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TEACHER LITERACY NEEDED IN AN AI ERA FOR FUTURE ELEMENTARY SCHOOL TEACHERS IN INDONESIA: A SYSTEMATIC LITERATURE REVIEW

Muhammad Arief Budiman[1)], Nyan-Myau Lyau[2)]

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[1 2] College of humanities and applied sciences, National Yunlin University of Science and Technology

Abstract

The integration of Artificial Intelligence (AI) into education is reshaping the competencies required of elementary school teachers, particularly in Indonesia. This study employs a systematic literature review (SLR) to identify the core and emerging competencies essential for future elementary educators in an AI-driven era. Guided by the PRISMA framework, the review analyzed 63 relevant studies from 2020 to 2025 across multiple countries, with a significant focus on Indonesian contexts. Key competencies identified include pedagogical, personality, social, and professional dimensions, as well as specialized skills such as digital literacy, technological-pedagogical content knowledge (TPACK), metacognitive understanding, and adaptability to educational change. The findings emphasize the increasing importance of innovation, inclusion, and AI ethics awareness in teacher preparation programs. In term of pedagogical approach, in the AI era, Indonesian elementary school teachers must adopt student-centered, technology-integrated pedagogies—such as personalized, collaborative, and blended learning—while leveraging AI for data-driven instruction, fostering digital ethics, and engaging in continuous professional development to meet diverse student needs and prepare them for a complex, evolving world. This research contributes to educational policy and curriculum development, offering evidence-based insights for reforming teacher education and professional development to align with technological advancements and the demands of the Society 5.0 era..

Keyword*: Teacher Competencies, Elementary School Teachers, Systematic Literature Review, Core Teaching Competencies, Future Teacher Skills*

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Coressponding Author:
Jl. Jaten baru 3 no 6 Semarang 50192 Indonesia.
E-mail: [1] absolutegreen@gmail.com

INTRODUCTION

The rapid development of Artificial Intelligence (AI) is transforming various sectors, including education (du Plessis et al, 2014; Nyshanova et al, 2014; Otajanov, 2024). In Indonesia, the integration of AI in elementary education presents new opportunities and challenges for teachers (Atmono, 2017; Rosni, 2021; Yuwono, 2021). To ensure effective teaching and learning processes, it is crucial to identify the core competencies required for future elementary school teachers (Aulia, 2023; Das, 2018; Romy, 2021). This research proposal aims to conduct a systematic literature review (SLR) to analyze existing studies on the competencies needed in an AI-driven educational landscape.

The rapid development of Artificial Intelligence (AI) is reshaping various sectors, including education (Lim, 2025; Halimahturrafiah, 2023; Ayapbergenova, 2020). AI-driven technologies, such as adaptive learning systems, automated assessments, and intelligent tutoring programs, are increasingly being integrated into classrooms worldwide (Matvienko, 2022; Hirt, 2025; Demszky, 2025). These advancements present both opportunities and challenges for educators, particularly at the elementary level, where foundational learning takes place (Abdurasulova, 2023; Zhaukumova, 2021; Griban, 2020). As AI continues to evolve, it is essential to examine how it impacts teaching methodologies and the competencies required by teachers to navigate this transformation effectively (Shchur, 2024; Muliati, 2021; Hamonangan, 2025).

In Indonesia, the integration of AI in elementary education is gradually gaining traction, influenced by global trends in digital learning (Hardinata, 2021; Syahid, 2022; Qian, 2024). The government's push for digitalization in schools, combined with the increasing availability of AI-powered educational tools, necessitates a shift in teachers' roles (Dadakina, 2020; Sayfullina, 2020; Kyrpychenko, 2021). Educators are no longer just knowledge providers but also facilitators who must adapt to AI-enhanced learning environments (Tudor, 2015; Rasmitadila, 2023; Le et al, 2024). However, many teachers may lack the necessary skills to maximize AI's potential in the classroom (Kukk, 2012; Supa'at, 2023; Sultanbek, 2015). Understanding the competencies they need is crucial for preparing future educators.

To ensure effective teaching and learning in an AI-driven educational landscape, identifying the core competencies required for elementary school teachers is imperative (Sirotová, 2016; Daineko, 2020; Prayitno, 2023). These competencies may include digital literacy, AI ethics awareness, data-driven decision-making, and the ability to personalize instruction using AI tools (Lebid, 2023; Bilier, 2023; Bauersfeld, 2025). Without proper training and skill development, teachers may struggle to integrate AI effectively, leading to gaps in learning outcomes (Jannah, 2024). Addressing this issue requires a comprehensive review of existing research on teacher competencies in AI-enhanced education.

The relevance of this research lies in the growing impact of Artificial Intelligence (AI) on the education sector, especially in elementary schools. As AI-driven tools like adaptive learning systems, intelligent tutoring, and automated assessments become more prevalent, teachers must adapt their instructional methods and professional competencies. In Indonesia, educational reforms such as the Merdeka Curriculum emphasize digital integration and personalized learning, underscoring the need for teachers to be equipped with relevant skills.

This study responds directly to these changes by identifying the competencies elementary school teachers need to thrive in AI-enhanced classrooms, making it highly applicable to current educational realities.

The urgency of the research is grounded in the increasing demand for immediate changes in teacher preparation and professional development. Many Indonesian teachers, particularly in under-resourced areas, still lack the digital literacy and pedagogical adaptability required to effectively incorporate AI in the classroom. Without timely intervention, these gaps could exacerbate educational inequalities and limit the effectiveness of ongoing curriculum reforms. Furthermore, as AI introduces new ethical considerations—such as digital responsibility, data privacy, and algorithmic fairness—teachers must be prepared to guide students through these complexities. This research provides critical insights to help address these pressing challenges.

