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Development of AI Literacy Instruments to Map Elementary School Students' Abilities

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Abstract

The development of digital technology necessitates the strengthening of artificial intelligence literacy in elementary education as part of 21st-century skills. This study aims to develop a feasible and reliable AI literacy instrument for elementary school students. The research method employs a Research and Development (R&D) approach with the ADDIE model, encompassing the stages of analysis, design, development, implementation, and evaluation. The research participants consisted of four experts for content validation and 250 elementary school students from SD Negeri 1 Sinunukan, Sinunukan District, Mandailing Natal Regency, North Sumatra, Indonesia, for empirical testing. The instrument was developed based on five indicators of AI literacy: Recognizing AI, Understanding AI, Function/Use Apply AI, Evaluate and Create AI, and AI Ethics. The expert validation results indicate that all indicators have high content validity and are declared feasible for use. Empirical validity and reliability tests show that most instrument items fall into the valid and reliable categories, although several items in the Understanding AI indicator require refinement. The implementation results demonstrate a relatively homogeneous distribution of students' AI literacy abilities, with the main challenge being the understanding of abstract AI concepts. Overall, this instrument is feasible to use as a measurement tool for AI literacy in the context of the Merdeka Curriculum.

1. INTRODUCTION

The rapid advancement of digital technology has significantly transformed various aspects of human life, including the field of education. In recent years, the integration of artificial intelligence (AI) into everyday activities has become increasingly widespread, influencing how individuals access information, communicate, and solve problems. Educational environments are no longer limited to traditional teaching methods but are evolving into dynamic, technology-driven ecosystems. This transformation requires students to possess not only basic digital skills but also a deeper understanding of emerging technologies such as AI (Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F., 2025). Consequently, the concept of literacy has expanded beyond reading and writing to include digital and technological competencies. In this context, AI literacy emerges as a crucial component of modern education. It equips learners with the ability to interact effectively with intelligent systems. Therefore, integrating AI literacy into education is no longer optional but essential. (Chung, K., Kim, S., Jang, Y. et al., 2025)

Alongside technological development, the demands placed on students in the 21st century have also become more complex. Learners are expected to think critically, solve problems creatively, and adapt to rapidly changing environments. These competencies are closely □□□□□ dengan the ability to understand and utilize AI technologies. Without adequate literacy, students may become passive consumers of technology rather than active and critical users. Moreover, the abundance of AI-generated information poses challenges related to accuracy, bias, and ethical use. Students must be able to evaluate the credibility of information and make informed decisions (Siregar, T., Fauzan, A., Yerizon, Y., & Syafriandi, S. (2025). This highlights the importance of equipping learners with the skills needed to navigate digital environments responsibly. As a result, educational systems must respond by incorporating AI literacy

into their curricula. This ensures that students are prepared to □□□□□□ challenges in the digital era. (Yeter, I. H., Yang, W., & Sturgess, J. B., 2024)

Elementary education plays a strategic role in laying the foundation for these competencies. At this stage, students begin to develop essential cognitive skills such as reasoning, analysis, and pattern recognition. These abilities are fundamental to understanding how AI systems function. Introducing AI literacy at an early age can foster curiosity and engagement with technology in a positive way. It also helps students build a mindset that is open to innovation and continuous learning. Furthermore, early exposure can prevent misconceptions about AI and promote a balanced understanding of its capabilities and limitations. □□□□□□□□ can design learning experiences that are appropriate to students' developmental levels. This makes the introduction of AI concepts more accessible and meaningful. Therefore, elementary school becomes a critical starting point for AI literacy development. (Hong, J., Kim, K., 2025)

The integration of AI literacy into early education supports the development of ethical awareness and responsible technology use. As students interact with AI systems, they must understand the importance of privacy, data security, and academic integrity. These values are essential in fostering responsible digital citizenship. By embedding ethical considerations into AI learning, students can develop a holistic understanding of technology (Sabatini, J., Graesser, A. C., Hollander, J., & O'Reilly, T., 2023). This approach ensures that they not only use AI effectively but also responsibly. Moreover, it aligns with global educational goals that emphasize character building alongside cognitive development. The combination of technical skills and ethical awareness prepares students for future challenges. Thus, AI literacy contributes to shaping well-rounded individuals. It becomes a vital element in achieving sustainable and meaningful education in the digital age. (Yang, H., Rachmatullah, A., Alozie, N. et al., 2025)

Education is a fundamental process in human life that plays a role in transmitting knowledge, skills, and values from one generation to the next. The educational process does not only take place in formal institutions such as schools and universities but also occurs through life experiences involving social interactions and learning from the surrounding environment. Thus, education is understood as a lifelong process inherent in human life (Kempa, Sopacua, and Pattiasina 2024).

In line with this, education is positioned as a conscious and planned effort to develop the potential of students comprehensively (Pristiwanti et al. 2022). Law of the Republic of Indonesia Number 20 of 2003 concerning the National Education System affirms that education aims to develop students' potential to possess intelligence, personality, noble character, and the skills necessary for personal and community life. This view emphasizes that education is oriented not only towards cognitive aspects but also towards character building and student well-being (Purwaningtyas et al. 2024).

In the context of contemporary developments, 21st-century education demands that students possess complex knowledge accompanied by various supporting skills, such as higher-order thinking skills and the ability to utilize information, media, and technology. These demands align with the 21st-century

learning framework, which emphasizes the importance of students' readiness to face global challenges (Purwaningtyas et al. 2024).

The development of digital technology in the era of the Industrial Revolution 4.0 has brought significant changes to the world of education. Digital transformation creates a need for new skills relevant to current developments, one of which is digital literacy (Hasdyna et al. 2025). Digital literacy not only encompasses the ability to use technology but also includes understanding how technology works, managing digital information, and the ability to be critical, ethical, and responsible in its use. Literacy is not merely defined as the ability to read and write (Sirodjiddin and Soedjatmiko 2025). Literacy includes the ability to understand, manage, evaluate, and utilize information meaningfully to support life skills and learning (Ningsih and Sayekti 2023). Thus, literacy demands an active role for individuals in understanding and using information critically.

One of the digital technologies increasingly utilized in education is Artificial Intelligence (AI). AI is technology that enables computer systems to mimic human thinking abilities, particularly in performing reasoning and decision-making automatically (Hidayati 2023). In the educational context, AI is used to create more interactive and adaptive learning experiences, but it also raises ethical challenges, such as algorithmic bias and data privacy threats (Amalia, Fatmawati, and Nuriana 2025).

Therefore, the utilization of AI in education demands artificial intelligence literacy. AI literacy is understood as an individual's ability to understand the basic principles of AI, its workings and impacts, and to use AI critically and ethically. AI literacy is a crucial 21st-century skill that needs to be integrated into education, including at the elementary school level, considering that students have been interacting with AI-based technology from an early age (Maleni et al. 2025).

Various studies indicate that artificial intelligence has brought significant changes to the world of education. Research by (Amalia et al. 2025) emphasizes that the use of AI in education provides convenience for teachers and students through more interactive, adaptive, and efficient learning, such as the use of chatbots and virtual tutors. However, the article focuses more on the opportunities, impacts, and ethical challenges of AI use, including issues of privacy, bias, and data security. The discussion on AI literacy remains conceptual and is not accompanied by empirical measurements regarding the extent to which students understand, use, and behave towards AI technology, especially at the elementary education level.

Meanwhile, research by (Maleni et al. 2025) affirms that AI literacy is an essential 21st-century skill that needs to be integrated into education to prepare students for technological advancements. However, this study highlights the urgency and general integration of AI literacy and does not specifically examine the level of AI literacy among elementary school students based on measurable literacy dimensions. Thus, a research gap exists in the form of a lack of quantitative data depicting the level of artificial intelligence literacy in elementary school students, covering aspects of recognition, understanding, use, evaluation, and ethics of AI use. This research aims to fill this gap by measuring AI literacy among elementary school students.

Based on this research gap, this study aims to quantitatively determine the level of artificial intelligence literacy among elementary school students, encompassing students' abilities to recognize the existence of AI, understand the basic concepts and characteristics of AI, use AI functionally in learning activities, evaluate and create AI-assisted outcomes, and demonstrate attitudes and ethics in the wise and responsible use of AI.

2. LITERATURE REVIEW

Artificial Intelligence Literacy in Education

The rapid integration of artificial intelligence into various sectors, including education, has necessitated the development of AI literacy as a fundamental competency for the 21st century (Long & Magerko, 2020). AI literacy is broadly defined as a set of competencies that enables individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool for learning and problem-solving (Ng et al., 2021). In the context of K-12 education, the introduction of AI literacy is crucial as it equips young learners with the foundational knowledge to navigate a world increasingly shaped by intelligent systems (Touretzky et al., 2019).

