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Teacher Competencies in the Era of the Industrial Revolution 4.0: Transformation of Roles, Digital Skills, and Challenges of 21st-Century Education

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Abstract

The Industrial Revolution 4.0 era has brought major disruption, changing the educational landscape through the integration of digital technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT). These changes demand a fundamental transformation of the teacher's role, from a mere deliverer of material to a dynamic learning facilitator. This study aims to analyze the transformation of the teacher's role, the mastery of digital skills, as well as the challenges and strategies in facing 21st-century education. The research method used is a literature study (library research) by analyzing various relevant scientific sources. The results show that teachers in the digital era must master Technological Pedagogical Content Knowledge (TPACK), data literacy, and social-emotional learning (SEL) skills to create student-centered learning. The main challenges identified include technological infrastructure gaps and the need for continuous training. As a strengthening strategy, higher education institutions play a central role in shaping the character and work ethic of future educators, while teachers must adopt a lifelong learning mindset. The conclusion of this article emphasizes that the success of educational transformation depends on the synergy between technological sophistication and the cultivation of strong character values.

Keywords: *Industrial Revolution 4.0, Teacher Competence, Digital Skills, Educational Transformation, Facilitator.*

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INTRODUCTION

The Industrial Revolution 4.0 has brought significant disruption that has fundamentally transformed the educational landscape through the integration of advanced technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and big data. This era requires the education sector to adapt rapidly in order to ensure that learning processes remain relevant to global developments. Teachers, as central actors in education, are now at a critical point where they must redefine their existence and roles, no longer merely acting as transmitters of information but as drivers of innovation within a technology-based learning ecosystem (Soleh, 2025: 186).

These changes have shifted the traditional teaching paradigm, which tends to be teacher-centered, toward a student-centered learning model. In the digital era, information can be accessed by students anytime and anywhere,

meaning that teachers no longer monopolize academic knowledge. This transformation requires teachers to facilitate 21st-century skills, including critical thinking, creativity, collaboration, and communication, in order to equip students with competencies aligned with the demands of the modern workforce (Yani, 2024: 68).

However, the transformation of teachers' roles is not without challenges. Various obstacles remain, ranging from gaps in digital literacy to unequal access to technological infrastructure. A key challenge is how to balance the sophistication of digital tools with the cultivation of character values and ethics among young learners. Teachers are required to become creative individuals who can utilize digital platforms as tools for shaping students' moral development, ensuring that technology strengthens the humanistic aspects of education rather than replacing them (Mukaromah & Ningsih, 2024: 51).

In addition to technical challenges, strengthening teacher competencies also depends heavily on institutional policies and educators' willingness to engage in lifelong learning. Higher education institutions have a strategic responsibility to cultivate work ethics and discipline among prospective teachers from an early stage so that they are prepared to face the dynamic changes brought about by industrial transformation (Fatimah et al., 2023: 1). Therefore, a comprehensive strategy is required that integrates technological mastery with strong pedagogical foundations so that education in Indonesia can produce a golden generation that is competitive at the global level.

RESEARCH METHOD

This study employs a library research method using a qualitative descriptive approach. The main focus in preparing this article is to conduct an in-depth review by comparing various scientific journals, academic books, and policy documents that have been previously published. This research does not involve direct field data collection; instead, it explores and synthesizes ideas and findings from relevant literature concerning teacher competencies, educational transformation, and challenges in the era of the Industrial Revolution 4.0.

By comparing findings from these literature sources, this study aims to provide a comprehensive overview of strategies for strengthening the role of educators in the 21st century.

RESULTS AND DISCUSSION

Result

Based on the literature review, three main points were identified regarding teacher readiness in the digital era:

1. Competency Shift – Teachers are now required to master Technological Pedagogical Content Knowledge (TPACK) so that technology is not merely used as a tool but is integrated into teaching methods and learning processes (Alexia, 2025: 1).
2. Digital Literacy Gap – There is still a disparity in digital competencies among educators, along with limitations in technological infrastructure in certain regions (Mutaqin et al., 2025: 10).