What sets this research apart is its comprehensive and systematic approach. By conducting a systematic literature review of 63 recent studies from 2020 to 2025, the research presents a clear thematic framework outlining nine key areas of teacher competencies, ranging from core pedagogical skills to AI ethics and inclusive teaching strategies. Its unique contribution lies in combining global perspectives with a strong focus on the Indonesian context, providing both breadth and depth. In doing so, the study not only enriches academic discourse but also offers actionable recommendations for educational policy-makers, curriculum developers, and teacher training institutions to ensure that elementary school teachers are well-prepared for the AI-driven future.

This research proposal aims to conduct a systematic literature review (SLR) to analyze existing studies on the competencies needed for future elementary school teachers in Indonesia. By synthesizing findings from previous research, this study seeks to identify key skills, knowledge areas, and pedagogical approaches that educators must develop. The SLR methodology will provide a structured and evidence-based understanding of the topic, offering insights into how teacher education programs can be adapted to meet AI-related demands.

This research will answer three research questions: (a) What key skills needed by elementary school teachers in AI era? (b) What knowledge areas needed by elementary school teachers in AI era? (c) What pedagogical approaches must be developed by elementary school teachers in AI era?.

METHOD

This study employs a systematic literature review (SLR) approach to examine the core competencies required for elementary school teachers in the AI era. The SLR method ensures a structured, replicable, and comprehensive assessment of existing literature on the topic. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, this review involves a systematic search, selection, and synthesis of relevant studies. The objective is to identify key competencies, trends, and challenges that elementary school teachers must address in the evolving landscape of artificial intelligence in education.

The data collection process began with defining inclusion and exclusion criteria. Studies included in the review were published between 2015 and 2024, focusing on AI-related

competencies for elementary school teachers. Peer-reviewed journal articles, conference papers, and reputable reports were considered, while opinion pieces, non-academic sources, and studies unrelated to elementary education were excluded. The search was conducted using multiple academic databases, including Scopus, Web of Science, ERIC, and Google Scholar, utilizing keywords such as “elementary school teacher competencies,” “AI in education,” “teacher professional development in AI,” and “future teaching skills.”

The study selection process followed a three-stage approach: (1) initial screening based on title and abstract relevance, (2) full-text review to assess alignment with the research objective, and (3) quality appraisal using the Mixed-Methods Appraisal Tool (MMAT). Duplicates were removed, and studies that met the eligibility criteria were included for detailed analysis. Any discrepancies in the selection process were resolved through discussions among researchers to ensure accuracy and reliability.

For data extraction and synthesis, key information from the selected studies was systematically organized, including study objectives, research methods, identified competencies, and recommendations. A thematic analysis was conducted to categorize competencies into major themes such as digital literacy, AI ethics, adaptive teaching strategies, and technological integration. Patterns, gaps, and emerging trends were also identified to provide a comprehensive understanding of how AI is reshaping elementary education and teacher preparedness.

To ensure research rigor and validity, a critical appraisal of the selected literature was conducted. The credibility of sources, research methodologies, and findings were assessed to minimize bias. Additionally, inter-rater reliability was maintained by involving multiple researchers in the review process. The findings from this SLR contribute to the ongoing discourse on teacher education, offering insights into necessary skill sets for elementary school teachers to effectively navigate AI-driven educational environments.

The researcher aimed to identify relevant scholarly articles for their study by conducting searches in two prominent academic databases: Web of Science and Google Scholar. To ensure comprehensive coverage of the topic, they employed a specific set of keywords during their search process. These keywords included: Teacher competency, Teacher competencies, Elementary school, Indonesia, Elementary school teacher, Indonesian elementary school

By using these keywords, the researcher intended to retrieve articles that specifically address the topic of teacher competency (both singular and plural forms) within the context of elementary education in Indonesia. The inclusion of variations like "elementary school teacher" and "Indonesian elementary school" further broadens the search to capture a wider range of relevant studies. This systematic approach to keyword selection across reputable academic databases like Web of Science and Google Scholar helps the researcher gather a robust and relevant collection of literature for their investigation.

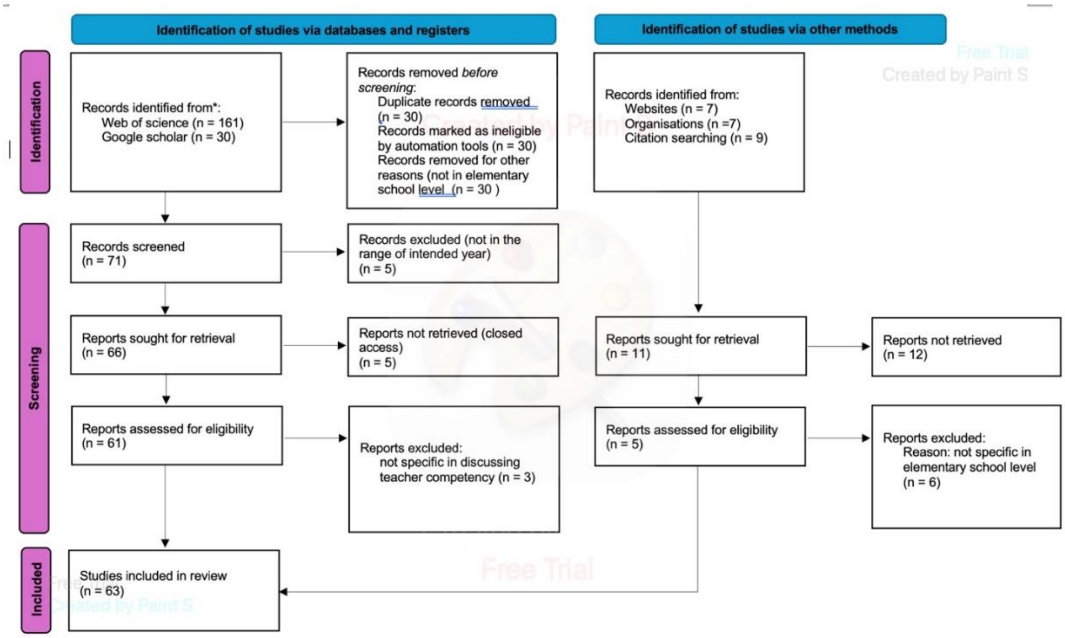


Fig 1 PRISMA screening overview styled after Liberati et al (2009) and Passow and Passow (2017)