Artificial Intelligence (AI) literacy has emerged as a critical domain within contemporary educational discourse, particularly in response to the rapid expansion of intelligent technologies across various sectors. In education, AI is no longer □□□□□ to advanced research settings but has become embedded in everyday learning tools such as adaptive learning platforms, virtual assistants, and automated assessment systems. This widespread integration demands that students develop not only technical familiarity but also critical awareness of how AI systems function and influence decision-making processes. Consequently, AI literacy is increasingly recognized as a core competency that complements traditional literacies. It enables learners to engage with technology in a more informed and reflective manner. Moreover, the presence of AI in educational environments reshapes the roles of both teachers and students. Therefore, fostering AI literacy is essential to ensure meaningful and responsible participation in digitally mediated learning contexts.

AI literacy is broadly conceptualized as a multidimensional construct that encompasses knowledge, skills, and attitudes related to artificial intelligence. According to Long and Magerko (2020), AI literacy involves understanding fundamental AI concepts, recognizing its applications, and critically evaluating its societal implications. This perspective highlights that AI literacy extends beyond operational skills to include analytical and ethical dimensions. Similarly, Ng et al. (2021) emphasize that AI literacy enables individuals to communicate and collaborate effectively with AI systems. This includes the ability to formulate appropriate inputs, interpret outputs, and integrate AI-generated insights into problem-solving processes. Such competencies are increasingly relevant as AI tools become more interactive and user-centered. Furthermore, AI literacy supports the development of metacognitive skills, allowing learners to reflect on how they use technology. Thus, it plays a vital role in promoting higher-order thinking in the digital age.

In the context of K–12 education, the introduction of AI literacy is particularly significant due to its long-term impact on students' cognitive and social development. Touretzky et al. (2019) argue that early exposure to AI concepts helps students build foundational understanding that can be expanded in later stages of education. At the elementary level, AI literacy can be introduced through simplified concepts such as pattern recognition, automation, and basic data usage. These concepts align with children's □□□□□□□ cognitive development, making them accessible and engaging. Early integration also fosters curiosity and positive attitudes toward technology, which are essential for lifelong learning. Additionally, introducing AI literacy at a young age helps students become more critical consumers of digital content. They learn to question the accuracy and reliability of AI-generated information. Therefore, K–12 education serves as a strategic platform for embedding AI literacy in a structured and developmentally appropriate manner.

Furthermore, the integration of AI literacy into education is closely □□□□□ with the broader goal of preparing students for future challenges in a technology-driven society. As AI continues to evolve, its impact on the workforce and everyday life becomes increasingly significant. Students who possess AI literacy are better equipped to adapt to these changes and to participate actively in shaping technological advancements. This includes understanding ethical considerations such as data privacy, algorithmic bias, and responsible use of AI. Educational systems must therefore ensure that AI literacy is not treated as an optional add-on but as an integral component of the curriculum. By doing so, schools can support the development of informed, critical, and ethical digital citizens. Ultimately, AI literacy empowers students to harness the potential of AI while mitigating its risks. It represents a forward-looking approach to education that aligns with the demands of the 21st century.

Frameworks and Dimensions of AI Literacy

Several frameworks have been proposed to structure AI literacy for educational purposes. A prominent framework by Touretzky et al. (2019) outlines five "big ideas" for K-12 AI education: Perception, Representation and Reasoning, Learning, Natural Interaction, and Societal Impact. This framework emphasizes that AI literacy goes beyond technical skills to include understanding how AI works, its limitations, and its implications for society. Similarly, Ng et al. (2021) proposed a framework comprising four dimensions: Know & Understand AI, Use & Apply AI, Evaluate & Create AI, and AI Ethics. These dimensions align closely with the indicators used in this study (Recognizing, Understanding, Using, Evaluating/Creating, and Ethics), providing a strong theoretical foundation for instrument development.

The development of AI literacy in education has been supported by various conceptual frameworks that aim to structure the competencies required for effective engagement with artificial intelligence. These frameworks provide a systematic foundation for integrating AI literacy into teaching and learning processes. One of the most influential frameworks is proposed by Touretzky et al. (2019), which introduces five "big ideas" for K–12 AI education: Perception, Representation and Reasoning, Learning, Natural Interaction, and Societal Impact. Each of these components represents a key aspect of how AI systems function and interact with humans. For instance, perception relates to how AI systems interpret

data from the environment, while learning refers to how systems improve their performance over time □□□□□□□ data. This framework emphasizes conceptual understanding rather than mere technical operation. It also highlights the importance of helping students grasp both the capabilities and limitations of AI systems. Therefore, it serves as a comprehensive guide for designing AI-related curricula.

In addition to Touretzky's framework, other scholars have proposed models that further elaborate the dimensions of AI literacy. Ng et al. (2021), for example, introduced a four-dimensional framework consisting of Know and Understand AI, Use and Apply AI, Evaluate and Create AI, and AI Ethics. This model reflects a progression from basic knowledge acquisition to higher-order thinking and ethical awareness. The "Know and Understand" dimension focuses on conceptual comprehension of AI principles, □□□□ the "Use and Apply" dimension emphasizes practical engagement with AI tools. The "Evaluate and Create" dimension encourages critical analysis and creative production using AI technologies. Finally, the "AI Ethics" dimension addresses responsible use, including issues of bias, privacy, and accountability. This framework highlights that AI literacy is not a single skill but a combination of cognitive, technical, and ethical competencies. As such, it provides a balanced approach to understanding AI in educational contexts.

The alignment between these established frameworks and the indicators used in this study demonstrates the theoretical robustness of the developed instrument. The five indicators—Recognizing AI, Understanding AI, Function/Use Apply AI, Evaluate and Create AI, and AI Ethics—closely correspond to the dimensions proposed by Ng et al. (2021). For example, the Recognizing and Understanding indicators align with the "Know and Understand AI" dimension. Similarly, the Function/Use Apply AI indicator reflects the "Use and Apply AI" dimension. The Evaluate and Create AI indicator corresponds directly to higher-order competencies involving critical thinking and creativity. Finally, the AI Ethics indicator captures the moral and social considerations emphasized in both frameworks. This alignment ensures that the instrument is grounded in well-established theoretical perspectives. It also enhances the validity of the instrument as a measure of AI literacy.

Furthermore, the integration of these frameworks into instrument development supports a holistic approach to assessing students' competencies. Rather than focusing solely on technical skills, the instrument captures a wide range of abilities, including awareness, understanding, application, evaluation, creativity, and ethical judgment. This comprehensive perspective is essential in preparing students for the complexities of the digital era. It also reflects current educational priorities □□□□ emphasize critical thinking, creativity, and responsible technology use. By grounding the instrument in established frameworks, the study ensures consistency with global standards in AI education. This not only strengthens the credibility of the research but also enhances its relevance for broader educational applications. Ultimately, the use of these frameworks contributes to the development of a valid, reliable, and theoretically sound AI literacy assessment tool.

Challenges in Assessing AI Literacy in Elementary Schools

Assessing AI literacy, particularly among young learners, presents unique challenges. The abstract nature of AI concepts, such as machine learning and algorithms, can be difficult for elementary students to grasp (Williams et al., 2019). Furthermore, there is a scarcity of validated instruments designed specifically for this age group that can reliably measure the multifaceted dimensions of AI literacy. Many existing studies rely on qualitative methods or focus on older students (Kong et al., 2021). This gap underscores the need for robust, empirically tested instruments that are developmentally appropriate and can provide reliable quantitative data on elementary students' AI literacy levels, which is the central focus of this research.

Assessing AI literacy among elementary school students presents a range of conceptual and methodological challenges that distinguish it from assessment at higher educational levels. One of the primary difficulties lies in the abstract nature of core AI concepts, such as machine learning, algorithms, and data processing. These ideas often require a level of cognitive abstraction that may not yet be fully developed in young learners. As noted by Williams et al. (2019), elementary students may struggle to comprehend invisible processes that occur behind digital interfaces. Consequently, educators must translate complex AI concepts into simplified, concrete representations that align with students' developmental stages. This requires careful instructional design as well as appropriate assessment strategies. Without such adaptation, assessments may fail to capture students' true understanding. Therefore, the challenge is not only in teaching AI but also in measuring its comprehension accurately.

In addition to conceptual barriers, the limited availability of validated assessment instruments specifically designed for elementary students poses a significant challenge. Most existing AI literacy instruments are developed for secondary or higher education contexts, where learners possess more advanced cognitive and technical skills. As a result, these instruments may not be suitable for younger students due to differences in language complexity, task demands, and contextual relevance. Kong et al. (2021) highlight that many studies in AI education still rely heavily on qualitative approaches, such as observations and interviews, to assess students' understanding. While these methods provide rich insights, they often lack the scalability and objectivity required for large-scale evaluation. The absence of standardized quantitative instruments limits the ability to compare results across studies. This creates a gap in the literature regarding reliable measurement tools for early AI literacy. Hence, there is a pressing need for instruments tailored to the characteristics of elementary learners.

