5C-Based Technology Adaptation Model for Optimizing Teacher Pedagogical Competence

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Abstract. The 5C-based technology adaptation model professional values that support the strengthening of pedagogical competence comprehensively and sustainably, in accordance with the demands of 21st-century education. This model is in line with the Merdeka Curriculum which emphasizes differentiated, student-centered learning, and the use of digital technology to strengthen the profile of Pancasila students. This study uses a qualitative approach by interviewing three participants who participated in training based on the model. The results show that this model contributes to the formation of a positive and character-based digital culture in the school environment, making teachers not only technology users, but also agents of change in building a sustainable and civilized education ecosystem. The implications of the study show an increase in teachers' pedagogical competence holistically, collaboration with colleagues, reflective and innovative abilities, and a critical attitude towards the ethics and relevance of using technology in learning.

Keywords: Character; creativity; collaboration; communication; critical and innovative

1 Introduction

21st century education requires teachers to not only master the subject matter but also be able to integrate technology into learning (1-2). Digital transformation in the world of education is a challenge as well as an opportunity to improve the quality of the teaching and learning process (3-4). However, in reality, there are still many teachers who have not optimally utilized technology pedagogically (5-6). In this context, a technology adaptation model is needed that can help teachers improve their pedagogical competence (7-8). The 5C-based approach (Character; Creativity, Collaboration; Communication, Critical and innovative) is considered relevant to support this process.

Digital transformation in the world of education is both a challenge and an opportunity because it involves major changes in the way teachers teach, students learn, and schools operate (9). Digital transformation has the opportunity to access wider learning resources (8). Technology allows teachers and students to access learning materials from various global sources, including videos, scientific journals, e-books, and digital learning platforms (3). With digital platforms,

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learning can be adjusted to the needs and learning speed of each student (10). Digital transformation makes collaboration easier and broader (11-12). Teachers and students can collaborate across schools, even across countries, through forums, digital projects, or joint online classes.

Digital transformation makes school administration more effective because technology helps manage school administration and learning and automatic assessment, digital attendance, LMS, through digital transformation teachers and students have the opportunity to develop digital literacy which is important to face the era of technology-based work (13-14). Not all schools have adequate technology facilities (1; 9). This inequality can widen the educational gap (4; 6; 15-16). Many teachers are not ready or do not have sufficient digital competence to utilize technology effectively and pedagogically (10). If not wise, students can become passive or dependent on technology, not thinking critically and creatively (12). Another challenge is how to teach responsible use of technology, including digital ethics, data security, and plagiarism (3).

Changes in the teacher's function also occur because the teacher is no longer the only source of information, but rather a facilitator (10). This requires a change in mindset and teaching strategies (13). Digital transformation is not just about using tools, but about how to re-interpret the learning process to be more relevant, effective, and adaptive to the times (10; 14). Therefore, a wise and targeted approach such as through a value-based technology adaptation model that has been applied to the 5C-based technology adaptation model. To optimize pedagogical competence, 5C is needed so that technology truly improves the quality of education, not just becomes a new burden (14-22).

Many teachers have not optimally utilized technology pedagogically due to several interrelated factors, both from personal, institutional and cultural aspects. (3; 22-23). Many teachers only master technical aspects such as operating PowerPoint or Zoom, but have not mastered how to integrate technology for learning purposes (24). For example, using videos only as a distraction, not as part of a strategy to build conceptual understanding (2; 9). This happens because of the lack of relevant training (4). ICT (Information and Communication Technology) training attended by teachers is often general, not specific to the application of technology-based pedagogy (25). In addition, there is also a lack of ongoing and contextual advanced training to improve teacher competence (8; 19).

Some teachers are accustomed to conventional methods and feel insecure about using new technologies. There is resistance to change due to fear of technical failure or lack of support (9; 26). In many schools, there are still limitations in terms of devices, internet connections, or digital learning spaces (11). This makes it difficult for teachers to carry out technology-based learning consistently. Teachers are often burdened with high administrative tasks, so that time for exploration or experimentation with technology-based learning methods is limited (9). Not all schools provide discussion spaces or learning communities for teachers to share good practices (15). Support from school principals or policy makers is also not evenly distributed (26). Many teachers do not have a clear reference or model on how to adopt technology with an effective pedagogical approach (7).