Table 1. Comparison of Traditional Teacher Roles vs Teacher Roles in the Industry 4.0 Era

Characteristic	Traditional Role	Role in the Industry 4.0 Era
Learning Center	Teacher-centered	Student-centered
Learning Media	Textbooks	Multimedia & Artificial Intelligence
Learning Objective	Knowledge Transfer	Character Development & 4C Skills

Discussion

Transformation of Teachers' Roles in the Era of the Industrial Revolution 4.0

The Industrial Revolution 4.0 has brought very rapid fundamental changes through the integration of digital technologies, such as Artificial Intelligence (AI) and the Internet of Things (IoT), into all aspects of life, including the field of education. These changes require the education sector to carry out large-scale adaptations in order to remain relevant to the continuously evolving global dynamics. Teachers, as the front line in the learning process, now face both challenges and opportunities to redefine their existence. Amid this wave of disruption, the role of teachers is no longer merely to be the primary source of knowledge for students, but must transform into the main driving force within a technology-based learning ecosystem (Soleh, 2025: 186–187).

One of the most prominent aspects of this transformation is the shift in the teacher's role from an instructor to a facilitator and motivator of learning. In an era where information can be easily accessed through the internet, teachers no longer monopolize academic truth. Instead, teachers must be able to facilitate students in filtering, analyzing, and utilizing information critically. Teachers play a role in creating an inspiring learning environment in which students are encouraged to explore their own potential through more personal and adaptive approaches (Yani, 2024: 68).

In addition to role changes, teachers in the 4.0 era are also required to master 21st-century skills known as the 4C, namely critical thinking, creativity, collaboration, and communication. Teachers are not only required to teach these skills to students but must also be able to practice them in daily teaching methods. The ability to design innovative learning based on real problem solving has become a new competency standard. This aims to ensure that graduates produced have high competitiveness and are able to adapt to the increasingly complex needs of the modern workforce (Syarif & Janata, 2024: 1).

The integration of digital technology into the curriculum is an inevitability that must be faced by every educator. Teachers are expected to be able to utilize digital platforms and interactive learning media to improve the quality and efficiency of the teaching and learning process. This transformation also includes the use of data to monitor student progress more accurately so that educational interventions can be carried out more precisely. By mastering adequate digital literacy, teachers can help students navigate the digital world wisely and productively (Fitrianti et al., 2024: 29).

This transformation of roles does not only stop at the technical aspect as digital facilitators but also includes strengthening the aspect of religiosity in the learning process. Teachers in the digital era have a great responsibility to build

student competencies based on character values, particularly Islamic values, in order to protect them from the negative impacts of information openness. Effective strategies involve optimizing technology as a means of da'wah and polite education so that students are not only digitally intelligent but also possess strong spiritual stability (Utami et al., 2025: 15).

However, this role transformation is not without obstacles, because there are still real challenges such as the digital literacy gap and limited infrastructure in various regions. Many teachers still feel difficulties integrating technology into teaching practices due to the lack of continuous training. Therefore, strong institutional support and the willingness of educators to continuously develop themselves are needed. Consistent professional development is the key so that teachers do not merely become spectators of technological change, but become active actors who are able to lead innovation in the classroom (Soleh, 2025: 188).

The transformation of teachers' roles in the era of the Industrial Revolution 4.0 is a journey toward a more open and adaptive mindset (growth mindset). The success of education in the future greatly depends on the ability of teachers to align technological sophistication with the cultivation of character values and ethics. Great teachers in this era are those who are able to continue learning throughout life and view technology as a tool to strengthen humanity, not replace it. Thus, this transformation process is expected to create a future generation that is excellent, creative, and ready to face the challenges of the times.

Teachers' Digital Skills in 21st-Century Learning

Teachers' digital skills in 21st-century learning have now become a major pillar in facing technological disruptions brought by the Industrial Revolution 4.0. In this era, teachers are required to have technical abilities in operating various digital devices and integrating them into the teaching and learning process. Mastery of information technology is no longer merely an added value, but a basic necessity so that teachers can manage abundant information and facilitate learning access for students. This transformation creates an educational ecosystem in which learning resources can be accessed anytime and anywhere without being limited by the physical classroom space (Dito & Pujiastuti, 2021: 59).

In addition to technical aspects, the essence of teachers' digital skills lies in their ability to facilitate the needs of Generation Alpha who are very familiar with technology. Teachers must be able to design learning materials that are not only informative but also interactive and relevant to students' lives. This includes the use of Artificial Intelligence and big data processing to understand students' learning styles more personally. With adequate digital skills, teachers can turn technological challenges into opportunities to improve the quality of national education (Amrullah et al., 2024: 1313).