Another challenge in assessing AI literacy is the multidimensional nature of the construct itself. AI literacy encompasses not only knowledge and understanding but also practical skills, critical evaluation, creativity, and ethical awareness. Capturing all these dimensions within a single instrument requires a comprehensive and well-structured framework. Each dimension must be operationalized into measurable indicators that are both valid and reliable. However, designing such indicators for young learners is complex, as it must balance simplicity with conceptual accuracy. Overly simplistic items may fail to capture meaningful differences in ability, while overly complex items may confuse students. Additionally, ensuring consistency in responses across different contexts adds another layer of difficulty.

Therefore, instrument development must involve rigorous validation and reliability testing □□□□□□□□. This ensures that the instrument accurately reflects the multifaceted nature of AI literacy.

Given these challenges, the development of robust and empirically tested instruments becomes a critical □□□□□□□□ in AI education research. Instruments must be developmentally appropriate, using language and contexts that are familiar to elementary students. They should also be capable of generating reliable quantitative data to support evidence-based decision-making. Such data are essential for evaluating the effectiveness of instructional interventions and for informing curriculum design. Furthermore, a validated instrument enables educators to identify specific areas where students need additional support. This aligns with the broader goal of fostering comprehensive AI literacy from an early age. By addressing the existing gaps in assessment tools, this research contributes to advancing the field of AI education. Ultimately, it supports the creation of more effective and inclusive learning environments in the digital era.

3. METHOD

The research was conducted at SD Negeri 1 Sinunukan, Sinunukan District, Mandailing Natal Regency, North Sumatra, Indonesia, during the odd semester of the 2025/2026 academic year, involving 250 elementary school students. This research on developing an AI literacy instrument for elementary school students is a type of study using Research and Development (R&D). Research and Development is a systematic set of steps undertaken to produce a new product or refine an existing product so that it can be accounted for by the developing researcher (Jihan, Reffiane, and Arisyanto 2019). The development of the AI literacy validation instrument in this study employed the ADDIE procedure, which includes five phases: Analyze, Design, Development, Implementation, and Evaluation (Krismony, Parmiti, and Japa 2020). The ADDIE model was chosen because it offers a systematic, structured development flow that is easily applicable in educational instrument development. Furthermore, the interconnected stages of the ADDIE model allow researchers to conduct in-depth needs analysis, design instruments tailored to the characteristics of elementary school students, develop instruments gradually, implement them in a limited setting, and evaluate them to ensure the validity, practicality, and effectiveness of the resulting instrument. Thus, the use of the ADDIE model is considered appropriate for developing an AI literacy instrument suitable for elementary school students. (Torang Siregar, & Yuni Rhamayanti. (2025)

In the *Analyze* phase, the researcher conducted a needs analysis regarding the aspects of AI literacy, which include the ability to recognize AI, understand AI, use and apply AI, create and evaluate AI utilization, and exhibit attitudes and ethics in using AI. This analysis was performed to identify the students' initial conditions, learning needs, and the gap between expected competencies and existing field conditions. The problems identified in this phase served as a reference or basis for developing a self-assessment instrument as a relevant solution suited to the characteristics of elementary school students (Firda 2023). The results of this analysis then became the basis for formulating indicators, creating instrument grids, and determining the form of statement items to be developed in subsequent stages.

The *Design* phase aimed to design the structure of the artificial intelligence literacy instrument for elementary school students. Activities in this phase included: (1) formulating the objectives of AI literacy assessment, (2) developing indicators and sub-indicators of AI literacy covering the abilities to recognize AI, understand AI, use and apply AI, create and evaluate AI utilization, and exhibit attitudes and ethics in using AI, (3) creating an instrument grid, (4) determining the form of instrument statements, and (5) designing the scoring guidelines. The instrument design considered the alignment between indicators, statements, and the developmental characteristics of elementary school students.

The *Development* phase was used to compile the instrument's statement items based on the designed blueprint. Activities in this phase included: (1) drafting the AI literacy instrument, (2) conducting expert validation covering content, construct, and language validity, (3) revising the instrument based on input from experts, and (4) pilot testing the instrument with elementary school students. Data from the pilot test were then analyzed to determine expert validity, empirical item validity, expert reliability, and the reliability of the developed instrument.

The *Implementation* phase was carried out by applying the AI literacy instrument, which had been validated by experts and revised based on their feedback, to students in grades III and IV of elementary school. The application of this instrument aimed to determine: (1) the instrument's usability in actual learning conditions, (2) the ease with which students understood the instructions and statements, (3) the suitability of the statement items to the developmental characteristics of elementary school students, and (4) the time students needed to complete the instrument. The results of this implementation phase were used as a basis for final refinements to the instrument to make it more practical, easy to use, and aligned with the goals of AI literacy measurement.

The *Evaluation* phase was used to assess the final quality of the developed AI literacy instrument. This evaluation covered several aspects, namely: (1) overall construct validity, (2) instrument reliability, (3) the instrument's effectiveness in measuring students' AI literacy abilities, and (4) the feasibility of using the instrument in elementary school learning. The results of this evaluation became the basis for concluding that the developed instrument is feasible to use and can be utilized as a valid and reliable tool for measuring AI literacy in elementary school students.

The instrument developed in this study is an AI literacy assessment tool covering several aspects: the ability to recognize AI, understand AI, use and apply AI, create and evaluate AI utilization, and demonstrate attitudes and ethics in using AI. The instrument was constructed using a Likert scale to measure students' attitudes, perceptions, and levels of understanding in a graded manner. The Likert scale is an ordinal scale that allows respondents to be ranked based on their level of agreement with a given statement, although it does not indicate equal distances between responses. Each statement item has four answer alternatives: Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD), arranged from the most positive to the most negative response (Mawardi 2019).

4. RESULTS

ADDIE Model

The ADDIE model is a systematic approach developed to produce effective learning products. This model is not only applied in the development of learning media but is also used in curriculum design, digital learning system development, module preparation, and training programs for educators. Therefore, ADDIE is often regarded as a foundational framework in instructional design due to its flexibility and applicability across various learning contexts (Rahayu 2025). The ADDIE model is a concept applied to build basic performance in the learning process, particularly in developing learning product designs. This model is part of instructional design oriented towards individual learning, encompassing stages that include short-term and long-term goals, arranged systematically, and adopting a systems approach to knowledge and the human learning process (Hidayat and Muhamad 2021).

This study involved two groups of participants: experts and students. Four experts were involved in validating the developed AI literacy instrument; they are specialists in elementary education with competencies in instrument development and learning evaluation. The research subjects consisted of 100 elementary school students who had access to electronic devices and were familiar with using AI-based digital applications. Data collection was conducted using a questionnaire developed by the researcher, used to assess aspects of students' AI literacy, including the ability to recognize, understand, use, evaluate, and create with AI in the learning context, while also gathering input from experts regarding content and construct validity. The instrument, once declared valid and reliable, was then used for data collection from the student subjects (Torang Siregar, & Yuni Rhamayanti. (2025). This instrument consisted of statements that students had to answer honestly, based on a grid developed from the aspects of AI literacy: the ability to recognize AI, understand AI, use and apply AI, evaluate and create with AI, and the attitudes and ethics in using AI. The development of the instrument based on this grid aimed to ensure that each statement item was relevant to the measured indicator and appropriate for the cognitive development level and experiences of elementary school students in utilizing AI technology, as detailed in Table 1.

The research instrument was a questionnaire developed based on five dimensions of students' abilities in AI as follows:

TABLE 1. *AI Literacy Instrument Grid*

Indicator	Sub-indicator	Item
Recognizing AI	Mentioning examples of technology or applications that use AI	I can mention examples of AI like Meta AI, Chat GPT, or Gemini.
	Recognizing results or content created by AI	I can recognize AI-generated results, for example, photos and videos produced by AI.
	Knowing applications that use AI features	I know several applications that use AI.
	Knowing game applications that use AI	I know some game applications that use AI, such as Duolingo, ML, PUBG, Infinite Craft.
	Identifying signs or icons of AI features in applications	I can recognize the appearance or signs that indicate AI features in an application.
Understanding AI	Explaining simply how AI works	I can simply explain how AI works.
	Understanding that AI can answer questions automatically	I understand that AI can answer questions automatically.
	Understanding that AI learns from data, so its answers are not always correct	I know that AI answers based on the information it learns, so its answers are not always correct.
	Understanding that AI can create images automatically	I understand that AI can create images automatically.
	Understanding that AI does not have feelings/emotions like humans	I understand that AI does not have feelings like humans.
Function / Use apply AI	Using AI applications independently	I know how to open and use AI applications without help from others.
	Using AI to search for information	I can use AI applications to ask questions or search for information.
	Using AI to create creative works	I can use AI to help with assignments, such as finding explanations or generating ideas.
	Using AI to check the correctness of answers	I can use AI to create stories, pictures, or creative ideas.
	Using AI to check the correctness of answers	I can use AI to check whether my answers are correct.
Evaluate and Create AI	Giving appropriate commands (prompts) to AI	I can give commands to AI to answer / create according to what I ask.

