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AI Literacy of Elementary School Teachers in Developing Quality Learning Tools: A Systematic Literature Review

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Abstract

Artificial intelligence (AI) is increasingly used in education to support instructional planning. However, the link between elementary school teachers' AI literacy and the quality of instructional materials remains rarely synthesized systematically. This study aims to analyze and synthesize literature regarding primary teachers' AI literacy in designing high-quality instructional materials. Employing a Systematic Literature Review (SLR) guided by the PRISMA 2020 framework, 28 out of 36 identified articles were selected for final thematic synthesis after applying inclusion and exclusion criteria. The corpus comprises 8 Scopus-indexed articles (predominantly Q1), 9 SINTA-accredited national articles (SINTA 3–5), and 11 non-accredited journal articles. The findings indicate that while AI enhances planning efficiency, idea generation, and resource adaptation, output quality heavily depends on teachers' prompt formulation, critical evaluation, and integration with pedagogical-content knowledge tailored to elementary students' developmental needs. Merely adopting AI tools does not guarantee instructional rigor; teachers remain central designers and evaluators. Consequently, continuous professional development integrating prompt engineering, pedagogical reasoning, and ethical considerations is crucial to producing contextual, sound, and high-quality elementary learning materials.

Keywords: Artificial Intelligence, AI Literacy, Elementary School Teachers, Instructional Materials

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Abstrak

Kecerdasan buatan (AI) semakin banyak digunakan dalam pendidikan untuk mendukung perencanaan pembelajaran. Namun, hubungan antara literasi AI guru sekolah dasar dan kualitas bahan ajar masih jarang dianalisis secara sistematis. Penelitian ini bertujuan untuk menganalisis dan mensintesis literatur mengenai literasi AI guru sekolah dasar dalam merancang bahan ajar berkualitas tinggi. Dengan menggunakan Systematic Literature Review (SLR) yang dipandu oleh kerangka kerja PRISMA 2020, 28 dari 36 artikel yang diidentifikasi dipilih untuk sintesis tematik akhir setelah menerapkan kriteria inklusi dan eksklusi. Korpus tersebut terdiri dari 8 artikel yang terindeks di Scopus (sebagian besar Q1), 9 artikel nasional yang terakreditasi SINTA (SINTA 3–5), dan 11 artikel jurnal yang tidak terakreditasi. Temuan menunjukkan bahwa meskipun AI meningkatkan efisiensi perencanaan, pembangkitan ide, dan adaptasi sumber daya, kualitas hasil sangat bergantung pada formulasi prompt oleh guru, evaluasi kritis, serta integrasi dengan pengetahuan pedagogis-konten yang disesuaikan dengan kebutuhan perkembangan siswa sekolah dasar. Hanya mengadopsi alat AI tidak menjamin ketatnya proses pembelajaran; guru tetap menjadi perancang dan evaluator utama. Oleh karena itu, pengembangan profesional berkelanjutan yang mengintegrasikan rekayasa prompt, penalaran pedagogis, dan pertimbangan etis sangat penting untuk menghasilkan bahan pembelajaran sekolah dasar yang kontekstual, kokoh, dan berkualitas tinggi.

Kata Kunci: Kecerdasan Buatan, Literasi AI, Guru Sekolah Dasar; Perangkat Pembelajaran

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INTRODUCTION

Digital transformation has changed the way education is designed, delivered, and evaluated. At the elementary school level, these changes are becoming increasingly evident through the use of digital technology and artificial intelligence (AI) to support adaptive, interactive, and personalized learning experiences. In the broader K–12 educational landscape, various AI-based learning tools have shown immense potential to facilitate diverse pedagogical needs, though successful adoption hinges on teacher readiness and instructional alignment (Yim & Su, 2024). AI can help teachers generate materials, media, and assessment items, as well as conduct learning analyses more efficiently (Mukti et al., 2025; Nurmawati et al., 2026).

These changes are not only related to the use of technological devices but also to the development of teachers' professional competencies in utilizing AI critically, ethically, and pedagogically. Miao & Cukurova (2024) through its AI Competency Framework for Teachers, identifies five dimensions of teachers' AI competencies: a human-centered mindset, AI ethics, AI foundations and applications, AI pedagogy, and AI for professional development. These five dimensions demonstrate that AI competencies are not limited to the ability to operate applications but also encompass the ability to consider the human role in decision-making, safeguard privacy and data security, critically evaluate AI outputs, integrate AI into learning strategies, and utilize technology to foster continuous professional development. UNESCO also categorizes the development of these competencies into three levels—Acquire, Deepen, and Create—which describe the progression from basic mastery toward deepening understanding and creating AI-assisted learning practices. Thus, teachers' AI literacy encompasses both technical skills and ethical, pedagogical, and professional considerations in determining the appropriate use of AI to meet learning needs.

In the context of learning, teachers' AI literacy includes the ability to understand the characteristics and limitations of AI, select appropriate technologies, integrate them with pedagogical strategies, and critically and ethically evaluate AI outputs. UNESCO specifically defines AI pedagogy as the ability to select and validate AI tools and integrate them into lesson planning, teaching, learning, and assessment (Miao & Cukurova, 2024). Thus, AI literacy has direct relevance to teachers' ability to develop instructional materials.

