Technological Competence, Content Competence, School Infrastructure Support, Teacher's Motivation, The role of Teacher Involvement in the Learning Process and Effectiveness of Implementing the Merdeka Curriculum have a Cronbach alpha value greater than 0.70. Thus, all constructs have good data reliability and have met Cronbach alpha.

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Inner Model Measurements

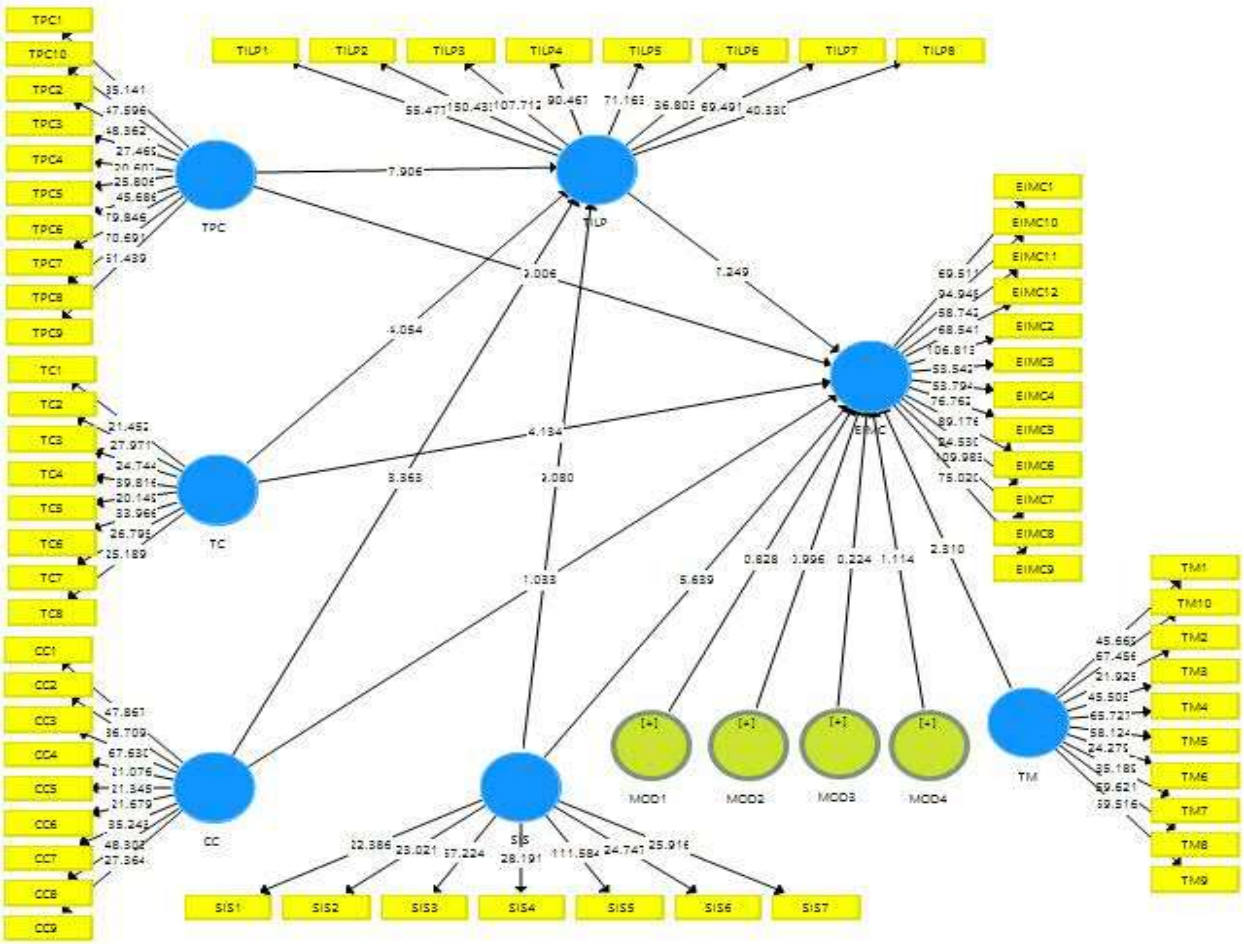

Figure 4.2 The Inner Model

Coefficient Of Determination (R-square)