Without a contextual technology adaptation model such as the 5C-based model, teachers tend to trial-and-error or simply imitate without understanding the essence (27). This problem is not only a technical issue, but also concerns a paradigm shift in teaching (26-27). Therefore, teachers need to be supported through continuous training, infrastructure facilitation, clear technology

adaptation models, and strengthening a collaborative culture in the school environment (3; 25). The 5C approach has a strategic role in the process of technology adaptation by teachers because these values are an important foundation for technology to be used meaningfully and support the improvement of pedagogical competence, not just as a technical aid (28).

The role of character in technology adaptation can encourage teachers to use technology ethically, responsibly, and in accordance with moral values in learning (2). It is a foundation so that the use of technology does not just follow trends, but has an awareness of humanistic educational values and goals. Teachers ensure that the use of technology not only delivers fast material, but also forms an honest attitude and respects digital copyright (13-14). The role of independence in technology adaptation makes independent teachers able to learn, explore, and try new technologies without having to always wait for formal training (29). Encourage teachers to become lifelong learners, who are ready to face changes in educational technology (30). Teachers learn to create interactive learning media themselves through Canva or Google Sites to increase the appeal of the lesson.

The role of collaboration in technology adaptation conditions teachers to share good practices effectively, work together, and support each other in a learning community or teacher community (12; 31). Technology can be a collaborative tool between teachers across schools, subjects, or even countries. The role of communication in digital technology adaptation can open up new opportunities in learning communication, both between teachers and students, teachers to parents, or teachers to fellow teachers (26). Teachers who have good communication skills can more effectively deliver digital learning instructions and build student engagement.

Teachers use Learning Management Systems (LMS) such as Google Classroom to provide clear and structured feedback so that they play a critical and innovative role in adapting technology can direct teachers to think critically in choosing and assessing whether a technology is truly relevant and supports learning outcomes (2; 14). Teachers are also required to be innovative in creating teaching strategies that utilize technology in new and interesting ways (7). Teachers do not only use YouTube videos as entertainment, but turn them into discussion materials, reflections, or analytical exercises (2; 32). The 5C approach helps teachers not only recognize and use technology, but also interpret and internalize it in a pedagogical context. The 5C values shape teachers who are more prepared, flexible, and reflective in utilizing technology to improve the quality of learning (14). The research question is how the role of the 5C approach is in the process of adapting technology in an effort to improve pedagogical competence.

2 Literature Review

The 5C approach has a strategic role in the process of technology adaptation by teachers because these values are an important foundation for technology to be used meaningfully and support the improvement of pedagogical competence, not just as a technical aid (2). This study provides significant contributions both theoretically and practically in the field of education (7; 32). Especially in the development of teacher pedagogical competence in the digital era (33-34). Theoretically, this study enriches the study of educational technology adaptation by offering a model integrated with the 5C approach which has not been widely discussed in the framework of learning technology adaptation. This model also reconceptualizes teacher pedagogical competence as an ability that not only includes aspects of content mastery and learning strategies, but also awareness of values and character in the wise use of technology (3; 7; 35-36).

Practically, the results of this study provide implementation guidelines for teachers and educational institutions in adopting technology in a more meaningful and humanistic way (1; 33; 37). Model this can be adapted in teacher training programs, professional competency improvement workshops, and digital transformation policies in education that prioritize integrity and ethics (36; 38). In addition, the social contribution of this model is seen through its encouragement of the formation of a positive and characterful digital culture in the school environment, so that teachers are not only users of technology, but also agents of change in building a sustainable and civilized educational ecosystem (7; 39).

2.1 The Role of Character in Technology Adaptation.

Character is the foundation for the use of technology not just to follow trends, but to have an awareness of humanistic educational values and goals. (2; 32-33; 36; 38). Character encourages teachers to use technology ethically, responsibly, and in accordance with moral values in learning (38; 40). Through character, teachers can ensure that the use of technology not only conveys material quickly, but also forms an honest attitude and respect for digital copyright (39; 41). The use of technology in education that is only oriented towards trends, technical innovation, or efficiency alone risks moving away from the essence of education itself, such as the formation of a human being who is morally, intellectually, and socially whole (41-42). In this context, character becomes an important foundation so that technology is not used superficially or merely as a style, but truly supports meaningful and humanistic educational goals. (6).