The PRISMA flow diagram meticulously outlines the systematic process undertaken to identify, screen, and select relevant studies for a comprehensive systematic review. The initial phase, termed "Identification," details the sources and quantities of records retrieved. Through the exploration of databases and registers, specifically Web of Science (n=180) and Google Scholar (n=30), a total of 210 records were initially identified. Subsequently, a series of removals occurred before the formal screening process: 30 duplicate records were eliminated, another 30 records were flagged as ineligible by automation tools, and a further 30 records were excluded for not pertaining to the elementary school level. This process left 90 records to proceed to the subsequent screening stage. Concurrently, the identification of studies through other methodologies, including websites (n=9), organizations (n=9), and citation searching (n=10), yielded an additional 28 records.

The "Screening" phase involved evaluating the titles and abstracts of the identified records for their relevance to the research question. From the database and register search, 90 records underwent screening, resulting in the exclusion of 5 records that fell outside the intended year range. Consequently, the full texts of 85 reports were sought for retrieval. From the "other methods" search, 16 reports were sought for retrieval. However, access to some reports was limited, with 5 reports from the database/register search and 12 reports from the "other methods" search proving to be non-retrievable due to closed access.

The "Eligibility" stage focused on a thorough assessment of the full-text reports against predefined inclusion and exclusion criteria. Among the reports retrieved from the database and register search, 80 were assessed for eligibility, leading to the exclusion of 3 reports that did not specifically discuss teacher competency. From the "other methods" search, 10 reports were assessed for eligibility, with 6 being excluded for not being specific to the elementary school level.

Finally, the "Included" stage signifies the culmination of the selection process, indicating the studies that satisfied all the inclusion criteria and were incorporated into the systematic review. A total of 87 studies were included in the review, representing the final yield of the rigorous identification,

screening, and eligibility assessment phases. This PRISMA flow diagram provides a transparent and detailed account of the study selection process, ensuring the rigor and replicability of the systematic review.

RESULTS AND DISCUSSION

Result

Overview of Included Studies

Table 1 List of articles being discussed.

N0	**Authors**	**competencies**
1	Liudmila V. Daineko, Olga E. Reshetnikova	: The study focuses on the application of project-based learning to develop professional competencies in students, implying a need for teachers to be proficient in designing and implementing such educational methods.
2	Grygoriy GRIBAN, Olena NIKULOCHKINA, Olena VARETSKA, Daria SUPRUN	Information competency
3	Sydorenko Natalia, Borisenko Nataliia, Denysenko Veronika, Hrytsenko Iryna	Online competencies; key and professional competencies (including information and digital competence, competence of pedagogical partnership, ability to learn throughout life)
4	Victoria Y. Dadakina	Prognostic competence
5	Nadezhda A. Sayfullina	Prognostic competence
6	G. S. Ayapbergenova, S. A. Nurgalieva, N. A. Bisembaeva, M. P. Kabakova, M. N. Koishibaev	Project skills
7	Khaydarova M.N.	Professional communication competency
8	Tetiana Boliak	Professional competence of primary school teachers
9	Akhmedov Akmal Yusufovich & Egamberdiev Oyatillo Alisher ogli	Communicative competence
10	I Gede Dharman Gunawan, Pranata, I Made Paramarta, I Komang Mertayasa, I Made Pustikayasa & I Putu Widyanto	Pedagogic competence -Personality competence -Social competence -Professional competence
11	Sri Lestari Handayani, Trie Utari Dewi	Professional competence
12	Aceng Hasani, Dase Erwin Juansah, Indah Juwita Sari, and R. Ahmad Zaky El Islami	Teaching STEM concepts in an integrated way.
13	J. Slowik, M. Peskova, O. V. Shatunova, E. Bartus	Professional skills and competences of teachers for working in inclusive education.
14	Sh.S. Zhaukumova, N.N. Khanina, G.K. Tleuzhanova	Communicative competence
15	Lisdewi Muliati, Masduki Asbari, Multi Nadeak, Dewiana Novitasari, Agus Purwanto	The article investigates the general competency of elementary school teachers.
16	Rosni Rosni	Pedagogic, personality, social, and professional competencies
17	Imam Yuwono, Dewi Ratih Rapisa	Pedagogical competence
18	Elly Romy, Muhammad Ardansyah, & Hambali	Pedagogic competence