Table 17. Determination Coefficient Results

Var	R Square
EIMC	0.949
TILP	0.870

Source of Data; Results of Author Observation SmartPLS Method 2024

The test results in the first model obtained an R-square value of 0.949 which indicates that the constructs of Teacher Pedagogical Competence, Technological Competence, Content Competence, School Infrastructure Support, Teacher's Motivation and The role of Teacher Involvement in the Learning Process and are able to explain the Effectiveness of Implementing the Merdeka Curriculum by 94.9% and the remaining 5.1% is explained by other constructs. Meanwhile, the test results in the second model obtained an R-square value of 0.870 which indicates that the Teacher Pedagogical Competence, Technological Competence, Content Competence and School Infrastructure Support constructs are able to explain The role of Teacher Involvement in the Learning Process by 87% and the remaining 13% is explained by other constructs.

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Path Coefficient

The path coefficient result in hypothesis testing consequently yields great insights into the connection between variables. The effect of Teacher Pedagogical Competence (TPC) on the Effectiveness of Implementing Merdeka Curriculum (EIMC) is very strong and supports hypothesis H1 can be accepted with t-statistic of 9.006 (p-value = 0.000). In parallel Technological Competence (TC) has a strong impact on EIMC with a t-statistic of 4.134 and a p-value of 0.000, thus presenting evidence in favor of H2. However, as Content Competence (CC) does not influence EIMC with t = 1.033, p = 0.302, H3 is rejected. Conversely, the results reveal that School Infrastructure Support (SIS) has strong positive effect on EIMC as indicated with t-statistics 5.639 and p-value 0.000 which supports the H4 These results elucidate the importance of pedagogical, technological, and infrastructural support in the implementation of the Merdeka Curriculum and indicate that when it comes to the effectiveness of the Merdeka Curriculum, competence in the content may not be enough.

Table 18. Hypothesis Test Results Based on Path Coefficient

Var	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
CC -> EIMC	0.026	0.029	0.025	1.033	0.302
CC -> TILP	0.130	0.130	0.039	3.363	0.001
SIS -> EIMC	0.303	0.296	0.054	5.639	0.000
SIS -> TILP	0.530	0.535	0.058	9.080	0.000
TC -> EIMC	-0.067	-0.068	0.016	4.134	0.000
TC -> TILP	-0.114	-0.114	0.028	4.054	0.000
TILP -> EIMC	0.298	0.300	0.041	7.249	0.000
TM -> EIMC	0.086	0.088	0.037	2.310	0.021
TPC -> EIMC	0.350	0.351	0.039	9.006	0.000
TPC -> TILP	0.387	0.382	0.049	7.906	0.000
MOD1 -> EIMC	-0.036	-0.035	0.044	0.828	0.408
MOD2 -> EIMC	-0.011	-0.012	0.011	0.996	0.320
MOD3 -> EIMC	0.004	0.003	0.019	0.224	0.823
MOD4 -> EIMC	0.052	0.051	0.046	1.114	0.266

Source of Data; Results of Author Observation SmartPLS Method 2024

The Effect of Teacher Involvement in the Learning Process on the Effectiveness of Implementing the Merdeka Curriculum

The hypothesis test results obtained a t-statistic value of 7.249 and a p-value of 0.000. Because the p-value <0.05, it can be concluded that H5 is accepted, which means that Teacher Involvement in the Learning Process has a significant effect on the Effectiveness of Implementing the Merdeka Curriculum.

Intervening or Mediation Tests

The mediation tests show that Teacher Involvement in the Learning Process (TILP) play a significant role as a mediating variable of the relationships between competencies and the Effectiveness of Implementing the Merdeka Curriculum (EIMC). Hypothesis 6 is supported because TILP was found significant as a mediator when Teacher Pedagogical Competence (TPC) has an effect on EIMC, t-stat = 5.766, p = 0.000. Likewise, hypothesis 7 is confirmed with TILP mediating the effect of Technological Competence (TC) on EIMC with t-statistic (3.554) and p-value (0.000). While hypothesis 8 is validated since TILP emerges as a

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mediator between Content Competence (CC) and EIMC (p = 0.003, t = 3.001 in Table 5). Finally, hypothesis 9 is supported with TILP having a mediating effect (t-stat 5.295, p-value 0.000) in the relationship between School Infrastructure Support (SIS) and EIMC. The results highlight the importance of teacher engagement in enhancing the contribution of competencies and resources to the effectiveness of the curriculum.