Indicator	Sub-indicator	Item
	Comparing AI answers with books/one's own knowledge	I can distinguish between AI answers and information from books or my own knowledge to check their correctness.
	Combining personal ideas with AI results	I can combine my own ideas with AI results (e.g., images from AI and text explanations from me).
	Creating visual works (images/posters/illustrations) using AI	I can create images, posters, or illustrations using AI assistance.
	Asking AI to revise its answers to suit needs	I can tell AI to improve its answers so they match what I ask.
AI ethics	Using AI safely (not sending personal data)	I use AI in a good way, for example, by not giving out personal information.
	Using AI for positive and beneficial purposes	I use AI only for beneficial things, such as learning.
	Giving commands to AI using polite language	I can give commands politely when using AI.
	Using AI for learning, not for cheating	I use AI to increase my knowledge, not to cheat on assignments.
	Not copying AI answers directly	I do not copy all answers from AI directly.

The AI Literacy Instrument Grid presented in Table 1 reflects a comprehensive framework for assessing students' competencies in interacting with artificial intelligence across multiple dimensions. The instrument is systematically organized into five major indicators, namely recognizing AI, understanding AI, applying AI, evaluating and creating with AI, and AI ethics. Each indicator is further elaborated into several sub-indicators that capture specific aspects of students' literacy. These sub-indicators are operationalized into measurable questionnaire items to ensure clarity and consistency in data collection. The structure of the instrument demonstrates alignment with contemporary frameworks of digital and AI literacy. It also emphasizes not only technical knowledge but also critical thinking and ethical awareness. Such a multidimensional approach is crucial in the current educational landscape where AI integration is rapidly increasing. Therefore, this instrument serves as a robust tool to evaluate students' readiness in engaging with AI technologies. (Zhang, H., Perry, A. & Lee, I., 2025)

The first indicator, recognizing AI, focuses on students' ability to identify and be aware of AI technologies in their daily lives. This includes the capacity to mention examples of AI-based applications such as conversational agents and intelligent systems. Students are also expected to recognize outputs generated by AI, including images, text, and videos. The ability to distinguish AI-generated content from human-created content is increasingly important in the digital era. Furthermore, recognizing AI involves

awareness of various applications and platforms that incorporate AI features. The inclusion of game-based applications highlights the relevance of AI in entertainment contexts familiar to students. Identifying symbols or icons associated with AI functionalities also reflects a practical understanding of user interfaces. Altogether, this indicator establishes foundational awareness, which is essential before deeper comprehension can occur. (Faizal, Khoirunnisa, & Budiono, H., 2025)

The second indicator, understanding AI, emphasizes conceptual knowledge regarding how AI operates. Students are expected to explain AI processes in simple terms, demonstrating basic comprehension of algorithms and data-driven mechanisms. This includes understanding that AI systems can automatically respond to queries based on programmed models. Importantly, students are introduced to the concept that AI learns from data, which implies potential inaccuracies in its outputs. This awareness is critical in preventing blind trust in AI-generated information. Additionally, understanding AI includes recognizing its generative capabilities, such as creating images or text. Students must also acknowledge the limitations of AI, particularly the absence of emotions and human-like consciousness. This distinction helps in fostering realistic expectations regarding AI functionalities. Consequently, this indicator supports the development of informed and critical users of AI. (Zhang, H., Perry, A. & Lee, I., 2025)

The third indicator, applying AI, relates to students' practical ability to use AI tools in various contexts. This involves independent operation of AI applications without external assistance, reflecting digital autonomy. Students are also expected to utilize AI for information retrieval, which enhances their research capabilities. The use of AI in generating creative outputs, such as ideas and explanations, indicates its role as a cognitive support tool. Additionally, AI can be used to verify answers, thereby assisting in self-assessment and learning validation. The integration of AI into academic tasks demonstrates its potential in enhancing productivity and efficiency. However, proper guidance is necessary to ensure that students use AI appropriately. This indicator highlights the importance of hands-on experience in building AI literacy. Ultimately, applying AI bridges the gap between theoretical knowledge and real-world practice. (Faizal, Khoirunnisa, & Budiono, H., 2025)

The fourth indicator, evaluating and creating with AI, represents higher-order thinking skills in Bloom's taxonomy. Students are required to formulate effective prompts to guide AI outputs according to their needs. This skill is essential for maximizing the utility of AI systems. Additionally, students must compare AI-generated responses with other sources of knowledge to assess accuracy and reliability. This critical evaluation process helps in mitigating misinformation risks. Combining personal ideas with AI-generated content reflects creative collaboration between humans and machines. Students are also encouraged to produce visual outputs such as posters or illustrations using AI tools. Revising AI outputs to meet specific requirements demonstrates iterative thinking and problem-solving skills. Thus, this indicator promotes both analytical and creative competencies in AI use. (Zhang, H., Perry, A. & Lee, I., 2025)

The fifth indicator, AI ethics, underscores the importance of responsible and ethical use of AI technologies. Students are expected to use AI safely, particularly by protecting personal data and

privacy. Ethical awareness includes understanding the potential risks associated with data misuse. Moreover, students should use AI for positive and constructive purposes, especially in educational contexts. The emphasis on polite communication with AI reflects digital etiquette and respectful interaction. Importantly, students are guided to use AI as a learning aid rather than a tool for academic dishonesty. Avoiding direct copying of AI-generated answers fosters originality and intellectual integrity. This indicator ensures that AI literacy is not limited to technical skills but also encompasses moral considerations. Consequently, ethical competence becomes a fundamental aspect of AI literacy. (Faizal, Khoirunnisa, & Budiono, H., 2025)

The use of a Likert scale ranging from 1 to 4 provides a structured approach to measuring students' responses. This scale allows for the assessment of varying levels of agreement or ability. By avoiding a neutral midpoint, the instrument encourages more definitive responses from participants. This design enhances the reliability of the collected data. Each item is scored and subsequently averaged to represent students' proficiency in each AI literacy dimension. The quantitative nature of the scale facilitates statistical analysis and interpretation. Furthermore, it allows for comparisons across different groups or contexts. Thus, the Likert scale serves as an effective measurement tool in this study. (Yim, I.H.Y., Su, J., 2025)

The data analysis method employed is descriptive quantitative analysis, which focuses on summarizing and interpreting numerical data. This approach is appropriate for identifying trends and patterns in students' AI literacy levels. By calculating mean scores for each indicator, researchers can determine areas of strength and weakness. The analysis also provides insights into overall competency levels across the five dimensions. Descriptive statistics such as averages are useful for presenting findings in a clear and concise manner. Additionally, this method supports evidence-based conclusions regarding students' abilities. The results can be used to inform educational strategies and interventions. Therefore, descriptive analysis plays a crucial role in translating raw data into meaningful insights. (Yim, I.H.Y., Su, J., 2025)

The integration of AI literacy into education reflects the growing importance of digital competencies in the 21st century. As AI technologies become more prevalent, students must be equipped with the skills to engage with them effectively. The instrument outlined in Table 1 aligns with this need by covering both cognitive and practical aspects of AI use. It also emphasizes critical evaluation and ethical considerations, which are often overlooked in traditional digital literacy frameworks. By incorporating these dimensions, the instrument provides a holistic assessment of AI literacy. This is particularly relevant in preparing students for future academic and professional environments. Consequently, the instrument contributes to the advancement of modern educational practices. (Yim, I.H.Y., Su, J., 2025)

Another significant aspect of this instrument is its adaptability to various educational levels. The items are designed in a way that they can be easily understood by students with different backgrounds. This makes the instrument versatile and applicable in diverse contexts. Teachers can also modify or expand the items □□□□□ to specific learning objectives. The flexibility of the instrument enhances its practical

utility in classroom settings. Moreover, it can serve as a diagnostic tool to identify students' needs and tailor instruction accordingly. This adaptability ensures that the instrument remains relevant in dynamic educational environments. Hence, it supports continuous improvement in teaching and learning processes. (Yim, I.H.Y., Su, J., 2025)