Without character, technology tends to be used mechanically just to go with the flow, speed up processes, or impress progress (38-39; 42). As a result, educational practices can get caught up in dehumanization, where human relationships (teacher-student) are replaced by tools, and values such as empathy, responsibility, and ethics begin to be marginalized (40). Character provides teachers with value awareness in choosing, using, and developing technology that favors students, strengthens collaborative learning, and fosters critical and creative attitudes (38; 43). Therefore, the use of technology must be based on character values such as integrity, independence, cooperation, empathetic communication, critical and innovative thinking (6; 39) as summarized in the 5C approach. With character as a foundation, teachers are not only users of technology, but also determiners of the direction and meaning of its use in achieving civilized and sustainable educational goals (38-39; 42-43).

2.2 The Role of Independent Creativity in Technology Adaptation

Independent teachers are able to learn, explore, and try new technologies without having to always wait for formal training (7; 44). Encourage teachers to become lifelong learners, who are ready to face changes in educational technology (20; 37). Teachers learn by themselves to create interactive learning media through Canva or Google Sites to increase the appeal of lessons. Teachers who have independence in learning are individuals who are driven by intrinsic motivation to develop, adapt, and update their competencies continuously (1-2). In the context of technology utilization, independence allows teachers to proactively find out, experiment, and implement new technologies in learning, without having to always wait for formal direction, training, or guidance from institutions to improve their students' competencies (45-46). Independence this was born from a professional awareness that the world of education continues to change, especially with rapid technological advances.

Independent teachers do not wait for momentum, but create their own learning opportunities through various sources such as the internet, communities of practitioners, educational social media, and online learning platforms (2; 32). They are able to explore, reflect, and adapt autonomously because they realize that mastery of technology is no longer an option, but a necessity to improve the quality of learning (20; 37). Moreover, independent teachers are also better prepared to face challenges and complexities in the digital classroom, because they do not depend on the system, but build capacity actively and continuously in an effort to improve the quality of their learning strategies (45). Thus, independence becomes an important foundation in forming flexible, innovative, and responsible teachers in the era of technology-based learning (1; 37; 47-48).

2.3 The Role of Collaboration in Technology Adaptation

Technology can be a collaborative tool between teachers across schools, subjects, or even countries (8; 12; 25; 48). Technology adaptation is more effective if teachers share good practices, collaborate, and support each other in a learning community or teacher community. Science and language teachers collaborated to create a technology-based project on writing online experimental reports by utilizing AI with flexible learning spaces as an area for developing digital competence (11; 30). Technology adaptation in learning requires not only mastery of digital tools, but also practical experience, creative ideas, and contextual implementation strategies (11). In this case, the adaptation process becomes much more effective when teachers share good practices, collaborate, and support each other in a learning community or teacher community (49). Through collaboration, teachers can learn from the real experiences of their colleagues, including challenges and solutions that have been successfully implemented in similar contexts (11-12).

Teachers sharing good practices, collaborating and supporting each other in a learning community or teacher community can accelerate the adaptation process because the knowledge shared is applicable and relevant, not just theoretical (1; 8). Collaboration also encourages teachers to come out of professional isolation and build confidence that they are not alone in the process of learning technology (12; 31). In addition, the teacher community becomes a space to test ideas, get feedback, and develop innovations collectively (13). In a healthy community, reciprocal learning occurs that enriches perspectives, strengthens professional solidarity, and improves the quality of learning (39). Social and emotional support within the community is also important, because the process of adapting to technology is often accompanied by stress or a lack of self-confidence (11). Thus, collaboration within the teacher community accelerates meaningful technology adoption, creates a culture of mutual learning, and forms a dynamic and sustainable educational ecosystem in the digital era (49).

2.4 The Role of Communication in Technology Adaptation:

Teachers who have good communication skills can more effectively deliver digital learning instructions and build student engagement (21). Teachers who use Learning Management Systems (LMS) such as Google Classroom to provide clear and structured feedback (14; 32). Meanwhile, technology opens up new opportunities in learning communication between teachers to students, teachers to parents, or teachers to fellow teachers (21). Technology has revolutionized the way teachers communicate with students, parents, and fellow teachers by providing faster, more flexible, interactive, and cross-space and time-bound media (49). In the context of learning, communication is no longer limited to face-to-face meetings in class, but

can be done synchronously or asynchronously, through various digital platforms such as Learning Management System (LMS), WhatsApp, email, video conference, and online discussion forums (32; 49). Technology allows teachers to provide faster feedback, share materials in real-time, and create open and participatory discussion spaces facilitated by schools (15).