19	Soewarto Hardinata, Yudhie Suchyadi, Dian Wulandari	Technological literacy
20	Olena Kyrpychenko, Iryna Pushchyna, Yaroslav Kichuk, Nataliia Shevchenko, Olga Luchaninova, Viktor Koval	The document does not explicitly mention “teacher competency”.
21	Halyna A. Rusyn, Viktoriia V. Stynska, Liudmyla O. Matsuk, Yevheniia Y. Korostelova, Serhii P. Stetsyk	Professional competencies
22	Zhanara Zhumash, Aziya Zhumabaeva, Saniya Nurgaliyeva, Gulbanu Saduakas, Larisa Anatolevna Lebedeva, Saule Bazarbaevna Zhoraeva	Professional teaching competence
23	Castañeda, L, Esteve-Mon, FM, Adell, J, Prestridge, S	Holistic teaching competence in the digital era
24	Wandika Wita Susilowati & Suyatno	Educational Competence -Competence for Technological Commercialization -Competence in Globalization -Competence In Future Strategies -Counsellor Competence
25	Yulya Zhurat, Nina Rudenko, Adile Bekirova, Olena Borovets, Tetiana Doroshenko, & Tamara Skoryk	Professional, psychological-pedagogical and autopsychological types of competence, professionalism and willingness to work in the education system.
26	Servista Bukit, Ekayanti Tarigan	Pedagogic competence
27	Yudhie Suchyadi, Mira Mirawati, Fitri Anjaswuri, Dita Destiana	(pedagogic, personality, social and professional)
28	Aah Ahmad Syahid, Asep Herry Hernawan, Laksmi Dewi	Digital competence
29	Olena Nikulochkina, Olena Varetska, Olena Khaustova, Svitlana Pomyrccha, Svitlana Pokrova, Natalia Kravets	Focuses on further training of primary school teachers in the context of educational reforms.
30	Bulkani, M. Fatchurahman, H. Adella, & M. Andi Setiawan	The competency is to develop animation learning media based on local wisdom in online learning.
31	Olena Matvienko, Liudmyla Popova	Intercultural skills and global awareness -Flexibility and adaptability -Strategic and innovative thinking -Organizational skills and time planning -Ability to make decisions -Ability to work in a team -Empathy / ability to build relationships -Ability to solve problems -Training orientation -Negotiation skills -Leadership skills -The ability to collect and process information
32	Supa'at & Ihsan	Professional competencies in utilizing digital technology
33	Nur Halimahturrafiah, Sufyarma Marsidin, Anisah Anisah, Rifma Rifma	A set of knowledge, skills and behaviors that must be possessed, internalized and mastered by teachers in carrying out their professional duties.
34	Abdurasulova Shaira Kushakovna	Methodical competence.
35	Rasmitadila, R., Effane, A., Kurniasari, D., Erlina, E, & Sumarni, D	Teachers' awareness of increasing competency to achieve learning goals for all students
36	Harun Joko Prayitno, Novia Sari	Professional competence
37	Desi Aulia, Irda Murni, Desyandri	Pedagogic, personality, social, professional
38	Inna LEBID, Olena ANDRYUSHCHENKO, Larysa PETRYCHENKO, Nadiia SKRYPNYK, Nataliia VYSHNIVSKA, Yuliia ZUBTSOVA	Professional competence
39	Oksana Bilier, Viktor Reshetniak, Olha Vasko, Alina Drokina, Yuriy Klanichka, Svitlana Barda	Innovative competencies, including readiness for continuous education, self-directed learning, professional adaptability, critical thinking, and collaboration skills.

40	Alwen Bentri, Abna Hidayati	Digital pedagogy competence
41	Ivan Vasylykiv	ICT competence
42	Zhanna Zhakiyanova, Altnay Zhaitapova, Amangul Orakova, Shynargul Baizhekina, Vladimir Shnaider, Farida Nametkulova	Professional competencies and Technological Pedagogical Content Knowledge (TPACK) competencies
43	William H. Ndimbo and Hyasinta Kessy	Instructional competences
44	Hamidulloh Ibda, Ibnu Syamsi, Rukiyati Rukiyati	Professional competence, digital competence, pedagogical content knowledge
45	Agustinus Tanggu Daga, Dinn Wahyudin, and Rudi Susilana	Pedagogic, professional, personality, and social competence
46	Otajanov Islom Amatovich	Pedagogical competence, methodological knowledge, and practical experience.
47	Son Quang Le, Duyen Thi Le, Dieu Thi Thanh Bui, Bach Xuan Tran	This study investigates the competencies of primary school teachers in Da Nang city, with a specific focus on their abilities to advise and support students in educational activities.
48	Widia Nur Jannah, Mubiar Agustin, Rahman, Tatang Herman	The teacher's ability to understand student metacognition
49	I.M. Savchuk	Inclusive competence
50	Sun Qian, Ahmad Johari Bin Sihes	Teacher competence
51	Berdibay Turlybekov, Guldana Seidaliyeva, Bahytzhan Abiev, Lazura Kazyhankyzy	Professional-pedagogical competence
52	Viktoriia Andriivna Shchur, Anastasiia Sergiivna Malinoshevska, Igor Valentynovych Povorozniuk	Natural, acquired, self-education, adaptive, and performance
53	Tatik Tatik, Hoa Nguyen & Tony Loughland	Pedagogical, personal, social, and professional
54	Tabea Daria Eberli, Johannes Thaddäus Jud, Carmen Nadja Hirt, Amina Rosenthal, Yves Karlen	self-regulated learning (SRL) competencies
55	Demszky, D., Liu, J., Hill, H. C., Sanghi, S., & Chung, A.	Questioning quality
56	Jieun Lim, Unggi Lee, Junbo Koh, Yeil Jeong, Yunseo Lee, Gyuri Byun, Haewon Jung, Yoonsun Jang, Sanghyeok Lee, Jewoong Moon	problem-solving skills.
57	Nico Junjungan Hamonangan, Matin, Siti Zulaikha	Educational competence - Competence for technological commercialization - Competence of globalization - Competence in the future strategies - Counselor competence
58	Jasmin L. Bauersfeld, Bernadette Gold, and Manfred Holodynski	Knowledge about classroom management (KCM) and professional vision of classroom management (PVCM)
59	Thu Nguyen Trang Dinh, Hung Van Nguyen, Anh Thi Lan Vu, Phuong Minh Nguyen, Thu Thi Anh Nguyen, Long Thanh Phan	Teaching competence and educational competence
60	Lakshmana Rao Pinninti	Action-research competencies
61	Devinta Puspita Ratri, Sri Rachmajanti, Mirjam Anugerahwati, Ekaning Dewanti Laksmi & Agus Gozali	Developing an English syllabus that integrates local culture

62	Arttu Korkeaniemi, Eila Lindfors, and Leena Kiviranta	Individual competencies
63	Seonyoung Hwang, Sunyoung Han	Competencies in designing mathematical modeling tasks

The systematic review included a total of 63 studies, carefully selected through a rigorous process detailed in the PRISMA flow diagram. The initial search yielded 210 records from Web of Science and Google Scholar. After removing duplicates and excluding ineligible records, 90 studies remained. An additional 28 records were obtained from other sources, including websites, organizations, and citation searching. The screening and eligibility assessment phases further narrowed down the selection, resulting in the final set of 63 studies that met the inclusion criteria.