Table 19. Mediation Test Results

Var	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
CC -> TILP -> EIMC	0.039	0.039	0.013	3.001	0.003
SIS -> TILP -> EIMC	0.158	0.161	0.030	5.295	0.000
TC -> TILP -> EIMC	-0.034	-0.034	0.010	3.554	0.000
TPC -> TILP -> EIMC	0.115	0.114	0.020	5.766	0.000

Source of Data; Results of Author Observation SmartPLS Method 2024

Test of Moderation

This suggests that Teacher's Motivation is not a significant moderator of the influences of several competencies and resources on Effectiveness of Implementing the Merdeka Curriculum (EIMC). Concretely, test results for Teacher Pedagogical Competence (TPC), Technological Competence (TC), Content Competence (CC), and School Infrastructure Support (SIS) are all revealed to be without any significant moderation effects. The value of t-statistic is 0.828 and the p-value is 0.408 and therefore hypothesis 10, that there is no significant difference between trading performance and trust perception in TPC is rejected. For TC, the t-statistic is 0.996 with a p-value of 0.320, the null hypothesis 11 is rejected. Hypothesis 12: For CC, p-value=0.823 and t-statistic=0.224, we reject hypothesis 12. Lastly, regarding SIS, t-statistic is 1.114, p-value is 0.266, hypothesis 13 is rejected. For this reason, Teacher's Motivation does not moderate role to improve these factors to the effectives of Merdeka Curriculum.

Table 20: Moderation Test Results

Var	**Original Sample (O)**	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**T Statistics (|O/STDEV|)**	**P Values**
CC -> EIMC	0.026	0.029	0.025	1.033	0.302
CC -> TILP	0.130	0.130	0.039	3.363	0.001
SIS -> EIMC	0.303	0.296	0.054	5.639	0.000
SIS -> TILP	0.530	0.535	0.058	9.080	0.000
TC -> EIMC	-0.067	-0.068	0.016	4.134	0.000
TC -> TILP	-0.114	-0.114	0.028	4.054	0.000
TILP -> EIMC	0.298	0.300	0.041	7.249	0.000
TM -> EIMC	0.086	0.088	0.037	2.310	0.021
TPC -> EIMC	0.350	0.351	0.039	9.006	0.000
TPC -> TILP	0.387	0.382	0.049	7.906	0.000
MOD1 -> EIMC	-0.036	-0.035	0.044	0.828	0.408
MOD2 -> EIMC	-0.011	-0.012	0.011	0.996	0.320
MOD3 -> EIMC	0.004	0.003	0.019	0.224	0.823
MOD4 -> EIMC	0.052	0.051	0.046	1.114	0.266

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Source of Data; Results of Author Observation SmartPLS Method 2024

Discusion

These empirical results come up with informative insights on how different competencies and resources affect the effectiveness of the Merdeka Curriculum implementation in Indonesia. Here, we get into what the results mean, and per review have provided as complete a discussion as possible, through the lens of existing literature and theory.

Teacher Pedagogical Competence and the Effectiveness of Implementing the Merdeka Curriculum

An important aspect of this study is that teacher pedagogical competence is found to significantly affect schools in carrying out the Merdeka Curriculum. This is in line with various studies focusing on teacher qualifications and skills, and so is pedagogical competence, which play an important role of how well the teacher can engage with the curriculum, and facilitate learning. Teachers with a high degree of pedagogical competence not only maneuver through the complexity of the curriculum but are also able to modify the curriculum to meet the needs of student diverse needs (Darling-Hammond, 2017). Having pedagogical competence also creates a situation where students are more likely to have meaningful interactions with the curriculum, resulting in better learning outcomes (Hattie, 2009).

The finding in the current study supports the claim that how well teachers design lessons and facilitate learning can be linked to their professional knowledge that directly affects success in curriculum delivery (Schulz et al, 2019). This aligns with general educational research that shows a link between teacher quality and educational outcome (Kraft et al., 2018). Renowned among all of those is the Merdeka Curriculum, with the focus on student-centered learning and holistic aspects of students dripping down to the teacher, who need become adaptable, creative, and innovative in forming models. Thus, improving the pedagogical competence of teachers is absolutely needed to support the successful implementation of this curriculum.