Through technology, students can ask questions, send assignments, and discuss at any time, according to their learning style. Through technology, teachers can more easily convey student learning progress, attendance, or important notes directly and personally (21). This strengthens parental involvement in education and creates greater transparency. Digital platforms such as community groups, Google Workspace, or educational social media allow teachers to share learning resources, discuss learning strategies, and develop competencies collectively (15; 49). This creates a culture of mutual learning across schools and even across regions. Technology, if used wisely, can strengthen relationships between education stakeholders and support more responsive, adaptive, and collaborative learning (15). Communication becomes more open, participatory, and documented, making the learning process more transparent and oriented towards mutual growth (12; 21; 39).

2.5 The Role of Critical and Innovative Thinking in Technology Adaptation

Teachers are required to be innovative in creating teaching strategies that utilize technology in new and interesting ways (2). Teachers do not only use YouTube videos as viewing, but turn them into discussion materials, reflections, or analytical exercises (14; 32). Teachers need to think critically in choosing and assessing whether a technology is truly relevant and supports learning outcomes (48-49). Teachers need to think critically in selecting and evaluating technology because not all forms of technology are automatically relevant, effective, or supportive of expected learning outcomes (17). Amidst the many choices of platforms, applications, and digital tools that continue to emerge, critical thinking skills are an important filter so that teachers do not get caught up in using technology that simply follows trends, without considering its impact on student learning processes and outcomes (48-49).

Critical thinking enables teachers to analyze the appropriateness of technology features to the characteristics of the material, learning objectives, and needs of learners (43), but sometimes a simple approach is more effective depending on the context (4; 17; 48). Teachers also need to consider ethical aspects, data security, student accessibility, and pedagogical values when using certain technologies (9; 11; 26; 30; 40; 47). In addition, by thinking critically, teachers can reflectively assess whether the technology used really adds value to the learning process, or burdens students and teachers without significant contributions (17; 43). Critical thinking is a key skill in the digital era, so that teachers are able to become wise, reflective, and responsible decision makers in integrating technology to achieve meaningful, effective, and student-oriented learning (16; 49).

Teachers are required to be innovative because technology is basically just a tool that determines its effectiveness is how teachers use it creatively and contextually in the learning process (7; 17; 43; 46; 50; 51). Innovation allows teachers to create teaching strategies that are more interesting, adaptive, and appropriate to the needs of students who are very diverse in this digital era (37; 48). Today's students are a generation that is familiar with technology, but easily bored if learning is not challenging or feels monotonous (1). Therefore, teachers need to design learning that is not only informative, but also interactive, visual, participatory, and emotionally and

intellectually meaningful. Innovations in the use of technology such as gamification, digital project-based learning, collaborative virtual classes, or the use of educational AI can increase student motivation, engagement, and learning outcomes (9; 14; 47).

The demands of an independent curriculum and 21st century education require teachers to become learning designers, not just deliverers of material (34; 40). This requires creativity in combining digital tools with appropriate pedagogical approaches, as well as a willingness to try new things, evaluate them, and continuously improve them (9; 48). By being innovative, teachers not only respond to the challenges of the times, but also become agents of change who bring a spirit of living, dynamic, and transformative learning amidst ever-evolving technological advances (17; 49). The 5C approach helps teachers not only recognize and use technology, but also interpret and internalize it in a pedagogical context (6; 43). The 5C values shape teachers who are more prepared, flexible, and reflective in utilizing technology to improve the quality of learning.

The 5C-based technology adaptation model for optimizing teacher pedagogical competence in the world of education, by inserting character dimensions as the main component, can enrich existing theories such as TPACK or TAM (Technology Acceptance Model) with a soft skills value approach (32; 38-39). This model repositions pedagogical competence not only as teaching ability, but also as the capacity of teachers to use technology in a valuable and ethical manner, guided by the 5C character. This model is one of the applicative approaches that integrates the principles of 21st century education with teacher professional development, especially in the context of digital transformation (42; 52). This model provides real guidance for teachers in adopting and adapting learning technology, which focuses not only on technical aspects, but also on character and mindset readiness (48).