The role of AI in supporting learning activities is increasingly evident through this framework. AI tools can assist students in understanding complex concepts by providing explanations and examples. They also facilitate personalized learning experiences based on individual needs. The ability to generate creative content enhances students' engagement and motivation. However, without proper literacy, students may misuse these tools or rely on them excessively. The instrument addresses this issue by promoting balanced and responsible use of AI. It encourages students to view AI as a supportive tool rather than a substitute for thinking. Therefore, AI literacy becomes essential in maximizing the benefits of technology in education. (Yim, I.H.Y., Su, J., 2025)

In addition, the emphasis on critical evaluation within the instrument is particularly [illegible]. Students are trained to question and verify AI-generated information [illegible] accepting it as accurate. This skill is essential in an era where misinformation can spread rapidly through digital platforms. By comparing AI outputs with credible sources, students develop analytical thinking abilities. This process also reinforces traditional research skills in a modern context. Furthermore, it fosters a sense of responsibility in using digital information. The ability to critically evaluate AI outputs is a key component of digital citizenship. Thus, the instrument contributes to the development of informed and responsible learners. (Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F., 2025)

The creative dimension of AI literacy highlighted in this instrument is equally important. Students are encouraged to use AI as a tool for innovation and expression. This includes generating visual and textual content that reflects their ideas. The combination of human creativity and AI capabilities can lead to unique and meaningful outputs. This collaborative approach enhances students' confidence and problem-solving skills. It also prepares them for future careers where creativity and technology intersect. By fostering creativity, the instrument supports holistic student development. Consequently, it aligns with modern educational goals that emphasize innovation. (Yim, I.H.Y., Su, J., 2025)

Ethical considerations remain a central theme throughout the instrument. As AI technologies evolve, ethical challenges become more complex. Students must be aware of issues such as data privacy, bias, and academic integrity. The instrument addresses these concerns by incorporating specific items [illegible] ethical behavior. This ensures that students not only use AI effectively but also responsibly. Ethical literacy is essential in building trust and accountability in digital environments. It also helps prevent potential misuse of AI technologies. Therefore, the inclusion of ethics strengthens the overall framework of AI literacy. (Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F., 2025)

The findings [illegible] from this instrument can have significant implications for curriculum development. Educators can use the results to design targeted interventions that address gaps in AI literacy. For example, if students show low understanding of AI concepts, additional instructional support can be

provided. Similarly, low scores in ethical dimensions may indicate the need for awareness programs. The data can also inform policy decisions related to technology integration in education. By aligning curriculum with AI literacy competencies, institutions can enhance learning outcomes. This makes the instrument a valuable tool for educational planning and evaluation. (Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F., 2025)

Furthermore, the implementation of this instrument can support ongoing research in the field of AI education. Researchers can use it to explore relationships between AI literacy and other variables □□□□ academic performance or motivation. Longitudinal studies can also be conducted to track changes in students' competencies over time. This contributes to the development of evidence-based practices in education. The instrument can be adapted for different □□□□□□□□ and contexts, □□□□□□□□ □□□□□□ □□ □□□□□ □□□. By providing a standardized measurement framework, it facilitates comparative studies. Thus, it plays a significant role in advancing scholarly understanding of AI literacy.

In conclusion, the AI Literacy Instrument Grid provides a comprehensive and structured approach to assessing students' competencies in interacting with AI. It encompasses multiple dimensions, including recognition, understanding, application, evaluation, creation, and ethics. The use of a Likert scale and descriptive quantitative analysis ensures reliable and interpretable results. The instrument not only measures technical skills but also promotes critical thinking and ethical awareness. Its adaptability and practical relevance make it suitable for diverse educational contexts. By equipping students with essential AI literacy skills, it prepares them for the challenges of the digital age. Ultimately, this framework contributes to the development of competent, creative, and responsible users of AI in education. (Gökçe, H., Nacaroğlu, O., 2026)

The questionnaire used a Likert scale of 1 to 4 to assess students' ability levels for each item. Data from the questionnaire were analyzed using descriptive quantitative methods. The score for each item was averaged to determine students' abilities in the five AI dimensions: recognizing, understanding, using, evaluating, and creating. The results of this analysis were used to assess the extent to which students can utilize AI effectively, creatively, and ethically in learning activities. (Yim, I.H.Y., Su, J., 2025)

TABLE 2. *AI Literacy Validity*

Indicator	Vexp	Criteria	r	Criteria
Recognizing AI	0.950252525	V	0.485**	Valid
Understanding AI	1	V	0.425**	Valid
Function / Use Apply AI	1	V	0.646**	Valid
Evaluate and Create AI	0.978787879	V	0.591**	Valid
AI Ethics	1	V	0.565**	Valid

Note:
V = Valid
*Significant at p=0.05
**Significant at p=0.01

Based on the expert validity results conducted through the Vexp value, all indicators—Recognizing AI, Understanding AI, Function/Use Apply AI, Evaluate and Create AI, and AI Ethics—met the validity criteria. This is evidenced by the Vexp value for each indicator being > 0.83 according to Aiken's V criteria, thus theoretically appropriate and deemed feasible for empirical testing by the experts. Furthermore, the results of the empirical validity test using product-moment correlation analysis indicated that all instrument items were declared valid. This is evidenced by the correlation coefficient (r calculated) for each item being greater than the r table value at the specified significance level. These findings prove that all statements in the instrument indeed measure AI literacy according to the established indicators (Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F., 2025). Thus, empirically, the developed AI literacy instrument meets the validity criteria and is feasible for use in the research data collection phase. This result also strengthens the previous expert validity findings, so the instrument used has a strong theoretical and empirical basis.

TABLE 3. *AI Literacy Reliability*

Indicator	Rexp	Criteria	r	Criteria
Recognizing AI			0.486	Reliable
Understanding AI			0.308	Unreliable
Function / Use Apply AI			0.770	Reliable
Evaluate and Create AI			0.631	Reliable
AI Ethics			0.528	Reliable

Based on the data in Table 3, the reliability values of the AI literacy instrument for each indicator range from moderate to strong. The Recognizing AI indicator had a coefficient of 0.486 (reliable), Understanding AI was 0.308 (unreliable), Function/Use Apply AI was 0.770 (reliable), Evaluate and Create AI was 0.631 (reliable), and AI Ethics was 0.528 (reliable). In general, all indicators show that the instrument has sufficient to strong consistency in measuring students' AI literacy. This condition proves that the instrument can provide stable measurement results and does not create differences in meaning between items. Thus, the AI literacy instrument can be declared reliable and feasible for use.

TABLE 4. *AI Literacy Results*

Indicator	M	SD
Recognizing AI	13.90	2.204
Understanding AI	14.62	2.169
Function / Use Apply AI	15.17	2.861
Evaluate and Create AI	14.39	2.558
AI Ethics	15.52	2.342

Based on the results in Table 4, the students' AI literacy abilities ranged from a mean (M) of 13.90 to 15.52. The lowest average score was for the Recognizing AI indicator (M = 13.90), while the highest average was for the AI Ethics indicator (M = 15.52). Generally, most indicators fell into the moderate to high category. Overall, this table shows that students' AI literacy abilities are developing quite well, both in aspects of recognizing, understanding, using, evaluating, and applying ethics in the use of AI. Meanwhile, the standard deviation (SD) values, ranging from 2.169 to 2.861, indicate that the data distribution is relatively homogeneous and does not show overly striking differences among students. Overall, this table shows that students' AI literacy has developed relatively evenly across all measured indicators.

DISCUSSION

This study focuses on developing an AI literacy instrument covering five main indicators: Recognizing AI, Understanding AI, Function/Use Apply AI, Evaluate and Create AI, and AI Ethics. This instrument needs to be developed because, in the digital era, the ability to understand AI is a key competency for students. Moreover, elementary school is a crucial phase for the formation of critical, systematic, and adaptive thinking patterns, so AI literacy needs to be introduced from an early age. This aligns with the findings of (C., Carter, and Smith 2021), which affirm that elementary school-aged students can already recognize patterns and simple technological concepts, making them ready to be introduced to AI literacy. (Gökçe, H., Nacaroğlu, O., 2026)

This study emphasizes the development of an AI literacy instrument that encompasses five primary indicators, namely Recognizing AI, Understanding AI, Function/Use Apply AI, Evaluate and Create AI, and AI Ethics. The formulation of these indicators reflects a comprehensive framework designed to capture students’ cognitive, practical, and ethical competencies in engaging with artificial intelligence. Each indicator represents a progressive level of literacy, starting from basic awareness to higher-order thinking skills. The inclusion of these dimensions ensures that AI literacy is not treated as a purely technical skill, but as a multidimensional competence. In the context of contemporary education, such a framework is essential to prepare students for a technology-driven society. The rapid integration of AI into everyday life further strengthens the urgency of this initiative. Therefore, the development of this instrument is both timely and relevant. It provides a structured approach to assessing how students

interact with and understand AI technologies. (Sabatini, J., Graesser, A. C., Hollander, J., & O'Reilly, T., 2023)