Digital skills also play a strategic role in fostering future competencies for students, especially those related to 4C skills. Through the use of collaborative platforms, teachers can train students to work together in teams across distances, communicate effectively in cyberspace, and think critically about the flow of existing information. Teachers who have high digital literacy will more easily direct students to become creators of solutions to various social problems around them, not merely passive users of available technology (Amrullah et al., 2024: 1314).

Furthermore, the aspect of teachers' creativity in the digital world greatly determines the success of students' character formation. Creative teachers are able to utilize social media and various multimedia content as interesting educational tools while still containing ethical values. Amid the challenge of moral degradation in the digital era, teachers must be present as role models who demonstrate how technology can be used wisely and productively. The integration between religious values and technological sophistication has become a new standard for teacher professionalism in the 21st century (Mukaromah & Ningsih, 2024: 51).

The application of digital skills also has implications for the efficiency of learning management in schools. Teachers who are skilled in using digital devices can conduct evaluations of learning outcomes more quickly, accurately, and transparently through online assessment systems. The use of a Learning Management System (LMS) allows teachers to monitor the development of each student's competencies continuously. This efficiency provides more space for teachers to focus on interpersonal interaction and emotional guidance for students, which remain roles that cannot be replaced by machines (Dito & Pujiastuti, 2021: 61).

However, the journey toward equal mastery of digital skills still faces challenges in the form of infrastructure and literacy gaps in various regions. Many teachers require continuous training in order to keep up with the very dynamic development of technology. Therefore, mental readiness or a lifelong learning mindset becomes the main capital for teachers to remain relevant. Institutional support and collaboration among educators are highly needed to ensure that every teacher has sufficient capacity to equip students with competencies that match the demands of the modern labor market (Sulistyanto et al., 2021: 25).

Mastery of technology by teachers must also be directed toward the development of holistic professionalism. Teacher professionalism in the digital era can be improved through active participation in professional discussions and collaboration among educators to solve ICT-based learning problems. Adequate digital skills allow teachers to implement more effective learning models, but their success still requires an approach that combines technical, educational, and spiritual aspects in a balanced manner (Putry et al., 2025: 16).

Strengthening teachers' digital skills ultimately aims to transform the educational paradigm into one that is more inclusive and innovative. Teachers no longer merely transfer theory in a one-way direction, but are able to create active and enjoyable learning experiences through digital simulations and technology-based projects (Nursyifa, 2019: 51). By aligning the sophistication of digital tools with the depth of knowledge, teachers can help students navigate an uncertain future with confidence. The success of this transformation will become the main foundation for the birth of a future generation that is excellent and competitive at the global level.

Teacher Competence in 21st-Century Education

Teacher competence in 21st-century education is the main foundation in facing the shift in the learning paradigm triggered by the massive advancement of digital technology. In this era, teachers no longer only act as deliverers of subject matter, but must also have the capacity to integrate information and communication

technology (ICT) into learning design. Mastery of digital tools, such as online learning platforms and artificial intelligence, has become a fundamental necessity so that teachers can create a flexible learning ecosystem. Thus, the educational process can take place without the limitations of space and time, allowing students to access learning resources from various parts of the world instantly (Dito & Pujiastuti, 2021: 59).

One crucial aspect of 21st-century competence is the teacher's ability to facilitate the 4C skills, namely critical thinking, creativity, collaboration, and communication in students. Teachers must be able to design learning scenarios that challenge students to solve complex problems innovatively. This requires teachers to move beyond conventional lecture methods and shift toward more active and student-centered approaches. Through this competence, teachers act as architects of learning experiences who help students develop sharp logical thinking to face future uncertainties (Soleh, 2025: 187).

Information and media literacy skills have also become mandatory competencies for professional teachers today. Amid the flood of digital information, teachers must have the ability to verify the accuracy of data sources and teach digital ethics to students. This competence is very important to ensure that technology is used as a productive educational tool rather than becoming a source for the spread of hoaxes or negative content. Teachers who possess strong media literacy will be able to guide students to become creative and responsible content producers in cyberspace (Amrullah et al., 2024: 1313).

In addition to cognitive and technical aspects, social and emotional competence remains the essence of the teaching profession that cannot be replaced by technology. Teachers in the 21st century must have high empathy and strong interpersonal communication skills to build harmonious relationships with students. In a digital era that tends to be individualistic, the role of teachers as motivators and inspirers becomes very vital in maintaining students' mental well-being. Teachers are expected to create an inclusive and supportive classroom atmosphere where every student feels valued in their developmental process (Yani, 2023: 68).