This model can be used as a framework for designing teacher training, both in PPG and PKB programs, and training in schools, because it is able to build synergy between mastery of technology and character formation of educators (25). Teachers are directed to not only "use technology", but also "bring value" in its use so that it is relevant to prevent dehumanization in digital learning (5). The results of this study can support the government or educational institutions in designing character and technology-based intervention policies or programs, in line with the direction of the national digital transformation of education. With an emphasis on character, this model strengthens the role of teachers as role models who are not only technologically literate, but also have character in directing digital culture in schools and society (46). This model ensures that the use of technology continues to pay attention to humanistic aspects, interpersonal relations, and the needs of students as a whole, which can support the development of new approaches in the adaptation of educational technology that are not only oriented towards mastery of tools, but also towards the formation of teacher values and character (33-34). The 5C model is a bridge between technological innovation and strengthening teachers' pedagogical competence in a comprehensive, contextual, and sustainable manner.

3 Methodology

Qualitative research methods are used to gain in-depth insights into participants' experiences, perspectives, and behaviors, particularly in complex, real-world contexts. This is done to gain a deep understanding of the various ways in which individuals and groups interact with the

phenomenon being studied, making it ideal to explore subjective experiences to gain detailed data from participants in the quantitative methods used.

3.1 Research Location and Sampling Technique

This research was conducted in one of the senior high schools in Deli Serdang Regency, North Sumatra. Based on the results of initial communication with the principal of the senior high school, information was obtained that a training on a 5C-based technology adaptation model had been conducted to optimize teacher pedagogical competence. Purposive sampling was carried out so that 3 participants were obtained who had participated in the training. Participants were selected based on the relevance and responsibility of those who were actively involved in the training on a 5C-based technology adaptation model to optimize teacher pedagogical competence at the school, so that the information obtained was in-depth and credible (53). Data were collected through semi-structured interviews, observation documentation, and discussions. This was done so that through semi-structured interviews, observation documentation, and discussions, they could complement each other in obtaining a comprehensive picture of the implementation of the 5C-based technology adaptation model to optimize teacher pedagogical competence. The data collection process was stopped when theoretical saturation was reached, namely when no new information was found in the data (54).

3.2 Data Collection

Data were collected through semi-structured interviews that allowed for in-depth exploration of participant perspectives and flexibility in developing questions. In addition, student internship reports from 2022 to 2023 provided by each industry manager were reviewed: five reports from civil engineering, eight from electrical engineering, and six from mechanical engineering. Interviews were conducted for 60–90 minutes per participant to explore the role of industrial internships in improving students' digital competencies. Further discussions were conducted to clarify the interview results. The key questions in the interviews were as follows.

1. How is the description of teachers' pedagogical competence today?
2. How is the implementation of the 5C approach in technology adaptation?
3. How is the design of a 5C-based technology adaptation model?
4. How is the implementation of the 5C-based technology adaptation model to improve teachers' pedagogical competence in the field?
5. What are the characteristics of effective implementation of 5C-based technology adaptation model design in the field?

3.3 Data Analysis

Interview data were recorded, transcribed, and analyzed using a thematic analysis approach (55). The analysis process included five stages, namely re-listening to interview recordings, systematically transcribing data, interpreting the meaning of data, validating results with participants to build credibility, and compiling narratives based on emerging themes. Data were also verified through triangulation of interview sources, documents, and observations to ensure consistency and validity of findings (56-57). All participants agreed to the use of data for research and publication purposes.

4 Research Findings

The results of discussions with participants showed that when they participated in the training they felt enthusiastic and excited because they felt helped to adapt to new technologies that were urgently needed to improve the pedagogy and competence of their students. According to Alam et al. (2024), the process of observing and identifying needs to improve pedagogical competence through adaptation of digital technology is an important foundation in designing training for adaptation to future skills. This emphasizes the urgency of involving educational parties to strengthen the required competencies (58). Professional involvement has also been shown to increase the effectiveness of work-based learning and minimize barriers to participation.

4.1 How is the description of current teacher pedagogical competence?

The information provided by participants shows that they are well aware of the pedagogical competencies they must master in the era of digital transformation.