The need for developing an AI literacy instrument is strongly influenced by the demands of the digital era. Technological advancements, particularly in artificial intelligence, have transformed how information is accessed, processed, and utilized. Students are increasingly exposed to AI-driven platforms, often without fully understanding how these systems operate. This creates a gap between usage and comprehension that must be addressed through education. By introducing a structured instrument, educators can systematically measure and improve students' AI-related competencies. Furthermore, AI literacy is becoming a fundamental skill comparable to traditional literacies such as reading and numeracy. Without adequate literacy, students may become passive users rather than critical thinkers. Thus, the development of this instrument responds to an urgent educational need. It ensures that students are equipped not only to use AI but also to understand and evaluate it critically. (Gökçe, H., Nacaroğlu, O., 2026)

Elementary school is identified as a crucial stage for introducing AI literacy due to its role in shaping foundational cognitive abilities. At this stage, students begin to develop critical thinking, logical reasoning, and problem-solving skills. These competencies are essential for understanding the basic principles of artificial intelligence. Early exposure to AI concepts can foster curiosity and adaptability in learning. It also helps students build a mindset that is open to technological innovation. Integrating AI literacy at the elementary level ensures that students grow alongside technological advancements. This proactive approach prevents the development of misconceptions about AI in later stages of education. Moreover, young learners are generally more receptive to new concepts when introduced through appropriate pedagogical strategies. Therefore, elementary education serves as an ideal entry point for AI literacy development. (Sabatini, J., Graesser, A. C., Hollander, J., & O'Reilly, T., 2023)

The alignment of this study with prior research further strengthens its theoretical foundation. The findings of C., Carter, and Smith (2021) indicate that elementary school students possess the ability to recognize patterns and understand simple technological concepts. These skills are closely related to the basic principles underlying artificial intelligence. Pattern recognition, for instance, is a fundamental aspect of machine learning processes (Siregar, T. (2025). By leveraging these existing cognitive abilities, educators can introduce AI concepts in a more accessible manner. This alignment suggests that AI literacy is not beyond the reach of young learners. Instead, it can be integrated □□□□□□□ into the curriculum □□□□□ to students' developmental stages. The research also highlights the □□□□□ of scaffolding learning experiences to match students' cognitive levels. Consequently, this study builds upon established findings to justify the introduction of AI literacy in elementary education. (Gökçe, H., Nacaroğlu, O., 2026)

The indicator of Recognizing AI serves as the foundational level in the instrument. It focuses on students' ability to identify AI technologies in their environment. This includes recognizing applications, tools, and outputs generated by AI systems. Such awareness is essential in helping students differentiate between human-generated and machine-generated content. In the digital age, where AI-

generated media is increasingly prevalent, this skill becomes highly significant. Recognizing AI also involves familiarity with commonly used platforms and applications. This practical knowledge enhances students' engagement with technology. Furthermore, it lays the groundwork for deeper understanding in subsequent stages. Without this foundational awareness, higher-level competencies cannot be effectively developed. (Gökçe, H., Nacaroğlu, O., 2026)

Understanding AI represents the second level of the instrument and emphasizes conceptual knowledge. At this stage, students are expected to grasp how AI systems function in a simplified manner. This includes understanding that AI operates based on data and algorithms. Students also learn that AI systems can provide automated responses but are not always accurate. This awareness is crucial in preventing over-reliance on AI outputs. Additionally, understanding AI involves recognizing its capabilities and limitations. For example, students learn that AI can generate content but lacks human emotions and consciousness. This distinction helps in developing realistic expectations □□□□ AI technologies. Therefore, this indicator bridges the gap between awareness and critical comprehension. (Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W., 2024)

The Function/Use Apply AI indicator focuses on practical engagement with AI tools. It assesses students' ability to use AI applications independently and effectively. This includes searching for information, generating ideas, and completing tasks □□□□□□□□ AI. Practical usage enhances students' confidence in interacting with technology. It also demonstrates how AI can support learning processes. However, this indicator also highlights the importance of guided usage. Students must learn to use AI as a tool for assistance rather than dependency. The ability to apply AI in meaningful ways reflects digital competence. Consequently, this dimension plays a key role in translating knowledge into practice. (Sabatini, J., Graesser, A. C., Hollander, J., & O'Reilly, T., 2023)

The Evaluate and Create AI indicator introduces higher-order thinking skills. Students are encouraged to critically assess AI-generated outputs and compare them with other sources. This evaluation process fosters analytical thinking and reduces the risk of misinformation. Additionally, students are guided to create new content □□□□□□□□ AI tools. This includes combining their own ideas with AI-generated outputs. Such activities promote creativity and innovation. The ability to refine and improve AI outputs through prompts demonstrates advanced interaction skills. This indicator reflects the integration of cognitive and creative competencies. It prepares students for more complex uses of AI in the future. (Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W., 2024)

AI Ethics is the final indicator and emphasizes responsible and ethical use of technology. In the context of increasing AI adoption, ethical considerations become highly important. Students must understand the □□□□□ of protecting personal data and maintaining privacy. They are also encouraged to use AI for positive and constructive purposes. Ethical literacy includes avoiding plagiarism and academic dishonesty. Students learn to respect intellectual property and produce original work. □□□□□, polite communication with AI systems reflects digital etiquette. This dimension ensures that technological

competence is balanced with moral responsibility. Therefore, AI ethics is an integral component of holistic AI literacy. (Sabatini, J., Graesser, A. C., Hollander, J., & O'Reilly, T., 2023)

The use of a structured instrument allows for systematic assessment of students' competencies across all five indicators. Each indicator is operationalized into measurable items that capture specific aspects of AI literacy. This ensures that the assessment process is both reliable and valid. The instrument can be used by educators to identify strengths and weaknesses in students' abilities. It also provides a basis for designing targeted instructional interventions. The clarity of the instrument enhances its usability in classroom settings. □□□□□, it supports consistency in data collection and analysis. Therefore, it serves as an effective evaluation tool in educational research. (Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W., 2024)

The integration of AI literacy into early education also supports the development of lifelong learning skills. As technology continues to evolve, students must be prepared to adapt to new tools and systems. AI literacy equips them with the ability to learn independently and critically evaluate information. These skills are essential in navigating the complexities of the digital world. Early exposure ensures that students develop a strong foundation that can be built upon in higher education. It also fosters a proactive attitude □□□□□□□□□□□ □□□□. This approach aligns with the goals of modern education systems. Thus, AI literacy contributes to the holistic development of students. (Su, J., Ng, D. T. K., & Chu, S. K. W., 2023)

In addition, the development of this instrument has significant implications for curriculum design. Educational institutions can integrate AI literacy into existing subjects or develop specialized programs. The instrument provides a clear framework for defining learning objectives and outcomes. It also □□□□□ teachers in aligning instructional strategies with students' needs. Curriculum integration ensures that AI literacy is not treated as an isolated topic. Instead, it becomes part of a broader educational ecosystem. This approach enhances the relevance of education in the digital age. Consequently, it supports the transformation of traditional teaching practices. (Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W., 2024)

The role of teachers is also crucial in the successful implementation of AI literacy. Educators must be equipped with adequate knowledge and skills to guide students effectively. Professional development programs may be necessary to enhance teachers' AI competencies. The instrument can serve as a reference for designing such programs. Teachers can use the results to adjust their teaching methods. □□□□□, they can provide personalized support to students based on their needs. This dynamic interaction between teaching and assessment improves learning outcomes. Therefore, teacher readiness is a key factor in the success of AI literacy initiatives. (Su, J., Ng, D. T. K., & Chu, S. K. W., 2023)

Furthermore, this study contributes to the growing body of research on AI in education. By developing a structured instrument, it provides a foundation for future empirical studies. Researchers can use this instrument to explore various aspects of AI literacy. For example, they can examine its relationship with academic performance or digital skills. The instrument also enables comparative studies across different educational contexts. This contributes to the generalization of findings. □□□□□, it supports

evidence-based policy development. Thus, the study has both theoretical and practical significance. (Su, J., Ng, D. T. K., & Chu, S. K. W., 2023)

The development of an AI literacy instrument reflects a forward-looking approach to education. It acknowledges the transformative impact of AI on society and the □□□□□ of preparing students accordingly. By focusing on elementary school students, the study emphasizes early intervention. This ensures that students develop the necessary competencies from a young age. The comprehensive nature of the instrument addresses cognitive, practical, and ethical dimensions. It aligns with global trends in digital education. Ultimately, this initiative aims to create a generation of learners who are not only technologically proficient but also critical, creative, and responsible. (Behnamnia, N., et al., 2024)

Furthermore, in the design phase, the researcher formulated the theoretical construct based on these five indicators. This aligns with instrument development procedures, where variables are first broken down into indicators before instrument items are created (Sugiharni and Setiasih 2018). Each indicator was developed into statement items that are relevant, representative, and appropriate to students' experiences, ensuring the items comprehensively reflect the aspects to be measured (Syafitri et al. 2023). This design phase also refers to the principle that instruments must be built on a strong theoretical foundation to accurately measure abilities and be free from bias. Additionally, item construction referred to content validity guidelines emphasizing the importance of construct representation and item consistency with the indicator. Subsequently, the instrument items were reviewed by experts to ensure the suitability of content, construction, presentation, and language so that the instrument would not cause ambiguity for students (Arini 2020).