Table 1 presents a comprehensive list of the articles included in the review, showcasing a range of identified competencies. Despite the diversity in study titles and target countries, a unifying theme emerged upon closer examination: the focus on teacher competencies in elementary school. The studies consistently emphasized the skills, knowledge, and attributes necessary for effective teaching at the elementary education level.

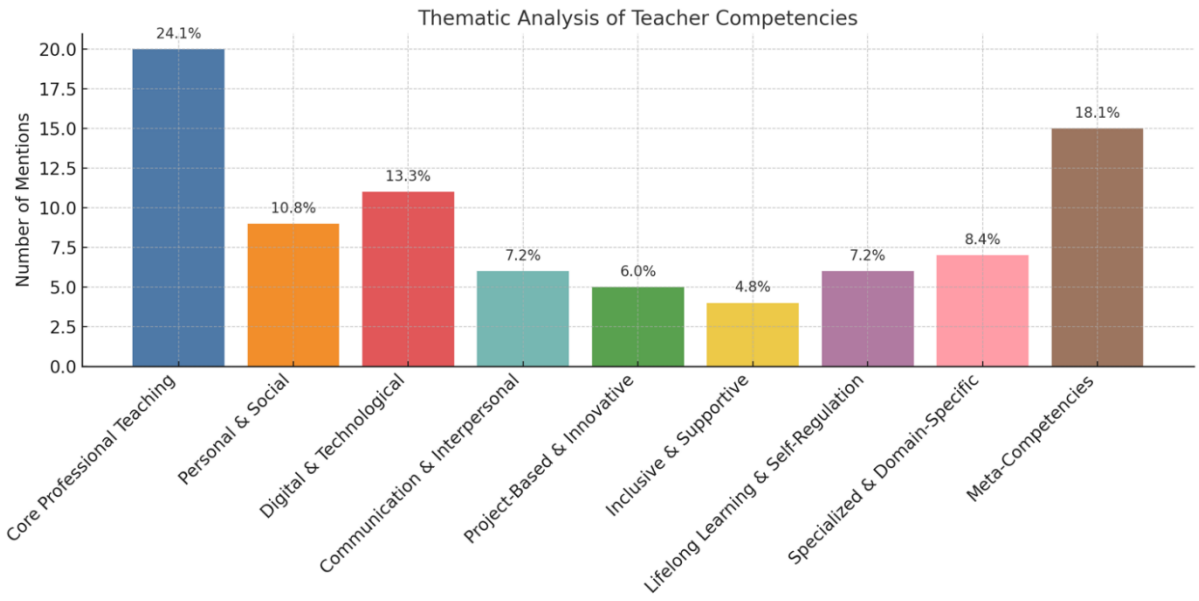
The "competencies" column contains keywords and phrases related to teacher development, professional learning, teaching practices, pedagogical approaches, and the assessment of teacher effectiveness within the context of elementary education. Even studies with seemingly broader titles might, in their specifics, address aspects of teacher competency relevant to the elementary grades. This column summarizes outcomes related to the impact of specific interventions on teacher skills, the identification of key competencies associated with student success in elementary school, or the evaluation of programs designed to enhance the professional capabilities of elementary teachers. The varying target countries then represent different contexts in which these aspects of teacher competency are being studied and addressed.

The overarching theme connecting these articles is the investigation and improvement of teacher competencies specifically within the elementary school setting. The research explores various facets of what makes an effective elementary teacher across different cultural and educational landscapes.

Based on the 83 collected articles, the researchers conducted an analysis and identified various competencies of elementary school teachers that were discussed across the literature. Using thematic analysis, they categorized these competencies into nine distinct groups: Core Professional Teaching Competence (24%), Meta-Competencies (18%), Digital and Technological Competence (13%), Personal and Social Competence (11%), Specialized and Domain-Specific Competence (8%), Communication and Interpersonal Competence (7%), Lifelong Learning and Self-Regulation Competencies (7%), Project-Based and Innovative Competence (6%), and Inclusive and Supportive Teaching Competence (5%). The analysis revealed that the most frequently mentioned category was Core Professional Teaching Competence, accounting for 24% of the identified competencies. This finding highlights the

fundamental importance of this competency for elementary school teachers, as it suggests that mastering this area is critical for those who aspire to become effective and successful educators.