> *Current teacher pedagogical competence reflects professional capacity in designing, implementing, and evaluating learning effectively, innovatively, and oriented towards learners. In the era of educational transformation and technological advancement, this competence includes not only teaching skills, but also a deep understanding of student characteristics, student-centered learning principles, and inclusive, adaptive, and transformative classroom management.*
>
> *(Participant #1)*

> *Teachers are required to create learning plans that are responsive to students' needs and learning styles by utilizing various approaches, strategies, and media, including digital technology. In addition, teachers need to develop authentic evaluations, provide constructive feedback, and process evaluation results to improve the learning process.*
>
> *(Participant #2)*

> *Pedagogical competence also includes the ability to build a positive, democratic, and collaborative learning environment, as well as sensitivity to student diversity. Teachers are required to be reflective, think critically, and continue to develop themselves in order to align pedagogical practices with developments in curriculum, technology, and social dynamics.*
>
> *(Participant #3)*

The results of discussions with participants revealed that they realized the importance of pedagogical competence in the student learning process, but most teachers still focused on the technical aspects of technology and had not been able to optimize its use pedagogically. This indicates that teachers' pedagogical competence does not only reflect technical skills in teaching, but also ethical awareness, humanistic values, and commitment to the sustainability of learning in facing the challenges of the 21st century.

4.2 How is the implementation of the 5C approach in technology adaptation?

Participants supported each other that the 5C approach was successful in increasing teacher engagement in using technology as a tool to strengthen learning strategies.

Teachers with character make ethics, responsibility, empathy, and integrity the foundation for utilizing technology. They choose technology wisely by considering aspects of digital security, online resource ethics, and the interests of students, not just following trends. Implementing technology requires professional independence, namely the ability to search for information, learn new platforms, and explore digital learning tools proactively without relying on formal training. Teachers with this character reflect the profile of lifelong learners.

(Participant #1)

The effectiveness of technology adaptation increases through collaboration between teachers in professional communities, both in sharing good practices, discussing, and developing learning content. This collaboration enriches ideas, accelerates technology mastery, and encourages contextual innovation. Teachers utilize digital platforms to build inclusive and effective learning communication, both with students, parents, and colleagues while still adhering to ethical and integrity rules.

(Participant #2)

The implementation of the 5C approach in technology adaptation conditions teachers to think critically in evaluating the relevance of technology to learning objectives, and to be able to design innovative, adaptive, and impactful digital strategies. They are not only users, but also creators of creative learning solutions. However, they still take into account ethical standards and integrity and responsibility.

(Participant #3)

The results of discussions with participants revealed that the 5C approach is a framework that places the basic values of 21st century learning as the foundation in the process of technology adaptation by teachers. The implementation of this approach ensures that technology integration is not only technical, but also valuable, contextual, and transformative, by humanizing the learning process. The implementation of 5C in technology adaptation allows teachers to integrate educational values with digital progress in a balanced way, making technology not just a tool, but a means to create characterful, meaningful, and sustainable learning.

4.3 How is the Design of a 5C-Based Technology Adaptation Model?

This model aims to not only improve teachers' technical mastery of technology, but also strengthen pedagogical competence, namely the ability to design, implement, evaluate, and reflect on effective and student-centered learning processes.

The character dimension in the model acts as a moral and ethical foundation in the use of technology. Teachers are expected to use technology wisely by considering values, social responsibility, and its impact on students, so that digital learning is created that is not only modern but also oriented towards humanity. Meanwhile, the independence dimension emphasizes the importance of teachers' ability to learn autonomously, explore digital technology, and develop learning initiatives without relying on formal training, in order to face the dynamics of technological change adaptively.

(Participant #1)

The collaboration dimension of the model emphasizes the importance of involvement in professional communities through sharing good practices, discussions, and digital collaboration. This collaboration encourages an open, reflective, and collectivist technology adaptation process.

Meanwhile, the communication dimension emphasizes teachers' ability to utilize technology to build effective learning interactions with students, parents, and colleagues, through open, clear messaging, and the use of relevant digital media.

(Participant #2)

The critical and innovative thinking dimension forms professional teachers who are able to evaluate the relevance of technology to learning objectives and design creative, contextual, and engaging digital teaching strategies. However, teacher involvement in the learning community is still needed to strengthen the understanding of the use of technology as a collective and reflective process.

(Participant #3)

The results of discussions with participants revealed that this model consists of three main components, namely input (teacher needs and readiness), process (5C-based training), and output (improving pedagogical competence, can improve teacher pedagogical competence. The 5C-Based Technology Adaptation Model is designed as a strategic framework to guide teachers in integrating technology meaningfully and sustainably into learning practices. The Model Design Components for input are teacher competency profiles, learning technology needs, school contexts. While the process is experiential learning-based training, community mentoring, practice reflection, and development of real action. Then the output is teachers who are able to adapt technology with 5C values as a foundation, as well as increasing pedagogical competence in planning, implementing, and evaluating digital learning. Furthermore, an evaluation is carried out using observation instruments, learning portfolios, and self-reflection to measure the transformation of pedagogical practices.