The quality of instructional materials must be assessed based on the coherence among learning objectives, content, methods, activities, and assessment, as well as their alignment with student characteristics and the learning context. These aspects are critical considerations in evaluating the suitability of an instructional design; therefore, quality cannot be judged solely by the speed at which documents are produced. In the context of AI utilization, Luo & Tahir (2025) reported that ChatGPT-assisted instructional designs received an average score of 21.0, higher than conventional designs, which scored 17.0. The evaluation covered several planning dimensions, including instructional methods, practical aspects, interdisciplinary elements, and core competencies. These findings provide insight into the evaluation results of AI-assisted learning designs in the context of that study, but they do not in and of themselves prove that all AI-assisted learning tools are of higher quality.

However, the use of AI does not automatically result in high-quality learning tools. Teachers still need to provide clear requirements, incorporate the learning context, evaluate outputs, and make iterative refinements. Luo & Tahir (2025) demonstrate that the optimization process is a crucial component because AI outputs may not fully align with classroom needs, thus requiring teacher screening and revision. Their framework emphasizes standards, practicality, engagement, comprehensiveness, and continued development as aspects of quality.

Evidence from the elementary school context also reveals this potential relationship. Hadi et al. (2026) found an increase in teachers' digital literacy following training in AI, Canva, and Wayground, including improved efficiency in lesson preparation and greater teacher confidence. Meanwhile, Nurmawati et al. (2026) reported that AI training helped teachers design learning materials, create questions, develop interactive media, and analyze assessments. These findings suggest that AI literacy has the potential to become a key capacity in improving the quality of elementary school teachers' learning materials.

Nevertheless, the literature indicates that the development of teachers' AI competencies still faces various barriers. UNESCO has identified the importance of digital infrastructure, internet access, the availability of AI resources, data security and privacy regulations, policy support, and professional development opportunities. Empirical findings among elementary school teachers also point to limitations in digital literacy, infrastructure, and training as barriers to AI integration (Mukti et al., 2025).

Research findings by Kaur (2025) and Song et al. (2026) indicate that studies on AI literacy have expanded across various levels of education; however, the focus of these studies remains diverse and has not yet provided balanced attention to all groups of educators and the contexts in which AI is used. This imbalance in attention needs to be examined through the distribution of educational levels studied, respondent groups, the AI competencies analyzed, and the contexts of AI application in learning. In particular, research on elementary school teachers' AI literacy in relation to the process of developing high-quality instructional materials requires further exploration, especially regarding teachers' ability to understand AI's limitations, evaluate the generated outputs, and integrate them with pedagogical knowledge and subject matter. Therefore, this article focuses on a literature synthesis regarding elementary school teachers' AI literacy competencies in developing instructional materials, thereby providing an overview of the required competencies, opportunities for AI utilization, and challenges that need to be addressed in teaching practice.

This research gap becomes more specific when AI literacy is linked to the quality of instructional materials. Studies on elementary school teachers have addressed experiences using AI, improvements in digital literacy, the use of AI as a learning medium, and AI training. However, the relationship between elementary school teachers' levels of AI literacy and the quality of instructional materials—including lesson plans or teaching modules, learning media, and assessments—has not yet been systematically synthesized in the available body of literature.

The novelty of this study lies in a literature synthesis that specifically examines elementary school teachers' AI literacy in the context of developing high-quality instructional materials. Unlike studies that focus on the conceptualization of AI literacy, the measurement of AI competencies, or the use of AI in instructional planning in general, this study examines the relationship between the dimensions of teachers' AI literacy competencies and pedagogical needs in developing instructional materials. The synthesis focuses on teachers' ability to understand the limitations of AI, design instructions, evaluate AI outputs, and adapt the results to learning objectives, content, assessments, and the characteristics of elementary school students. Through this focus, this study is expected to provide a mapping of relevant AI literacy competencies, opportunities for their utilization, and challenges that need to be addressed in the development of instructional materials. This claim of novelty is further based on a systematic comparison of the focus, subjects, and findings of previous studies that met the study's inclusion criteria.

This synthesis also enables the study to identify the dimensions of AI literacy most relevant to teachers' work, the factors that facilitate or hinder its implementation, and the measurement

approaches employed. UNESCO emphasizes that AI competencies must encompass technical, pedagogical, ethical, and professional development aspects, while AI-TPACK research positions the relationship between AI technology, pedagogy, and content knowledge as a crucial component of teacher competencies (Miao & Cukurova, 2024; Ning et al., 2024). Thus, this review aims to produce a more context-specific synthesis for elementary education.

Based on this background and the existing research gaps, this study aims to analyze and synthesize the literature on elementary school teachers' AI literacy in relation to the development of high-quality instructional materials. This study employs a Systematic Literature Review (SLR) method in accordance with the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). The review process consisted of four main stages: identification of relevant articles, screening based on inclusion and exclusion criteria, assessment of article eligibility, and selection of articles for the final synthesis. Of the 36 articles identified in the initial stage, 8 were eliminated for failing to meet the established criteria, leaving 28 articles selected for further analysis. Next, the selected articles were analyzed thematically to map the concepts and dimensions of teachers' AI literacy, its contribution to the quality of instructional materials, factors supporting and hindering the use of AI, as well as the methods and instruments used to measure teachers' AI literacy.

The research questions underlying this study are:

1. How are the concepts and dimensions of elementary school teachers' AI literacy defined in the literature?
2. To what extent does elementary school teachers' AI literacy contribute to the quality of instructional materials, including lesson plans/teaching modules, instructional media, and assessments?
3. What factors support and hinder the development and implementation of elementary school teachers' AI literacy?
4. What methods and instruments are used to measure teachers' AI literacy and the quality of instructional materials?