Key Competencies Identified



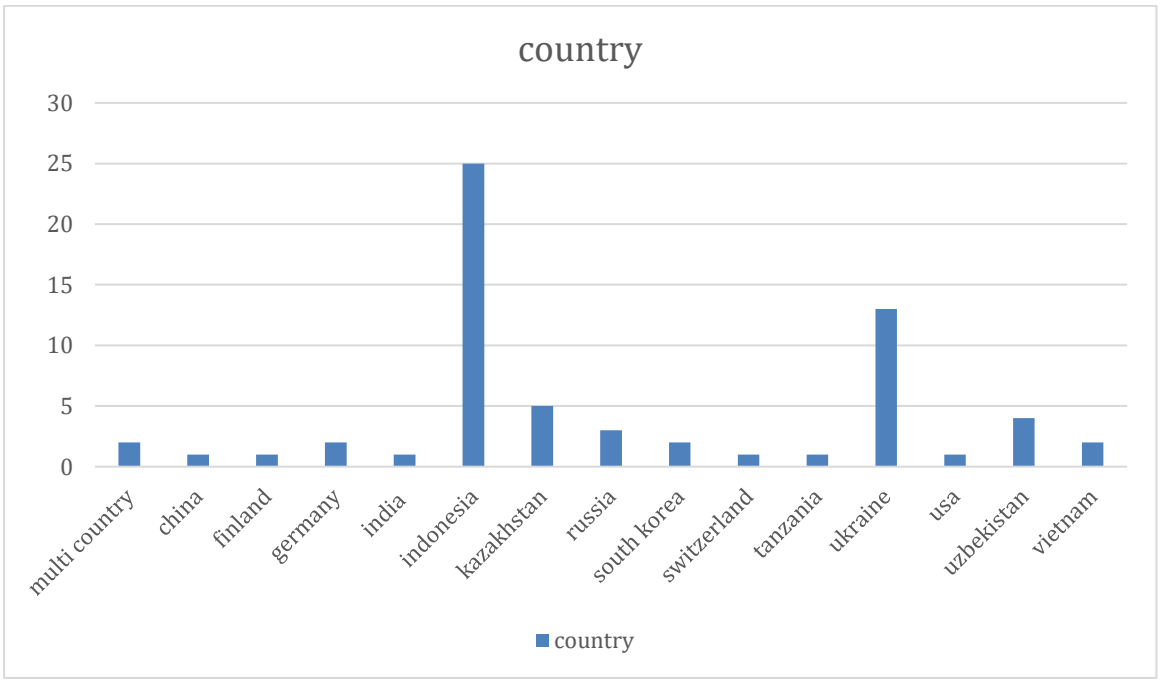
This findings present a thematic analysis of competencies derived from selected references to teacher development, particularly in the context of project-based learning, inclusive education, and digital transformation. A total of 83 mentions of competencies were categorized into nine thematic areas. The analysis highlights key competencies that are necessary for effective teaching in the 21st century. The most frequently mentioned theme is Core Professional Teaching Competence, accounting for 24% of all references. This category includes essential teaching skills such as pedagogical knowledge, professional ethics, instructional design, and methodological expertise. It reflects the fundamental capabilities required for lesson planning, classroom management, and assessment. These core competencies form the foundation of effective teaching practices. Meta-Competencies rank second, comprising 18% of the data. These are broadly defined abilities that encapsulate general professional standards, including terms such as "teacher competence" and "professional competencies." This theme also includes competencies that reflect adaptability, natural and acquired abilities, prognostic skills, and overall professionalism. The emphasis on meta-competencies suggests a holistic view of the teacher as a dynamic and reflective practitioner.

Digital and Technological Competence is a prominent theme with 13% of the mentions. This includes digital literacy, ICT competence, and the integration of digital tools in pedagogy. Teachers are increasingly expected to design and deliver content in online or hybrid settings and utilize educational technologies effectively. This theme underscores the growing importance of digital fluency in modern education. Personal and Social Competence (11%) includes competencies related to emotional intelligence, collaboration, leadership, and social interaction, representing 11% of the references. Personality traits such as empathy, integrity, and teamwork are essential for fostering a positive learning environment and maintaining strong relationships with students, colleagues, and the broader school community. With 8% of

mentions, Specialized and Domain-Specific Competence encompasses the skills needed for teaching specific content areas, such as STEM integration, mathematical modeling, and cultural-based curriculum design. It also includes knowledge of classroom management and the ability to align instruction with local educational contexts. Communication and Interpersonal Competence (7%) highlights the importance of effective communication skills, including professional communication, intercultural awareness, and the ability to counsel and advise students. Representing 7% of mentions, these skills are critical for both instructional delivery and professional collaboration.

Also comprising 7% of the references, Lifelong Learning and Self-Regulation Competencies includes self-directed learning, adaptability to educational reforms, and a commitment to continuous professional development. These competencies ensure that teachers remain current and responsive to changes in educational policies, technologies, and student needs.Project-Based and Innovative Competence, with 6% of mentions, reflects the need for educators to implement innovative pedagogies. This includes designing project-based learning experiences, problem-solving, and encouraging creativity and critical thinking in the classroom. The least frequently mentioned theme, at 5%, is Inclusive and Supportive Teaching Competence. It involves the ability to create inclusive classrooms that support diverse learners and provide educational counseling. Teachers must be equipped to recognize and address the needs of all students, including those with special needs. The thematic analysis reveals a comprehensive set of competencies that are critical for modern educators. The emphasis on core teaching skills, digital fluency, social-emotional intelligence, and lifelong learning reflects the evolving demands placed on teachers. As education systems continue to reform and adapt to technological and societal shifts, teacher competencies must be continually developed to ensure effective teaching and learning outcomes.

Publication Trends and Geographical Distribution



Research on primary school teacher competence has been widely conducted in both Indonesia and Ukraine due to several key reasons. First, primary school teachers play a central role in shaping students' foundational knowledge, skills, and character. At this stage, children begin to develop critical thinking, reading, writing, numeracy, as well as social and moral values. Therefore, teacher competence is seen as a crucial factor in ensuring the quality of basic education (Kinesheva, 2015; Fahmi, 2018; Sukapri, 2014).

Both Indonesia and Ukraine have undergone significant education reforms that place strong emphasis on teacher quality. In Indonesia, the implementation of the 2013 Curriculum and the more recent "Merdeka Curriculum" has introduced major changes in teaching approaches (Das, 2018; Atmono, 2017). These reforms require teachers to master a range of competencies, including pedagogical, professional, social, and personal skills. In Ukraine, education reforms following the post-Soviet transition focus on creating a more student-centered and democratic learning environment, which also demands improvements in teacher competence (Lebid, 2023; Griban, 2020; Savchuk, 2024).