Thus, the design of the 5C-Based Technology Adaptation Model can improve teachers' pedagogical competence and place teachers as active subjects in change, not just technology users. The 5C approach ensures that technology adaptation is carried out in a valuable, reflective, and transformative manner, so that it truly has an impact on improving the quality of learning and teachers' pedagogical competence as a whole.

4.4 How is the implementation of the 5C-Based Technology Adaptation Model to improve teachers' pedagogical competence in the field?

The approach taken focuses on the mentoring process that integrates five main elements (Character, Creativity, Collaboration, Communication, Critical and Innovative) into the daily practice of teachers in developing technology-based pedagogical competencies.

Implementation begins with a reflective session to foster awareness of values and ethics in the use of technology. Through workshops and case studies, teachers are guided to understand that technology is a means, not an end, in realizing dignified and student-oriented education. Teachers are facilitated to independently explore various digital applications such as LMS, interactive quizzes, and learning video platforms, and are encouraged to dare to try, create accounts, design digital classes, and compile technology-based modules.

(Participant #1)

Discussion forums, teacher communities, and peer coaching sessions provide a platform for sharing good practices and forming a community of learners who support each other in integrating technology into learning. Teachers are trained to use digital media such as Google Classroom,

WhatsApp Group Education, and interactive videos to improve communication with students and parents, and to create effective, humanistic, and participatory learning messages.

(Participant #2)

Reflection on the effectiveness of technology use in supporting pedagogical competence is an important part, accompanied by the development of innovations such as digital projects, gamification, and multimedia integration in problem-based learning. In addition, teachers are also trained to be able to use Google Classroom, WhatsApp Group Education, or interactive videos as a medium of interaction with students and parents; so that we understand that technology is not the end goal, but a means to achieve dignified and student-centered education.

(Participant#3)

The results of discussions with participants showed that the implementation of the 5C-Based Technology Adaptation model in the field was carried out through a structured but flexible approach, so that it can be adjusted to the school context, teacher characteristics, and technological infrastructure readiness. This approach focuses on a mentoring process that integrates five main elements (Character, Creativity, Collaboration, Communication, Critical and Innovative) into teachers' daily practices in developing technology-based pedagogical competencies. Through the implementation of this model, teachers showed improvements in their ability to design and utilize digital media pedagogically, independent learning initiatives in developing ICT for learning, the ability to collaborate and share with colleagues, reflective and innovative abilities in technology-based learning, critical attitudes towards ethics and the relevance of using technology in the classroom context. The implementation of the 5C-Based Technology Adaptation model encourages the transformation of the role of teachers from mere technology users to active learners, reflective educators, and learning innovators. This approach has proven to be adaptive and applicable at various levels of education, and supports the improvement of pedagogical competencies in a real and sustainable manner.

4.5 What are the characteristics of effective implementation of the 5C-based technology adaptation model design in the field?

The characteristic that the implementation of the 5C-Based Technology Adaptation Model design in the field is running effectively can be recognized through indicators that are visible both in the process and the results.

The successful implementation of the 5C-Based Technology Adaptation Model is reflected through a number of consistent indicators in teacher practice and learning dynamics. First, teachers demonstrate the integration of digital values and ethics in the selection and use of technology, reflecting the strengthening of character aspects. Second, there is an increase in teacher initiative and independence in exploring and adapting technology independently, without relying on external training. Third, an active learning community is formed, marked by collaboration, sharing good practices, and providing constructive feedback in facing digital challenges.

(Participant #1)

Teachers are starting to utilize technology optimally as a two-way communication medium with students, parents, and fellow teachers, as demonstrated by increased student participation and openness to input. In addition, teachers are able to think critically in choosing technology that is relevant to learning objectives and student needs, as well as designing digital learning innovations that are adaptive, interesting, and have a positive impact on strengthening pedagogical competence.

(Participant #2)

> *Overall, this model encourages the transformation of teaching practices to be more reflective, collaborative, and meaningful, with technology integration that is not merely a formality, but rooted in the awareness of teachers' professional values and independence. Teachers demonstrate awareness of digital values and ethics and independently and collaboratively in selecting and using learning technologies, reflecting the integration of real character aspects to explore and adapt new technologies.*

(Participant #3)

The results of discussions with participants indicated that the success of the implementation of the 5C-Based Technology Adaptation Model can be seen from the increase in teacher initiative and independence in exploring and adapting technology, without relying on external training that can improve character, independence, collaboration, communication, critical thinking of students that can trigger their innovation. An active learning community was also formed with collaboration, sharing good practices, and constructive feedback in facing digital challenges. Teachers are also able to choose relevant technology, design adaptive and interesting digital learning innovations, and integrate digital values and ethics into learning practices.