METHODS

This study employs a Systematic Literature Review (SLR) method with a qualitative approach. This method is used to identify, select, analyze, and synthesize various research findings related to elementary school teachers' artificial intelligence (AI) literacy in developing high-quality instructional materials. The selection of the SLR method was based on the study's objective, which did not focus on direct data collection from the field but rather on mapping and synthesizing findings from previous research to gain a more comprehensive understanding of the development of teachers' AI literacy and its application in the development of instructional materials. The research process was systematically structured in accordance with the PRISMA 2020 guidelines (Haddaway et al., 2020), ensuring a sequential and transparent execution of identification, screening, eligibility, and data synthesis stages.

Data Sources

The research data sources consist of scientific articles relevant to the themes of teachers' AI literacy, educators' AI competencies, the use of AI in education, prompt engineering, instructional planning, and the development of instructional materials. The literature analyzed comes from two groups of sources: 17 articles identified through an initial search and selection process, and 19 articles selected through a second search. Thus, the articles from both sources

were treated as part of the overall literature reviewed and synthesized based on their relevance to the research focus.

The 17 selected articles covered studies on AI literacy and prompt engineering, the use of AI in education, AI-assisted instructional planning, AI competencies of prospective teachers, educator readiness, the development of learning modules, AI training for elementary school teachers, the use of AI for instructional materials, and the development of instructional materials using prompts. Additionally, 19 other articles were identified to expand and strengthen the synthesis, particularly regarding teachers' digital and AI literacy, AI-TPACK, the use of ChatGPT, AI-assisted instructional planning, and the development of teacher competencies.

Inclusion and Exclusion Criteria

Inclusion criteria were established to ensure that the analyzed literature was directly relevant to the research objectives. Articles were included if they met most of the following criteria: (1) discuss artificial intelligence or generative AI in an educational context; (2) discuss literacy, competencies, readiness, skills, or the use of AI by teachers or educators; (3) relate to the process of developing instructional materials, such as modules, teaching materials, lesson plans, media, assessments, or learning activities; (4) are relevant to elementary education or provide a conceptual foundation applicable to the context of elementary school teachers; and (5) provide sufficient information to allow for data extraction and synthesis.

Articles were excluded if they had no connection to education or educator competencies, discussed AI solely from a technical perspective without any relation to learning, did not provide information relevant to the research focus, or were sources that could not be adequately analyzed.

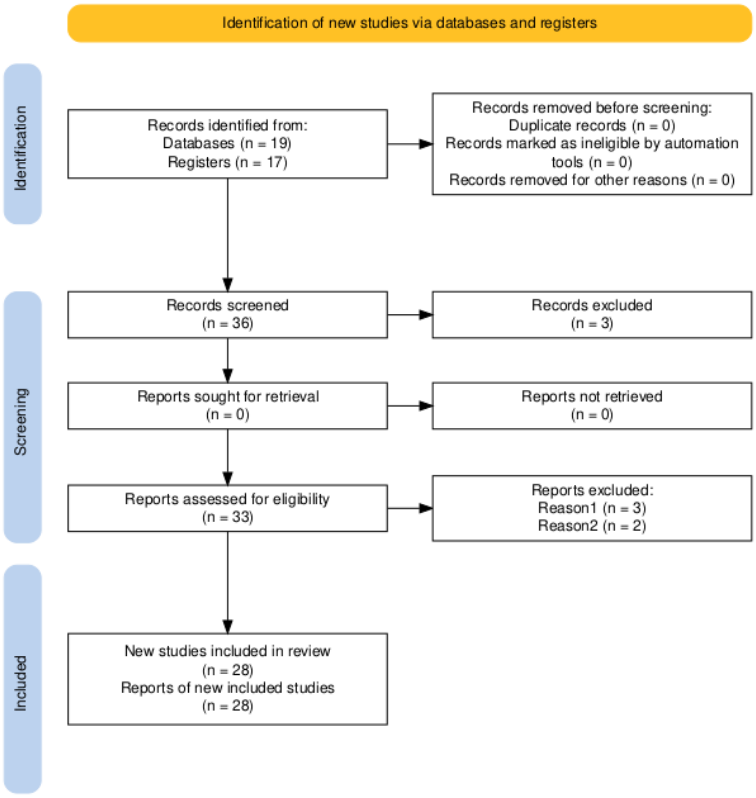


Figure 1. PRISMA 2020 Flow Diagram of Literature Search and Selection on Teachers' AI Literacy

Literature Collection and Selection Procedures

The literature collection process was conducted in several stages. The first stage was identification, which involved gathering articles related to keywords such as AI literacy, AI competency, teacher AI literacy, artificial intelligence in education, prompt engineering, lesson planning, learning materials, instructional materials, and elementary school teachers. The literature identified in this stage was then combined with articles found during the second search. The second stage involved screening based on titles and abstracts. At this stage, articles unrelated to the research focus were excluded. Relevant articles proceeded to the content review stage. The third stage involved assessing the suitability of the articles' content based on inclusion and exclusion criteria. The final stage involved determining which articles would be used in the synthesis.