The integration of character education into the digital curriculum is another competence that is highly emphasized. Creative teachers are required to be able to incorporate moral values, ethics, and religiosity through modern learning media that are attractive to the younger generation. A major challenge in the era of the Industrial Revolution 4.0 is how to maintain students' cultural identity and moral integrity amid the flow of globalization. Therefore, teacher competence in designing content that contains educational messages while remaining relevant to current developments becomes the key to the successful formation of the character of the next generation (Mukaromah & Ningsih, 2024: 51).

Continuous competence improvement or lifelong learning becomes an absolute requirement for teachers to remain relevant to the demands of the times. Teachers must possess a growth mindset that encourages them to continuously update their knowledge and skills independently as well as collaboratively. The rapid dynamics of industrial development often create a gap between the school curriculum and labor market needs. By continuously learning, teachers can bridge this gap and equip students with technical competencies and adaptive abilities required in the digital work environment (Sulistyanto et al., 2021: 25).

All of these competencies ultimately lead to efforts toward a more meaningful and impactful transformation of education. Competent teachers in the 21st century are those who are able to synergize the sophistication of technological tools with deep pedagogical knowledge to produce learning that stimulates curiosity. The success of an educator is now measured by the extent to which they can inspire their students to become resilient independent learners. With comprehensive mastery of competencies, teachers will remain the main pillar in producing an excellent golden generation at the global level.

Teachers' Challenges in Facing the Industrial Revolution 4.0

The Industrial Revolution 4.0 has brought major disruptions that fundamentally change the educational landscape. This era is characterized by the massive integration of digital technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT), which require teachers not only to act as knowledge transmitters but also as digital navigators for their students. The challenges faced by teachers are not limited to technical abilities but also involve mental readiness, shifts in teaching paradigms, and the ability to maintain moral integrity amid the rapid flow of digital information (Mutaqin et al., 2025: 1).

Some of the main challenges faced by teachers in this era include:

1. Digital Literacy Gap and TPACK Competence
   Many teachers still face obstacles in effectively integrating technology into teaching practices. The main challenge lies in mastering Technological Pedagogical Content Knowledge (TPACK), which is the ability to align subject knowledge, teaching methods, and the appropriate use of digital tools so that learning remains meaningful (Alexia, 2025: 1).
2. Changing Role into Facilitator
   Teachers are challenged to abandon their traditional role as the center of knowledge and shift toward becoming facilitators. This requires the ability to manage more dynamic and student-centered classrooms, where teachers must guide students to independently find and filter information in the digital world (Soleh, 2025: 187).
3. Dynamic Curriculum Adaptation
   The implementation of new curricula, such as the Merdeka Curriculum in Indonesia, requires teachers to be more flexible and creative in designing teaching modules that are relevant to industrial needs. This challenge often arises due to administrative obstacles and the lack of time to explore innovative learning media (Yanti et al., 2024: 1).
4. Infrastructure and Technology Access Gap
   In many regions, the real challenge faced is the uneven access to the internet and the availability of adequate digital devices. This often creates disparities in the quality of education and increases the workload of teachers in order to continue providing fair educational services despite limited facilities (Mutaqin et al., 2025: 10).
5. Character Building in the Digital Era
   Another significant challenge is maintaining students' morality and ethics amid open access to information. Teachers are required to become creative figures who are able to integrate character values through digital platforms

so that students are not only intellectually intelligent but also possess strong personal integrity (Mukaromah & Ningsih, 2024: 51).

6. The Need for Continuous Training
   There is a significant gap between the competencies currently possessed by teachers and the demands of the digital era. This creates a challenge for teachers to continuously engage in professional development through structured and sustainable training in order to minimize this gap (Sofiawati et al., 2025: 731).
7. Implementation of the Merdeka Curriculum in Religious-Based Schools
   Another challenge is how teachers in madrasahs or religion-based schools implement the Merdeka Curriculum amid limited digital facilities. Teachers are required to be creative in integrating digital learning media that remain aligned with moral values. Strategies to strengthen teacher competence must include motivation for continuous development so that teachers are able to face the challenges of digitalization without losing their identity as humanistic educators (Utami et al., 2025: 17).

Overall, these challenges require educators to adopt a lifelong learning mindset. Teachers must not only become observers of technological change but must become active actors who are capable of transforming digital challenges into opportunities for innovation in order to improve the quality of human resources in the future.