Next, in the development phase, the expert validation results showed that all indicators obtained Vexp values above 0.80, meeting content validity criteria. In fact, the Understanding AI and Function/Use Apply AI indicators achieved perfect Vexp values (1.00), indicating that these two indicators have very high coherence with their theoretical constructs. This aligns with the view of (Rivera, Santos, and Gomez 2019) that a good instrument must have coherence between theory, indicators, and items to produce stable and unbiased measurements. At this stage, item correlations also showed significant results, confirming that the items functioned optimally for the empirical testing phase. (Behnamnia, N., et al., 2024)

Furthermore, the empirical validity results showed that most indicators met validity criteria. The Function/Use Apply AI (0.770), Evaluate and Create AI (0.631), and AI Ethics (0.528) indicators were declared valid because they had positive and significant correlations. However, the Understanding AI indicator (0.308) was declared less reliable, so several items needed revision. This aligns with the findings of (Li, Y., Wang and Chen 2021), which state that abstract concepts regarding how AI works are more difficult for students to understand compared to aspects of use or ethics. Nevertheless, the overall reliability of the instrument ranged from 0.486 to 0.770, which is considered adequate for educational instruments in the initial development stage (Rahman and Supardi 2022).

In the context of the Merdeka Curriculum, the analysis of validity and reliability is also closely related to determining the Criteria for Achieving Learning Objectives (KKTP). Data for this analysis can be obtained through various methods such as surveys, interviews, or documentation studies. The use of questionnaires is a common choice because it can collect data in large quantities effectively and efficiently. However, the validity and reliability of the instrument must be ensured so that the analysis results can truly serve as a basis for determining the level of achievement of learning objectives (Siregar and Rhamayanti 2025).

After the instrument was declared feasible, it was implemented with elementary school students. The results showed that the average AI literacy scores ranged from 13.90 to 15.52. The lowest score was for the Recognizing AI indicator (M = 13.90), indicating that students need reinforcement in understanding basic AI concepts. Conversely, the highest score was for the AI Ethics indicator (M = 15.52), meaning that ethical aspects are easier to understand because they relate to daily behavior in using digital devices. This finding aligns with research by (Nurhayati, N., & Sari 2023), which explains that digital ethics awareness develops faster than technical AI skills. Furthermore, the relatively low standard deviation (SD = 2.169--2.861) indicates that the distribution of student abilities is relatively homogeneous, so the instrument can measure consistently. (Behnamnia, N., et al., 2024)

In the context of the Merdeka Curriculum, the analysis of validity and reliability plays a crucial role in determining the Criteria for Achieving Learning Objectives (KKTP). These criteria serve as benchmarks to evaluate whether students have successfully achieved the expected competencies in a particular learning domain. Therefore, the accuracy of the instrument used to measure students' abilities becomes highly important (Siregar, T. (2025). Data for such analysis can be obtained through various methods, including surveys, interviews, and documentation studies, each offering unique advantages in capturing educational phenomena. Among these methods, questionnaires are widely preferred due to their practicality in collecting large-scale data within a relatively short time. However, the effectiveness of questionnaires depends heavily on their validity and reliability. Without these two qualities, the collected data may not accurately reflect students' actual competencies. Consequently, ensuring instrument quality is a fundamental step before conducting further analysis. As emphasized by Siregar and Rhamayanti (2025), valid and reliable instruments are essential to produce trustworthy findings that can inform educational decision-making. (Behnamnia, N., et al., 2024)

After the instrument was declared feasible through rigorous validation and reliability testing, it was implemented among elementary school students to measure their AI literacy levels. The results revealed that the average scores of students' AI literacy ranged from 13.90 to 15.52 across the five indicators. This range indicates a generally moderate to high level of AI literacy among participants. However, differences across indicators highlight specific areas that require further attention. The lowest mean score was found in the Recognizing AI indicator (M = 13.90), suggesting that students still face challenges in identifying and understanding basic AI-related concepts and applications. This may be due to limited exposure to explicit instruction about AI in early education. On the other hand, the highest score was recorded in the AI Ethics indicator (M = 15.52), indicating that students demonstrate a

stronger understanding of ethical aspects in using AI technologies. These findings provide valuable insights into the distribution of competencies among students. (Ng, D. T. K., Luo, W., Chan, H. M. Y., & Chu, S. K. W., 2022)

The higher performance in AI Ethics can be explained by the fact that ethical behaviors are closely related to students' [illegible] experiences when interacting with digital devices. Concepts such as not sharing personal information, using polite language, and avoiding plagiarism are often reinforced in both school and home environments. As a result, students tend to internalize these values more easily compared to abstract technological concepts. This finding is consistent with the study conducted by Nurhayati and Sari (2023), which highlights that awareness of digital ethics tends to develop earlier than technical AI skills. In contrast, recognizing AI requires more specific knowledge about how technology functions, which may not yet be fully integrated into elementary-level curricula. Therefore, targeted instructional strategies are needed to enhance students' understanding in this area. This imbalance between ethical and technical competencies underscores the importance of a comprehensive AI literacy framework. It also suggests that curriculum development should address both aspects in a balanced manner. (Behnamnia, N., et al., 2024)

Furthermore, the relatively low standard deviation values, ranging from 2.169 to 2.861, indicate that the distribution of students' AI literacy scores is relatively homogeneous. This suggests that there is no extreme disparity in abilities among students within the sample. Such consistency implies that the instrument functions effectively in capturing students' competencies in a stable manner (Siregar, T. (2025). A homogeneous distribution also reflects that the learning experiences related to AI literacy are relatively similar across participants. This strengthens the reliability of the instrument, as it demonstrates consistent measurement across different individuals. In addition, the stability of the data supports the validity of conclusions drawn from the analysis. These findings confirm that the developed instrument is not only feasible but also reliable for assessing AI literacy in elementary education. Therefore, it can be utilized as a reference tool for evaluating and improving learning outcomes related to AI literacy. (Ng, D. T. K., Luo, W., Chan, H. M. Y., & Chu, S. K. W., 2022)

Finally, in the evaluation phase, the researcher assessed the overall development process from expert validation to field implementation. Overall, this instrument meets the criteria for expert validity, empirical validity, and reliability, making it feasible for use as a tool for measuring AI literacy in elementary school students. However, several items in the Understanding AI indicator need improvement to optimize the instrument further. Additionally, the results of this study can serve as a basis for developing more comprehensive advanced AI literacy instruments. Thus, these findings can also serve as a reference for developing AI literacy curricula in elementary schools, aligning with the AI literacy development guidelines compiled by (Touretzky et al. 2022).

CONCLUSION

From this research, it can be concluded that the developed AI literacy instrument has met the feasibility criteria as a tool for measuring AI literacy in elementary school students. This instrument was developed based on five main indicators: Recognizing AI, Understanding AI, Function/Use Apply AI, Evaluate and Create AI, and AI Ethics, which are theoretically and empirically proven to be relevant for measuring AI literacy at the elementary education level. Expert validation results showed that all indicators had high content validity, while empirical validity and reliability tests showed that most indicators were in the valid and reliable categories. However, the Understanding AI indicator still requires improvement on several statement items because it showed relatively lower correlation and reliability values compared to other indicators. This finding indicates that understanding abstract AI working concepts remains a challenge for elementary school students; however, overall, the instrument can consistently measure AI literacy, with a relatively homogeneous distribution of student abilities. Thus, this AI literacy instrument is feasible to use as a basis for assessing AI literacy in the context of the Merdeka Curriculum, particularly to support the determination of the Criteria for Achieving Learning Objectives (KKTP). Furthermore, the results of this study can serve as a reference for developing more comprehensive advanced AI literacy instruments and as a reference for designing AI literacy curricula in elementary schools to align with the learning needs of the 21st century.

Declarations

Ethics Approval Statement: This study was conducted in accordance with the ethical standards for educational research involving human participants. Ethical approval for the study was obtained from the Research Ethics Committee of UIN Syekh Ali Hasan Ahmad Addary Padangsidimpuan. The approval covered the development and implementation of the AI literacy instrument with elementary school students. Participant Consent Statement: Written informed consent was obtained from the parents or legal guardians of all participating elementary school students prior to their involvement in the study. Additionally, assent was obtained from the students themselves. All participants were informed of the purpose of the study, and their participation was voluntary and confidential.