The selection process considered not only the number of articles but also the relevance of their content. This is important because the literature on AI in education exhibits diverse characteristics. Some articles discuss elementary school teachers directly, while others discuss prospective teachers, educators at different levels, or conceptual aspects of AI literacy and prompt engineering. Literature that is not directly within the context of elementary school can still be used if it provides a strong theoretical contribution to understanding teachers' AI literacy. The selection process resulted in the exclusion of eight articles across two sequential screening phases. In the first phase (title and abstract screening), three records were excluded because they did not address artificial intelligence within an educational context or focused strictly on algorithmic and technical architectures without relevance to teacher competencies. In the second phase (full-text eligibility assessment), the remaining 33 articles were scrutinized in detail, resulting in the exclusion of five additional articles. The specific reasons for full-text exclusion were: (a) lack of direct relevance to instructional planning or materials development (n = 3), and (b) insufficient descriptive data to support rigorous thematic extraction and qualitative synthesis (n = 2). Consequently, 28 articles met all inclusion criteria and were included in the final synthesis (See Figure 1).

Data Extraction

Data from each article was extracted based on several key aspects, namely article identification, year of publication, research focus, research subject or context, research methods, the aspects of AI literacy or competencies examined, forms of AI utilization, instructional materials developed, and the main research findings. The extraction was conducted to identify recurring patterns across various studies. The extraction results were then grouped into themes with conceptual relationships. The main themes identified include: (1) teachers' AI literacy and competencies; (2) prompt engineering and prompt literacy; (3) the use of AI in the planning and development of learning materials; (4) evaluation and validation of AI outputs; (5) the benefits of using AI; (6) challenges and risks associated with using AI; and (7) teachers' professional development needs.

Data Analysis Techniques

The analysis was conducted thematically by comparing findings across articles. Each article was analyzed to identify similarities, differences, trends, and relationships among concepts. Findings with similarities were then grouped, while differing findings were used to enrich the interpretation and identify research gaps. The final synthesis was conducted by linking three main components: teacher competencies, the use of AI, and the quality of learning materials.

Based on this synthesis, the study examines not only whether teachers use AI but also how teacher competencies determine the quality of AI utilization. Thus, the use of AI is understood as a process involving technological understanding, the formulation of instructions, the evaluation of outputs, pedagogical decision-making, and the adaptation of results to meet students' needs. This analytical process yielded a conceptual framework showing that AI literacy serves as the foundation for the ability to use AI; this ability develops through prompt engineering and output evaluation skills, which are then integrated with pedagogical knowledge and subject matter to produce more relevant and high-quality learning materials.

RESULTS AND DISCUSSION

Literature Mapping Based on Research Focus

The synthesis of 28 articles meeting the inclusion criteria indicates that research on artificial intelligence (AI) in education encompasses several interrelated focuses. Based on thematic mapping, the research focuses include teachers' AI literacy and competencies, prompt engineering, AI-assisted instructional planning, the development of instructional tools and materials, teacher competency training, AI integration through the AI-TPACK framework, the evaluation and ethics of AI use, and collaboration between teachers and AI. These findings indicate that the analyzed literature not only discusses the use of AI as a technology to support learning but also examines teachers' competencies in understanding, using, evaluating, and integrating AI with pedagogical knowledge to develop instructional materials. Thus, the mapping of 28 articles reveals a variety of research focuses relevant to teachers' AI literacy and the development of high-quality instructional materials.

Among the 17 previously selected articles, several focus groups emerged. The first group discusses the fundamentals of AI literacy and competencies, such as the studies by Knoth et al. (2024), Hsu (2026), and Uğur (2026). The second group focuses on the use of AI for instructional planning, such as the studies by Lee & Zhai (2024), van den Berg & du Plessis (2023), Suranti and Pradmawati (2026), and Lu et al. (2026). The third group relates directly to elementary school teachers, such as the studies by Pane (2026), Nurmawati et al. (2026), Ratri et al. (2025), Prasongko et al. (2026), and Ridwan et al. (2026). Another group discusses the development of teacher competencies through AI training and prompt-writing skills. The initial list of articles used illustrates this scope.

Additional literature obtained during the second phase expands this mapping through studies on AI-TPACK, AI literacy, the use of ChatGPT, the development of instructional materials, and educator competencies. The existence of literature with diverse characteristics illustrates that teachers' AI literacy is a multidimensional construct. It is not enough for teachers to simply be able to operate AI applications; they must also understand the technology's functions, use it pedagogically, evaluate the results, and consider the ethical consequences of its use. In general, the mapping results indicate that the relationship between AI literacy and the quality of learning materials can be understood through several stages: understanding AI → skills in using AI → ability to craft prompts → evaluation of outputs → pedagogical integration → high-quality learning materials. This pattern is the key finding that links the various groups of literature.

Table 1. Literature Mapping Based on Journal Indexes

Category	Number
Scopus Q1	7
Scopus Q1/Q2	1
SINTA 1–3	1
SINTA 4	2
SINTA 5	6
Non-Accredited	11
Total	**28**