Additionally, both countries face challenges in teacher training and professional development. In Indonesia, there is a noticeable gap in teacher quality between urban and rural areas. Many teachers still lack adequate academic qualifications or professional certification (Judiani, 2011; Supaat, 2023; Halimahturrafiah, 2023). In Ukraine, the key challenges lie in modernizing teacher training systems to align with global trends in education, including digital transformation, as well as managing the effects of political and social instability (Kyrpychenko, 2021; Depcsinszka, 2022; Vasylykiv, 2023).

The focus on teacher competence has also been driven by partnerships with international organizations such as UNESCO, UNICEF, and the World Bank. These organizations support education programs in developing or transitioning countries, including Indonesia and Ukraine, which has led to an increase in local research aimed at improving teacher quality (Tatik, 2024; Susilowati, 2021; Boliak, 2020; Matvienko, 2022).

Ultimately, strengthening teacher competence is considered a strategic move to improve overall education quality. Countries that aim to compete globally often begin reforms at the level of basic education, with teachers as the primary agents of change. As a result, teacher competence continues to be a major focus in educational research in both Indonesia and Ukraine (Shchur, 2024; Zhurat, 2021; Hasani, 2020; Daga, 2023; Bundu, 2019).

Discussion

Although this research emphasizes the Indonesian context, it incorporates many studies from overseas to provide a broader, evidence-based understanding of how AI is transforming teacher competencies globally. The reason for including international literature is that many countries face similar challenges and opportunities in adapting to AI-enhanced education—such as integrating technology into classrooms, developing teacher digital literacy, and preparing students for the demands of the 21st century. These global experiences offer valuable insights, models, and strategies that can inform and strengthen Indonesia's own educational development.

The direct relevance of these overseas studies lies in the shared competencies and themes that are universally applicable to elementary school teaching in the AI era. For example, studies from Ukraine, Finland, and Australia discuss digital literacy, metacognition, inclusive education, and the ethical use of AI—all of which align with the skills needed by Indonesian teachers. While the educational systems may differ, the core competencies identified—such as adaptability, communication, problem-solving, and professional development—are highly transferable and provide a benchmark for evaluating and improving Indonesia's teacher education framework.

Moreover, using international studies helps to highlight gaps and inspire innovation within the Indonesian education system. By comparing findings across contexts, the research draws meaningful lessons that can guide curriculum reform, policy development, and teacher training programs. In short, these overseas studies are not just supplementary—they are integral to building a robust, future-oriented competency framework for Indonesian elementary school teachers in the AI era.

Key skill needed by elementary school teachers in AI era

In the era of artificial intelligence (AI), elementary school teachers in Indonesia are faced with new challenges and opportunities in the field of education (Sydorenko, 2020; Bulkani, 2022; Kunter, 2013). To meet the demands of the times, teachers must develop a set of essential skills that span two core domains: professional competence and personal competence (Bentri, 2023; Castañeda, 2021; Ibda, 2023). These two areas form the foundation for effective, relevant, and human-centered teaching in an increasingly technology-driven world.

Within the domain of professional competence, teachers are expected to possess strong AI and digital literacy. This includes a fundamental understanding of how AI works and the ability to utilize AI-based tools to support learning, such as adaptive learning platforms, AI-generated quizzes, or writing assistants (Judiani, 2011; Gilmanshina, 2015; Sturikova, 2016). In addition, the ability to design technology-integrated lesson plans is crucial (Ketrisha, 2016; Olesova, 2016; Mantra, 2017; Fahmi, 2018). Teachers must creatively and effectively incorporate digital tools into their instructional strategies while ensuring they are appropriate for the learners' needs and classroom context (Ketrisha, 2016; Olesova, 2016; Mantra, 2017; Fahmi, 2018).

Equally important is the ability to use student learning data effectively (Sukrapi, 2014; Kinesheva, 2015; Puchkova, 2016). As more digital platforms are used in the classroom,

teachers can analyze learning data to assess student progress and provide targeted interventions (Zakirova, 2016; Khairova, 2019; Ilyina, 2018). Creativity also plays a vital role in instructional innovation . (Depcsinszka, 2022; Vasylykiv, 2023; Dinh et al, 2025). Creative teachers can foster engaging and meaningful learning experiences using approaches such as STEAM (Science, Technology, Engineering, Arts, and Mathematics) and 21st-century competencies—critical thinking, communication, collaboration, and creativity (Pinninti, 2025; Ndimbo, 2023; Korkeaniemi, 2025). Furthermore, digital communication and collaboration skills are essential for teachers to interact with students, parents, and fellow educators through various online platforms.

On the other hand, personal competence emphasizes attitudes, values, and adaptability in the face of change. Teachers need to be lifelong learners who are open to change and committed to continuous professional growth through training and reflection (Hwang, 2025; Hasani, 2020; Susilowati, 2021). Ethical awareness and digital responsibility are also central to this domain. Teachers must understand and address issues such as AI-generated plagiarism, data privacy, and the responsible use of technology—and guide their students to do the same.

Emotional intelligence and empathy are becoming increasingly important as students grow up immersed in digital environments but still require human connection and support in their learning journeys. Teachers must also demonstrate critical and reflective thinking to evaluate the impact of technology in their practice and continuously improve their teaching methods. Finally, a strong commitment to humanistic values and cultural diversity is essential to ensure that education not only focuses on academic achievement but also cultivates moral character and digital citizenship rooted in Indonesia's multicultural society. Elementary school teachers in Indonesia must develop technology-driven professional competencies while strengthening their personal competencies in ethics, adaptability, and values. The synergy between these two domains ensures that the teacher's role remains relevant, meaningful, and impactful in educating the next generation in the AI era.