Strategies for Strengthening Teacher Competence in the Digital Era

Strategies for strengthening teacher competence in the digital era must be viewed as a systematic effort involving various stakeholders, ranging from higher education institutions to government policies. Universities play a central role as creators of scholars and shapers of personal discipline for prospective educators, where competence strengthening does not only target technical aspects but also the development of work ethics and leadership. Through strong partnership collaboration, educational institutions can produce graduates who are not only academically excellent but also possess high integrity and creativity in facing the rapid changes of the industrial world (Fatimah et al., 2023: 1).

Professional development for teachers in this era must focus on mastering the Technological Pedagogical Content Knowledge (TPACK) framework. This strategy emphasizes the importance of alignment between subject matter understanding, effective pedagogical methods, and the appropriate use of technology. By mastering TPACK, teachers can transform traditional classrooms into more interactive and student-centered learning environments. Strengthening this competence enables teachers to select the most relevant digital tools to increase student engagement and overall instructional effectiveness (Alexia, 2025: 1).

In addition to technical aspects, strategies for strengthening competence must also address the social-emotional dimension or Social-Emotional Learning (SEL). Amid the increasing use of machines and artificial intelligence, the role of teachers as figures who provide emotional support and moral guidance becomes increasingly vital. Competent teachers in the digital era are those who are able to balance technological sophistication with empathy in understanding students' psychological needs. This strategy aims to ensure that technology does not distance human interaction in schools, but instead strengthens the relationship

between educators and students through more open communication (Alexia, 2025: 2).

The implementation of continuous and targeted training becomes a key strategy to overcome the existing gap in digital literacy. Teacher training should be designed based on real needs in the field, rather than merely formal programs that are general in nature. The focus of training should include the ability to manage big data to monitor student development as well as the utilization of innovative multimedia-based learning media. With consistent institutional support, teachers will feel more confident in exploring various digital innovations that can facilitate both administrative tasks and their teaching activities (Sofiawati et al., 2025: 731).

Strategies for strengthening competence also greatly depend on the development of a lifelong learning mindset among educators. Teachers must not feel satisfied with their current abilities, considering that technologies such as the Internet of Things (IoT) and artificial intelligence continue to evolve. The motivation to continuously improve oneself independently through literature and professional practice communities will help teachers remain relevant to the characteristics of future generations. This adaptive mindset becomes the main capital for teachers to transform every technological challenge into an opportunity to create enjoyable learning innovations (Soleh, 2025: 187).

Infrastructure support and regulations that encourage innovation are also inseparable parts of strategies for strengthening competence. Without adequate technological access, digital competence training carried out by teachers will be difficult to implement optimally in the classroom. Governments and educational institutions need to ensure that every teacher has equal facilities to practice their digital skills. In addition, flexible curricula such as the Merdeka Curriculum provide space for teachers to experiment with technology-based teaching methods that are most suitable for the local conditions of their students (Mutaqin et al., 2025: 10).

Long-term strategies to strengthen teacher competence involve the active role of universities in instilling personal discipline and a strong work ethic from the period of teacher education. Collaborative partnerships between universities and schools are highly necessary to create adaptive learning innovations. By strengthening digital literacy and integrating technology into daily educational practices, teachers can bridge existing competence gaps and ensure that the quality of education remains maintained amid the flow of global disruption (Putry et al., 2025: 18).

Ultimately, strengthening teacher competence in the digital era aims to create an inclusive and high-quality transformation of education. Competent teachers are expected to bridge the gap between theoretical knowledge and real practices in the industrial world. By synergizing values of honesty, discipline, and technological mastery, teachers will remain an irreplaceable pillar in producing a future generation that is competitive on the global stage. The success of this strategy will determine how far our education system is able to adapt and excel amid the uncertainties of the Industrial Revolution 4.0.

CONCLUSION

The success of educational transformation in the era of the Industrial Revolution 4.0 is fundamentally determined by teachers' ability to harmonize

technological advancement with the cultivation of strong character values. By integrating digital competence, 4C skills—critical thinking, creativity, collaboration, and communication—and strong moral integrity, teachers can equip students with the capacity to navigate an increasingly complex and uncertain future with confidence and resilience. Therefore, collective and sustained efforts from various stakeholders are essential to strengthen teachers' capacity, ensuring that Indonesian educators are well prepared to nurture a golden generation that is not only academically excellent but also globally competitive and ethically grounded.

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