Table 2. Research Focus

No.	Focus of the Study	Literacy Analyzed	Synthesis of Findings
1.	Literacy and teachers' AI Competencies	Knoth et al. (2024); Hsu (2026); Pane (2026); Choudhury et al. (2024); Miao & Cukurova (2024)	Synthesis of articles on discussing AI literacy and competencies shows that teachers' AI literacy includes an understanding of the capabilities and limitations of AI, the critical use of AI, as well as ethical considerations in its application to learning. These conclusions were formulated based on the grouping of themes that appeared in relevant articles, and therefore do not assume that all studies discuss or support each of these aspects simultaneously.
2.	Prompt Engineering and Prompt Literacy	Knoth et al. (2024); Uğur (2026); Lu et al. (2026); Prasongko et al (2026); Kaharuddin et al (2026); Syahabudin & Rizal (2026)	The ability to craft prompts that clear, specific, and goal oriented learning has an impact on the relevance and quality of AI outputs that used by teachers.
3.	AI in Lesson Plans Instructional Plans	Lee & Zhai (2024); van den Berg & du Plessis (2023); Suranti & Pradmawati (2026); Raharjo & Nurjen (2026)	AI can help teachers develop and develop learning more efficiently. However, AI results still require review and adjustment based on the objectives and characteristics of the students.
4.	AI in Development Tools and Materials Teaching	Pane (2026); Ridwan et al, (2026); Mandailina et al. (2024); Zhai & Crippen (2026)	AI has the potential to assist teachers create modules, teaching materials, and learning tools in greater and varied, but the quality of the results still depend on the teacher's ability teachers to guide and validate the AI's output.
5.	Training and Development Teacher Competencies	Nurmawati et al. (2026); Hadi et al. (2026); Ridwan et al. (2026); Dahmiar et al. (2026); Ratri et al. (2025)	Training and workshops serve as strategies that can improve teachers' practical skills in using AI to support learning activities and the development of learning materials.
6.	AI-TPACK and Pedagogical Integration	Choudhury et al. (2024); Ning et al (2024); Cao et al. (2026); Setiawan et al (2025)	Effective use of AI requires not only technical skills but also the integration of AI knowledge with pedagogy and learning materials.
7.	AI Evaluation, Ethics, and Risks	Berg & Plessis (2023); Uğur (2026); Syahabudin & Rizal (2026); Miao & Cukurova (2024)	Teachers need to evaluate the accuracy, relevance, bias, and ethical aspects of AI outputs so that the resulting learning tools are free of errors and remain appropriate for the educational context.

No.	Focus of the Study	Literacy Analyzed	Synthesis of Findings
8.	Teacher-AI Collaboration	Raharjo & Nurjen (2026); Lee & Zhai (2024); Lu et al. (2026); Tian et al. (2024)	AI is best positioned as a teaching aid or assistant. Teachers retain control in setting objectives, selecting relevant outputs, conducting validation, and making pedagogical decisions.

Discussion

AI Literacy as a Core Competency for Teacher

AI literacy is one of the most consistent themes in the literature. Knoth et al. (2024) explain that interacting with AI systems based on large language models requires the ability to formulate precise and structured instructions. In other words, the ability to use AI effectively depends not only on the availability of technology but also on the user's literacy in understanding how the technology responds to instructions. In the context of elementary school teachers, these findings have important implications. Teachers who use AI to develop modules, instructional materials, or lesson plans need to understand the purpose of using AI and the characteristics of the expected outputs. Without adequate literacy, teachers may end up accepting AI-generated results directly without verification or adjustment.

This perspective aligns with the AI Competency Framework for Teachers developed by UNESCO, which identifies 15 competencies across five dimensions: a human-centered mindset, AI ethics, AI fundamentals and applications, AI pedagogy, and AI for professional learning. The framework also categorizes the development of teacher competencies into three levels: Acquire, Deepen, and Create. In the context of developing high-quality learning materials in elementary schools, the most relevant competencies include the ability to understand the functions and limitations of AI, evaluate the accuracy of AI-generated information, safeguard students' privacy and data security, and use AI to design materials, activities, and assessments that align with children's developmental characteristics. Furthermore, teachers must be able to assess the suitability of AI-generated outputs in relation to learning objectives and students' needs, ensuring that AI functions as a pedagogical support tool rather than a substitute for teachers' professional judgment. Thus, teachers' AI literacy is not limited to technical skills in using technology but also encompasses ethical and pedagogical considerations, as well as the ability to critically evaluate the outcomes of AI use.

The UNESCO framework demonstrates that teachers' AI literacy cannot be reduced to mere technical skills. The ethical and human-centered dimensions indicate that teachers must consistently consider students' safety, rights, privacy, and best interests when using AI. Meanwhile, the pedagogical dimension of AI situates the use of technology within the context of learning objectives and practices. Thus, in the context of developing instructional materials, AI literacy can be understood as a teacher's ability to understand, use, evaluate, and integrate AI in a pedagogically and ethically sound manner. This understanding serves as the foundation for a discussion of prompt engineering skills.

Table 3. Synthesis of the Relationship Between AI Literacy and the Quality of Learning Materials

Materials Aspects of Teacher AI Literacy	Skills Required	Impact on Learning Tools
AI Understanding	Understanding the functions, capabilities, and limitations of AI	Teachers can determine when and for what purposes AI is used in the development of learning tools

Materials Aspects of Teacher AI Literacy	Skills Required	Impact on Learning Tools
Prompt Literacy	Crafting clear, specific, and goal-oriented instructions	The relevance of AI outputs to learning objectives needs to be reviewed through an evaluation and adjustment process conducted by teachers
Pedagogical Literacy	Connecting AI to learning objectives, methods, content, and learner characteristics	Learning materials are not only informative but also tailored to learning needs
Content Literacy	Understanding the substance of the content to be developed	Teachers are able to verify the accuracy and relevance of AI-generated content
Evaluating AI Output	Checking the accuracy, relevance, bias, and appropriateness of the results	Reducing the risk of misinformation and materials that are out of context
AI Ethics	Understanding privacy, copyright, transparency, and the responsible use of AI	Learning materials are developed with ethical considerations in mind
Human-AI Collaboration	Using AI as an assistant in the development process	The development of learning materials becomes more efficient without compromising teachers' professional control