Technological Competence and Curriculum Effectiveness

Based on some research that has been done above, technological competence is also known to affect the effectiveness of the Merdeka Curriculum. With the world getting more digital day by day, it was very much needed to bring technology within the education system. A high level of technological competence allows teachers to optimise the available digital tools that can transform the act of teaching and learning into a more interactive and engaging experience (Dede, 2014). In addition, it opens doors to a variety of learning materials and helps instructors accommodate individual performance levels (Baker et al., 2015) in ways that conventional techniques cannot.

It is especially relevant considering that the Merdeka Curriculum revolves around flexibility and integration with multiple methodologies of teaching. Knowledge and skills to integrate technology meaningfully into their teaching areas empower teachers to address the personalized learning education approach encapsulated in the Merdeka Curriculum. Additionally, emergent use of digital tools in education, over the course of COVID-19, indicates that teachers need to be technologically savvy as to ensure the continuity of learning (Tondeur et al., 2020). Therefore, improving the technological competence of teachers is crucial for successful implementation of the curriculum.

Content Competence and Its Role in Curriculum Implementation

Although teacher pedagogical and technological competence are well established, content competence was the last and therefore least important. While content knowledge is important for teachers to teach accurately and to teach the appropriate concepts, it is not the only thing required for effective teaching. References Shulman (1986) indicates that knowledge of content is necessary but not sufficient. In order for content knowledge to be useful, it must be integrated with knowledge of pedagogy. This is consistent with the results of this research, which showed that teacher pedagogical competence contributes more to the effectiveness of curriculum implementation than content competence. The Merdeka Curriculum prepares

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teachers not just content delivery, but instead teacher preparing critical thinking, creativity and inquiryk skills from student. Thus, even though content knowledge is still a fundamental base, it needs to be supplemented with pedagogical and technological expertise to create more flexible, learner-centered approaches to learning. The result is consistent with new studies that highlight the need to combine content expertise with teaching expertise in current schooling (Grossman, 2018).

School Infrastructure Support and Curriculum Effectiveness

Support from School infrastructure also proved effective in the implementation of the Merdeka Curriculum. Some of them are material, such as classrooms and learning materials; others are organizational, such as administrative backing and professional development opportunities for teachers. A critical underpinning of any curriculum is effective infrastructure, which are the conditions through which teaching and learning can take place (OECD, 2017). Many different approaches come under the umbrella of the Merdeka Curriculum, which promotes flexibility and experiential learning but can only be applied in schools that promote these as values in their learning environments – collaborative group work, individual exploration, and wider range of activities.

Adequate infrastructure in place is required for educational success (World Bank, 2018). Typically well-resourced schools with technology, libraries, learning spaces, tend to produce a more engaging and effective learning environment. Overall, the large impact of school-level infrastructure support in this study suggests that investments in school-based facilities as well as an environment that promotes both teaching and learning make a difference. This is especially true in Indonesia, where the uneven distribution of infrastructure among regions may undermine the impact of education reforms (UNICEF, 2019).

The Mediating Role of Teacher Involvement in the Learning Process

Another important finding of this study is the mediating role of teacher involvement in the learning process. Teacher involvement in the learning process refers to the degree to which teachers actively engage with students, facilitate learning, and provide feedback. Research consistently shows that teacher involvement has a positive effect on student outcomes (Pianta et al., 2012). In this study, teacher involvement mediated the effect of various competencies and resources on the effectiveness of the Merdeka Curriculum, suggesting that the way teachers engage with the curriculum is critical to its success. Teacher involvement is especially important in the context of the Merdeka Curriculum, which promotes active, student-centered learning. Teachers who are deeply involved in the learning process can better facilitate students' exploration, critical thinking, and problem-solving skills. This aligns with the findings of Wang et al. (2020), who found that teacher involvement in active learning environments significantly enhances students' academic achievement and engagement.

Conclusion

Finally, this study emphasizes that teacher pedagogical competence, technological competence, school infrastructure support, and teacher involvement in the learning process are the determinants of the successful implementation of the Merdeka Curriculum. Together these are the makeup of the quality and effectiveness of an education. Though content competence still provides a critical foundation, it is the intertwining of pedagogical ability, technical knowhow and supporting infrastructure that delivers the recipe for success in terms of the curriculum. The results also highlight the necessity of ongoing professional training and upgrade of infrastructure in order to deliver the Merdeka Curriculum efficiently. Further studies should examine the interaction of these factors as well as their long-term effects on Indonesia's education outcomes.

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