Knowledge areas needed by elementary school teachers in AI era

In the rapidly evolving AI era, elementary school teachers in Indonesia must possess effective communication skills (Khaydarova, 2020; Rusyn, 2021; Zhumash, 2021). This communication extends beyond face-to-face interactions to include various digital platforms (Suchyadi, 2022; Turlybekov, 2024; Bukit, 2022; Zhakiyanova, 2023). Teachers need to convey messages clearly and empathetically to students, parents, and colleagues to ensure that the learning process runs smoothly, even when technology is heavily involved (Boliak, 2024; Handayani, 2020; Ratri, 2025).

Moreover, collaboration and teamwork are essential social competencies. Teachers should be able to cooperate with fellow educators, school staff, and other stakeholders to develop learning strategies integrated with AI technology (Gadušová, 2019; Slowik, 2020). The ability to adapt to social changes brought about by technological advances is also crucial, enabling teachers to help students adjust and face emerging challenges.

Empathy and social care are key to supporting student development (Akhmedov, 2020; Savchuk, 2024). Teachers must be sensitive to the emotional and social needs of students,

especially when interactions increasingly occur online, which can sometimes cause feelings of isolation or stress (Gunawan, 2020; Mantra, 2017). In this context, teachers also need conflict management and negotiation skills to resolve issues that may arise in both physical and virtual classrooms, fostering a conducive and harmonious learning environment.

Digital social literacy is vital for teachers to guide students on ethical technology use (Daga, 2023; Tatik, 2024; Zhurat, 2021). Teachers should educate students on responsible use of digital media and respect for social norms in the online world. Additionally, teachers need multicultural awareness and an inclusive mindset, valuing cultural diversity and students' varied backgrounds, ensuring equitable access to learning opportunities for all students, including through the fair and inclusive use of AI.

Pedagogical approaches must be developed by elementary school teachers in AI era

In the AI era, elementary school teachers in Indonesia must adopt pedagogical approaches that effectively integrate technology to enhance student learning. A student-centered learning approach supported by AI-powered tools allows teachers to personalize instruction, catering to the unique pace and learning style of each child (Almuhanna, 2024). This not only increases student engagement but also ensures that diverse learning needs are met more efficiently.

Collaborative and inquiry-based learning methods are essential for developing critical thinking, creativity, and teamwork skills among young learners (Lu, 2021). By encouraging students to work together on projects and explore questions with the support of AI resources, teachers can foster a deeper understanding of concepts and promote active learning. This approach also prepares students to navigate complex problems in a rapidly changing world.

Blended learning models that combine traditional face-to-face instruction with digital platforms offer flexibility and varied learning opportunities (Niyomves, 2024). AI-driven tools provide continuous practice, assessment, and feedback, enabling teachers to focus on mentoring and addressing individual challenges. This hybrid model balances the benefits of technology with the indispensable human element of teaching.

Teachers must also develop competencies in data-driven instruction by interpreting learning analytics generated through AI systems (Salas-Pilco, 2022). Such data can guide differentiated teaching strategies, allowing educators to monitor progress and adjust instruction to optimize student outcomes. This evidence-based approach empowers teachers to make informed decisions in the classroom.

Moreover, fostering digital literacy and ethical awareness is critical in helping students understand the responsible use of AI and technology. Elementary teachers play a key role in educating students about digital citizenship, privacy, and the social implications of AI, which builds a foundation for ethical behavior and informed decision-making (Yingsoon, 2025).

Continuous professional development and adaptability are vital for teachers to remain current with rapid technological advancements (Tang and Choi, 2009). Lifelong learning and openness to new pedagogical innovations enable educators to effectively integrate AI into their teaching practices, ensuring students are well-prepared for the future..

CONCLUSION

As education systems navigate the transformative influence of Artificial Intelligence, it is imperative that elementary school teachers possess a dynamic and evolving set of competencies. This systematic literature review has identified a comprehensive framework of core and specialized competencies—including pedagogical, social, personality, and professional dimensions—augmented by digital literacy, AI ethics, and adaptive teaching strategies. In the Indonesian context, where AI integration is accelerating alongside global trends, teacher preparedness remains a critical concern. The review highlights the necessity of reshaping teacher education and continuous professional development programs to foster these competencies. By aligning educational policies and teacher training initiatives with the demands of the AI era, Indonesia can better equip its elementary educators to create inclusive, innovative, and technology-enriched learning environments that support student success in the digital age.

In other words, as Artificial Intelligence reshapes education, Indonesian elementary school teachers will need a blend of core and emerging competencies. These include strong pedagogical, social, personality, and professional skills, along with digital literacy, understanding of AI ethics, and the ability to adapt teaching methods to new technologies. With AI becoming more prevalent, teacher education and ongoing training must evolve to build these skills. Aligning policy and professional development with these needs will help ensure that teachers can foster inclusive, innovative, and tech-rich classrooms that prepare students for the digital future.

This study has several limitations that should be acknowledged. First, as a systematic literature review (SLR), it relies solely on secondary data and does not include empirical findings from classroom observations or teacher interviews within the Indonesian context. While the inclusion of international studies enriches the discussion, differences in educational systems, cultures, and infrastructures may limit the direct applicability of some findings to Indonesia. Furthermore, the study's database scope and keyword-driven selection process may have excluded relevant works that use alternative terminology or are published outside major academic databases, potentially narrowing the comprehensiveness of the review.

To address these limitations, future research should incorporate field-based empirical studies involving Indonesian elementary school teachers. Qualitative methods such as interviews, focus groups, or case studies could offer deeper insights into teachers' real-world experiences with AI integration. Comparative research between urban and rural schools would also help highlight disparities in readiness and resource availability. Additionally, evaluating the effectiveness of ongoing teacher training programs and curriculum reforms related to AI competencies could provide actionable data for policymakers. Longitudinal studies tracking how teacher competencies evolve in response to technological change would further strengthen the foundation for sustainable educational development.

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