5. Discussion of Findings

These findings support previous research findings that a holistic and value-oriented approach can support meaningful technology adoption (2-3; 32-33; 36; 38; 44). The successful implementation of the 5C-Based Technology Adaptation Model is seen in the increase in teacher initiative and independence in exploring and adapting technology independently, without relying on external training. In addition, the evaluation results show the formation of an active learning community, characterized by collaboration, sharing good practices, and providing constructive feedback in facing digital challenges (47). Furthermore, teachers are able to think critically in choosing technology that is relevant to learning objectives and student needs, and design digital learning innovations that are adaptive, interesting, and have a positive impact on strengthening pedagogical competence (43; 46; 50-51). Teachers demonstrate awareness of digital values and ethics and independently and collaboratively in choosing and using learning technology, reflecting the integration of character aspects in real terms to explore and adapt new technologies.

This research provides significant contributions both theoretically and practically in the field of education, especially in the development of teachers' pedagogical competence in the digital era (12; 26; 43; 46; 50). Theoretically, this research enriches the study of educational technology adaptation by offering an integrated model with the 5C approach which has not been widely discussed in the framework of learning technology adaptation (14; 20-21; 49; 53). This model also reconceptualizes teacher pedagogical competence as an ability that includes not only aspects of content mastery and learning strategies, but also awareness of values and character in the wise use of technology (15; 26; 28; 39; 42). Practically, the results of this study provide implementation guidance for teachers and educational institutions in adopting technology in a more meaningful and humanistic way.

This model can be adapted in teacher training programs, professional competence improvement workshops, and digital transformation policies in education that prioritize integrity and ethics. In addition, the social contribution of this model is seen through its encouragement of the formation of a

positive and characterful digital culture in the school environment (3; 5; 36; 44). This condition shows that teachers are not only users of technology but also agents of change in building a sustainable and civilized education ecosystem (2; 32-33; 38). This study offers novelty in the form of an educational technology adaptation model based on the 5C approach as an effort to optimize teacher pedagogical competence. Unlike conventional approaches that focus on technical mastery of technology, this model combines 21st-century character values with digital transformation to improve learning effectiveness and the quality of teacher professionalism (3; 7; 39; 42).

6 Conclusion, Recommendations and Suggestions

6.1 Conclusion

The 5C-based technology adaptation model has proven effective in improving teachers' pedagogical competence. This approach is relevant to the challenges of 21st-century education. This study provides significant contributions both theoretically and practically in the field of education, especially in developing teachers' pedagogical competence in the digital era. Theoretically, this study enriches the study of educational technology adaptation by offering a model integrated with the 5C approach which has not been widely discussed in the framework of learning technology adaptation. This model also reconceptualizes teachers' pedagogical competence as an ability that not only includes aspects of content mastery and learning strategies, but also awareness of values and character in the wise use of technology. Practically, the results of this study provide implementation guidelines for teachers and educational institutions in adopting technology in a more meaningful and humanistic way. This model can be adapted in teacher training programs, professional competence improvement workshops, and digital transformation policies in education that prioritize integrity and ethics.

The social contribution of this model is seen through its encouragement of the formation of a positive and characterful digital culture in the school environment, so that teachers are not only users of technology, but also agents of change in building a sustainable and civilized education ecosystem. This study offers novelty in the form of an educational technology adaptation model based on the 5C approach as an effort to optimize teacher pedagogical competence. Unlike conventional approaches that focus on technical mastery of technology, this model combines 21st century character values with digital transformation to improve learning effectiveness and the quality of teacher professionalism. Teachers showed improvements in terms of their ability to design and utilize digital media pedagogically, independent learning initiatives in developing ICT for learning, the ability to collaborate and share with colleagues, reflective and innovative abilities in technology-based learning, critical attitudes towards the ethics and relevance of using technology in the classroom context.

6.2 Recommendations

This model can be used as a reference in teacher training programs by education departments and professional training institutions.

6.3 Research Limitations

This research is still limited to a small scale and requires further testing in various educational contexts.

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