Prompt Engineering as a Critical Skill

One of the most notable findings from the literature review is the importance of prompt engineering. A prompt is an instruction given to an AI system to generate a specific output. In an educational context, the quality of the prompt determines the extent to which AI can understand teachers' needs. Knoth et al. (2024) discuss prompt engineering as a skill in interacting with AI systems based on Large Language Models (LLMs). In an educational context, this skill is relevant for helping teachers formulate instructions that clearly articulate the context, learning objectives, and students' needs. The clarity of instructions is a crucial aspect to consider when teachers evaluate the alignment of AI outputs with the requirements for developing learning materials. These findings are reinforced by Lu et al. (2026), who demonstrate that simple prompts can result in incomplete instructional designs or ones that are poorly aligned with pedagogical needs. Their study developed a three-stage framework that breaks down the planning process into learning objective design, learning unit design, and activity design. This framework, grounded in pedagogical theory, yields higher-quality designs compared to the simple prompt approach.

These findings are important for elementary school teachers because instructional materials consist of various interrelated components. It is not enough for teachers to simply provide instructions such as "create a 5th-grade science learning module"; they must include a more complete context, such as grade level, subject matter, learning objectives, student characteristics, instructional approaches, time allocation, activity formats, and assessment. Therefore, the ability to craft prompts can be viewed as a practical skill in teachers' AI literacy, as it helps users convey context, instructions, and objectives in a more targeted manner. Nevertheless, the clarity of a prompt does not automatically guarantee the accuracy of AI outputs. AI systems based on Large Language Models (LLMs) still have the potential to generate inaccurate or misleading information, even if the responses provided seem convincing. Therefore, teachers need to verify the information, assess its alignment with learning objectives, and edit the AI output before using it in instructional materials.

The Use of AI in Instructional Planning

The literature indicates that one of the most rapidly developing applications of AI is assisting teachers in instructional planning. AI can be used to generate alternatives for learning

objectives, activity designs, questions, assessments, instructional materials, and ideas for learning media. Lee & Zhai (2024) found that ChatGPT was utilized by elementary school teacher candidates in planning science instruction through various instructional strategies. An analysis of 29 lesson plans showed that ChatGPT has the potential to support the development of learning questions, self-directed learning, learning support tailored to students' needs, and formative assessments. However, the study also identified risks of inaccurate information and the use of materials that lack technical support. Meanwhile, van den Berg & du Plessis (2023) demonstrated that generative AI can provide instructional materials and lesson plans for teachers and pre-service teachers, but the results must be critically evaluated. In practice, teachers remain responsible for verifying the accuracy of materials, adapting activities to learning objectives and student characteristics, and ensuring that strategies and assessments align with learning needs. Thus, ChatGPT can be utilized as a tool in the development of instructional materials, while the final decisions regarding content and its implementation remain with the teacher.

Suranti & Pradmawati (2026) also position AI as a support for effective and adaptive instructional planning. In this context, AI can help teachers develop several alternative instructional designs that are then tailored to students' needs. These findings show that the primary benefit of AI in planning is not merely to replace teachers' work, but to improve efficiency and provide alternatives that can be further developed. Teachers can use AI in the early stages to generate ideas, then select and modify them based on the classroom context.

AI in the Development of Modules and Teaching Materials for Elementary Schools

Literature directly related to elementary school teachers indicates that AI is beginning to be utilized in the development of modules and instructional materials. Pane (2026), for example, specifically examined the competencies of elementary school teachers in utilizing AI for the development of learning modules. In the same literature, the competencies discussed include AI literacy, the use of AI applications, the ability to write prompts, evaluation of outputs, integration of AI results into modules, and ethical considerations. These findings indicate that AI-assisted module development is a multi-stage process. Teachers must first identify learning needs, then use AI to help generate content or designs, evaluate the results, and make revisions. Thus, AI is more appropriately positioned as a tool for production and development rather than as an independent creator of learning materials.

Ridwan et al. (2026) also discuss the optimization of digital literacy through AI for instructional materials among elementary school educators. This focus demonstrates that enhancing teachers' ability to utilize AI is directly linked to the development of instructional materials. In the context of elementary schools, this process becomes increasingly important because instructional materials must take into account students' cognitive development levels, age-appropriate language use, the surrounding environmental context, and the characteristics of learning in elementary schools. Therefore, AI outputs need to be adapted by teachers so that they are not only factually accurate but also pedagogically appropriate.

Training as a Strategy for Developing Teachers' AI Literacy

The literature also indicates that teachers' ability to use AI needs to be developed through professional development activities. One common form is workshops or training sessions. Nurmawati et al. (2026) conducted a workshop on the use of AI to enhance the competencies of elementary school teachers. The target participants were teachers at SD Negeri 1 Kemiri in Blora Regency. The workshop was carried out through the stages of planning, implementation, evaluation, and reflection, using methods such as lectures, demonstrations, discussions, and hands-on practice with platforms like ChatGPT and Canva AI. These findings suggest that the

development of teachers' AI literacy needs to be carried out through practical experience. A theoretical introduction to AI concepts alone is not sufficient. Teachers need to practice using AI directly to complete tasks that are directly related to their work, such as designing lesson plans, instructional materials, media, and assessments.

Articles on the use of prompts and digital training for teachers also highlight the importance of these practical skills. Prasongko et al. (2026) specifically discuss the use of AI prompts by elementary school teachers, while Kaharuddin et al. (2026) and Dahniar et al. (2026) emphasize empowering educators and enhancing teacher competence through targeted practical training to develop efficient, adaptive, and technology-based learning tools. Based on this synthesis, AI training for teachers should not be limited to simply introducing the applications. Training needs to cover four key competencies: understanding AI, crafting prompts, evaluating AI outputs, and integrating AI results with pedagogical principles.

Evaluating AI Output as a Determinant of Learning Material Quality

One of the most critical aspects of the synthesis findings is teachers' ability to evaluate AI outputs. AI can generate text quickly and convincingly, but these outputs do not always align with learning objectives or students' needs. Lu et al. (2026) demonstrate that simple prompts can result in learning designs that are incomplete or misaligned with pedagogical needs. The study also shows that a prompt approach grounded in pedagogical theory can significantly improve the quality of learning designs. These findings indicate that the quality of AI-assisted instructional materials cannot be assessed solely based on the appearance or completeness of the generated text. Teachers need to validate several aspects, including: (1) the accuracy and truthfulness of the information; (2) alignment with the curriculum; (3) alignment of objectives, activities, and assessments; (4) alignment of the material with students' developmental levels; (5) use of language that is easy to understand; (6) relevance to the students' environmental context; and (7) ethical, privacy, and security aspects. Thus, the ability to evaluate AI outputs serves as a bridge between AI literacy and the quality of learning materials. Teachers who are only capable of generating AI outputs but cannot evaluate them cannot yet be said to possess adequate AI competencies in an educational context.

Integration of AI Competencies, Pedagogy, and Subject Matter Knowledge

The study findings indicate that the quality of AI use in the development of instructional materials can be assessed based on the precision and accuracy of the content, the alignment of learning strategies with established objectives, and the relevance of activities and assessments to the characteristics and needs of the students. Achieving these aspects requires teachers' ability to integrate knowledge of AI technology with pedagogical knowledge and subject matter. This perspective aligns with developments in AI-TPACK research, which emphasizes the importance of integrating knowledge of AI, pedagogy, and content to support appropriate and meaningful instructional planning.

When developing instructional materials, teachers must understand not only "how to use AI," but also "what AI is used for" and "how the results are applied in learning." For example, AI can generate designs for science learning activities, but teachers must determine whether these activities are appropriate for the characteristics of elementary school students, facilitate inquiry, and support learning objectives. This demonstrates that teachers' AI competencies are integrative in nature because they involve the integration of technological knowledge and pedagogical competencies. Technological skills without pedagogical understanding may result in instructional materials that do not align with learning objectives, student characteristics, or the coherence between content, activities, and assessment. Conversely, pedagogical competencies without the

ability to utilize AI technology can limit teachers' options for exploring learning resources and developing technology-assisted learning materials. Therefore, the use of AI in the development of learning materials must be accompanied by teachers' ability to integrate technology with appropriate pedagogical considerations.

Benefits of Using AI in the Development of Learning Materials

Based on the synthesis of articles meeting the inclusion criteria, the benefits of teachers' use of AI were grouped according to common findings related to the development of instructional materials. One identified aspect is the potential for time efficiency, namely the use of AI to assist in drafting initial designs for instructional materials, such as content, activities, and assessments. These designs must then be reviewed and refined by teachers before use. The benefits were categorized by examining the findings reported in each article and then identifying common themes across the articles. In this study, the term "key benefits" refers to themes that emerged from the literature synthesis, not to benefits that have been proven to be the greatest or most effective.

Second, variety in learning ideas. AI can generate several alternative activities, questions, methods, or forms of assessment that teachers can select and modify. Third, adaptation of learning materials. AI can be used to help tailor language, difficulty level, activity formats, or content presentation to specific needs. Fourth, support for teacher professional development. Interaction with AI can serve as a means for teachers to explore alternative learning approaches and expand their knowledge of instructional strategies. However, these benefits can only be realized if teachers possess adequate skills in using and evaluating AI. Therefore, improving AI literacy is a crucial prerequisite for optimizing these benefits.

Challenges and Risks of Using AI

Although it offers various benefits, the use of AI also presents a number of challenges. The first challenge is the possibility of inaccurate information. AI can generate answers that appear convincing but may not necessarily be correct. Therefore, teachers need to verify the information before incorporating it into learning materials. The second challenge is overreliance on AI. If teachers accept AI outputs without evaluation, learning materials may lose their contextual and professional characteristics. Teachers risk using generic materials that are not fully tailored to students' specific circumstances. The third challenge relates to ethics and data protection. Teachers need to exercise caution when entering information about students into AI systems. Principles of security, privacy, students' rights, and professional responsibility must remain key considerations. These challenges align with the UNESCO framework, which identifies AI ethics, a human-centered approach, and the responsible use of AI as integral components of teacher competence.

The Role of Teachers in Human-AI Collaboration

A synthesis of the literature indicates that the use of AI in education is best understood as a form of human-AI collaboration. Teachers are not positioned as passive recipients of AI outputs, but rather as designers and decision-makers who utilize AI to support their work. Lu et al. (2026) explicitly demonstrate that a structured prompt approach can transform teacher-AI interactions from merely receiving outputs into a collaborative design process. Teachers can review and modify results at each stage before proceeding to the next. This concept is highly relevant to the development of instructional materials. In this process, teachers can define learning objectives, ask AI to provide alternatives, review the results, refine the prompts, select appropriate outcomes, and then adapt them to the classroom context. Thus, the relationship between teachers and AI can be framed as the teacher acting as a designer and evaluator, while the AI serves as a development

assistant. This distinction is crucial to ensure that the use of AI does not diminish the professional role of teachers.

Final Synthesis: AI Literacy as the Foundation for Developing High-Quality Instructional Materials

Based on the overall findings of the study, it can be concluded that teachers' AI literacy is closely related to the quality of AI utilization in the development of instructional materials. This relationship is not direct or simple but involves several interrelated competencies. The first stage is understanding AI—that is, the teacher's ability to understand the functions, opportunities, limitations, and risks of AI. The second stage is using AI—that is, the ability to select and use applications that meet specific needs. The third stage is prompt engineering—that is, the ability to provide clear, specific, and goal-oriented instructions. The fourth stage is output evaluation, which refers to the ability to assess the accuracy, relevance, and quality of AI results. The fifth stage is pedagogical integration, which refers to the ability to adapt AI results to the curriculum, instructional materials, student characteristics, learning strategies, and assessments. The final stage is the development of instructional materials, which involves creating materials that have undergone a process of selection, adaptation, and validation by teachers.

Thus, the synthesized findings demonstrate that developing high-quality instructional materials is an iterative, multifaceted process rather than a direct technological outcome. It initiates with fundamental AI literacy, which empowers educators to execute effective prompt engineering by formulating targeted instructional queries. The resulting generative outputs are then subjected to critical output evaluation to screen for inaccuracies and biases. Subsequently, teachers perform pedagogical integration by aligning verified content with curriculum objectives, followed by contextual adaptation to accommodate young learners' cognitive readiness and classroom dynamics. Ultimately, this deliberate progression ensures the realization of robust, contextually relevant, and high-quality instructional materials.

This model demonstrates that the sophistication of AI is not the sole factor determining the quality of instructional materials. Teacher competence remains the central factor. This finding aligns with broader K–12 literature synthesized by Yim and Su (2024), which underscores that technological tools cannot independently ensure pedagogical success without teachers' critical competence and instructional guidance. The better teachers are at understanding and controlling the use of AI, the greater the likelihood that AI will be used to produce learning materials that are relevant and tailored to students' needs.

Research Implications

The results of this synthesis offer several implications. First, schools and educational institutions need to provide professional development programs that gradually enhance teachers' AI literacy. Such programs should not merely introduce applications but must also cover the practice of crafting prompts, evaluating outputs, developing learning materials, and AI ethics. Second, the development of teachers' AI competencies needs to be integrated with their pedagogical competencies. Training focused solely on technical skills risks resulting in the use of AI that is out of context. Conversely, training that connects AI to learning needs can help teachers create more meaningful learning materials.

Third, teachers need to cultivate a culture of verification and reflection regarding every AI output. AI can expedite teachers' work, but the final decision regarding the suitability of a learning resource must remain with the teacher. Fourth, future research needs to conduct more empirical studies on AI use among elementary school teachers, particularly studies that measure changes in

teachers' competencies before and after AI training, as well as the relationship between AI literacy and the quality of instructional materials actually used in the classroom.

Overall, this study confirms that AI literacy is a critical competency for elementary school teachers in the digital age. In the context of instructional material development, AI literacy encompasses an understanding of the technology's capabilities and limitations, the skill to design instructions, the ability to evaluate AI outputs, and the capacity to integrate these results with pedagogical knowledge and students' needs. These competencies are aspects that must be considered when examining the use of AI to support teachers' professional work. Therefore, the use of AI in the development of learning materials should position technology as a tool, while teachers continue to play a role in assessing, adapting, and determining the suitability of AI outputs based on learning objectives and student characteristics.

CONCLUSION

Based on the literature review conducted, it can be concluded that artificial intelligence (AI) literacy is a crucial competency for elementary school teachers in developing high-quality instructional materials. The use of AI requires not only technical skills to operate applications but also an understanding of AI's functions and limitations, the ability to design effective prompts, the capacity to evaluate AI outputs, and the skill to integrate AI results with pedagogical knowledge and instructional content.

AI has the potential to support the development of instructional materials by providing alternative learning ideas, assistance in organizing and developing content, and support in designing instructional modules, learning media, and assessments. The use of AI can also serve as an alternative to assist teachers in the lesson planning process. However, AI outputs still need to be reviewed and adapted by teachers based on learning objectives, the curriculum, student characteristics, and the learning context. Thus, AI can be positioned as a tool to assist in the development of instructional materials, while teachers remain responsible for the accuracy and appropriateness of the materials used.

The skill of designing prompts has now become an important competency, as the quality and relevance of AI outputs depend heavily on how clear the instructions provided are. However, a well-designed prompt does not guarantee that the AI's output will be entirely accurate. Therefore, teachers still need to verify the accuracy of the information, its alignment with the curriculum, learning objectives, and student characteristics, as well as ethical, privacy, and security considerations. Thus, AI should be viewed as an assistant or tool for teachers, not as a replacement for their professional role. Teachers continue to serve as designers, evaluators, and decision-makers in the process of developing instructional materials. This relationship can be illustrated through the several stages. The development of high-quality instructional materials is driven by foundational AI literacy, which enables targeted prompt engineering, followed by critical output evaluation, pedagogical integration, and contextual adaptation to primary learners' needs, ultimately resulting in high-quality instructional materials. Therefore, there is a need for practical and ongoing professional development for teachers, which includes an understanding of AI, prompt design, evaluation of AI outputs, integration of AI with pedagogy, as well as an understanding of ethics and data protection. The development of AI literacy combined with pedagogical competencies is expected to help teachers utilize AI effectively, critically, contextually, and responsibly, thereby producing more relevant and high-quality instructional materials for elementary school students.

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