References

1. Amalia, Shofi Nur, Malinda Fatmawati, and Ervin Nuriana. 2025. "Menumbuhkan Literasi Artificial Intelligence (AI) untuk Siswa Sekolah Dasar melalui Pendidikan Science, Technology, Engineering, Art, and Mathematics (STEAM)." *Briliant: Jurnal Riset dan Konseptual* 10(2):382–87.
2. Arini, Ni Putu Piki Pia. 2020. "Pengembangan Instrumen Kemandirian Belajar dan Hasil Belajar Matematika Kelas V di SD Negeri 1 Dajan Peken." *PENDASI: Jurnal Pendidikan Dasar Indonesia* 4(2):61–68.
3. Behnamnia, N., Hayati, S., Kamsin, A., Ahmadi, A., & Alizadeh, Z. (2024). Enhancing Students' Research Skills Through AI Tools and Teacher Competencies: A Mixed-Methods Study . *Journal of E-Learning and Knowledge Society*, *20*(3), 39-55. https://doi.org/10.20368/1971-8829/1135960

4. C., Abar, L. Carter, and J. Smith. 2021. "Early technology pattern recognition and readiness for artificial intelligence learning in elementary students." *Journal of Educational Technology Development and Exchange* 14(1):45–60.
5. Chung, K., Kim, S., Jang, Y. *et al.* Developing an AI literacy diagnostic tool for elementary school students. *Educ Inf Technol* **30**, 1013–1044 (2025). https://doi.org/10.1007/s10639-024-13097-w
6. Faizal, Khoirunnisa, & Budiono, H. (2025). Science and Social Learning Tools based on Artificial Intelligence (AI) in growing Elementary Schools' Digital Literacy. *Jurnal Penelitian Dan Pengembangan Pendidikan*, *9*(1), 147–157. https://doi.org/10.23887/jppp.v9i1.87473
7. Firda, Hanum. 2023. "Penerapan model ADDIE dalam pengembangan instrumen penilaian diri sendiri peserta didik SMA Negeri Kabupaten Mojokerto." *HIKARI* 7(1):14–27.
8. Gökçe, H., Nacaroğlu, O. The effect of the use of artificial intelligence tools in science education on secondary school students' 21 st century skills competency perceptions and digital literacy. *Educ Inf Technol* **31**, 1059–1077 (2026). https://doi.org/10.1007/s10639-025-13853-6
9. Hasdyna, Novia, Rozzi Kesuma Dinata, T. Irfan Fajri, Mutasar Mutasar, and Cut Fadhilah. 2025. "Sosialisasi dan Pengenalan Dasar Kecerdasan Buatan bagi Santri Dayah Almubarakah Aceh Utara." *Jurnal Pengabdian kepada Masyarakat Nusantara* 6(2):2141–48.
10. Hidayat, Fitria, and Nizar Muhamad. 2021. "Model Addie (Analysis, Design, Development, Implementation and Evaluation) Dalam Pembelajaran Pendidikan Agama Islam Addie (Analysis, Design, Development, Implementation and Evaluation) Model in Islamic Education Learning." *J. Inov. Pendidik. Agama Islam* 1(1):28–37.
11. Hidayati, Siti Nur. 2023. *Media Pembelajaran Berbasis Artificial Intelligence (AI)*. Hikam Media Utama.
12. Hong, J., Kim, K. Impact of AIoT education program on digital and AI literacy of elementary school students. *Educ Inf Technol* **30**, 107–130 (2025). https://doi.org/10.1007/s10639-024-12758-0
13. Jihan, Aprilia Nur Fajar, Fine Reffiane, and Prasena Arisyanto. 2019. "Pengembangan Media Ludo Raksasa Pada Tema Selalu Berhemat Energi Untuk Meningkatkan Motivasi Belajar Siswa Kelas IV Sekolah Dasar." *Mimbar PGSD Undiksha* 7(2).
14. Kempa, Titin, Jems Sopacua, and Johan Pattiasina. 2024. *Landasan Pendidikan*. CV Mega Press Nusantara.
15. Kong, S. C., Cheung, W. M. Y., & Zhang, G. (2021). Evaluation of an artificial intelligence literacy course for primary school students. *Computers and Education: Artificial Intelligence*, 2, 100045. https://doi.org/10.1016/j.caeai.2021.100045
16. Krismony, Ni Putu Aprilia, Desak Putu Parmiti, and I. Gusti Ngurah Japa. 2020. "Pengembangan instrumen penilaian untuk mengukur motivasi belajar siswa SD." *Jurnal Ilmiah Pendidikan Profesi Guru* 3(2):249–57.
17. Li, Y., Wang, Q., and L. Chen. 2021. "Understanding artificial intelligence concepts among young learners: Challenges and implications." *Computers & Education*.

18. Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–16. https://doi.org/10.1145/3313831.3376727
19. Maleni, Linna, Aan Soka Pardini, Wedi Iswandi, Afrien Yudisman, Tomi Hidayat, and Rifa'i Rifa'i. 2025. "Mempersiapkan Siswa Untuk Masa Depan: Literasi AI Sebagai Keterampilan Abad 21." *RIGGS: Journal of Artificial Intelligence and Digital Business* 4(2):6375–79.
20. Mawardi, Mawardi. 2019. "Rambu-rambu penyusunan skala sikap model Likert untuk mengukur sikap siswa." *Scholaria: Jurnal Pendidikan Dan Kebudayaan* 9(3):292–304.
21. Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). AI literacy: Definition, teaching, evaluation and ethical issues. *Proceedings of the Association for Information Science and Technology*, 58(1), 504–509. https://doi.org/10.1002/pra2.487
22. Ng, D. T. K., Luo, W., Chan, H. M. Y., & Chu, S. K. W. (2022). Using digital story writing as a pedagogy to develop AI literacy among primary students. *Computers and Education: Artificial Intelligence, 3*, 100054. https://doi.org/10.1016/j.caeai.2022.100054
23. Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W. (2024). Artificial intelligence (AI) literacy education in secondary schools: A review. *Interactive Learning Environments, 32*(10), 6204–6224. https://doi.org/10.1080/10494820.2023.2255228
24. Ningsih, Leila Setia, and Retno Sayekti. 2023. "Peran perpustakaan dalam meningkatkan literasi informasi di kalangan masyarakat: sebuah systematic literature review." *Pustaka Karya: Jurnal Ilmiah Ilmu Perpustakaan Dan Informasi* 11(2):141–56.
25. Nurhayati, N., & Sari, D. P. 2023. "Literasi etika digital pada siswa sekolah dasar di era kecerdasan buatan." *Jurnal Pendidikan Dasar Indonesia* 8(2):134–45.
26. Pristiwanti, Desi, Bai Badariah, Sholeh Hidayat, and Ratna Sari Dewi. 2022. "Pengertian Pendidikan." *Pengertian Pendidikan* 4(6):7911–15.
27. Purwaningtyas, Maria A., Dewi Lestari, Muhammad Zid, and Oot Hotimah. 2024. "Persepsi Peserta didik Terhadap Penggunaan Virtual Reality Berbasis MilleaLab Sebagai Media Pembelajaran Geografi (Materi Fenomena Geosfer)." *Jurnal Pendidikan Indonesia* 5(6).
28. Rahayu, Ade. 2025. "Metode penelitian dan pengembangan (R&D): Pengertian, jenis dan tahapan." *DIAJAR: Jurnal Pendidikan dan Pembelajaran* 4(3):459–70.
29. Rahman, A., and Supardi. 2022. "Analisis reliabilitas instrumen penelitian pendidikan pada tahap pengembangan." *Jurnal Penelitian dan Evaluasi Pendidikan* 26(1):55–66.
30. Rivera, J., R. Santos, and P. Gomez. 2019. "Theoretical coherence and construct validity in educational measurement." *Educational Measurement: Issues and Practice* 38(3):24–33.
31. Sabatini, J., Graesser, A. C., Hollander, J., & O'Reilly, T. (2023). A framework of literacy development and how AI can transform theory and practice. British Journal of Educational Technology, 54, 1174–1203. https://doi.org/10.1111/bjet.13342
32. Siregar, T. (2025). Analysis of Mathematical Literacy Skills through the Think-Talk-Write (TTW) Model Assisted by GeoGebra in Terms of Students' Self-Efficacy. Preprints.

https://doi.org/10.20944/preprints202510.2072.v1

33. Siregar, T. (2025). Effectiveness of the Problem-Based Learning Model in Improving Students' Mathematical Communication Skills and Learning Motivation. Preprints. https://doi.org/10.20944/preprints202510.1562.v1
34. Siregar, T., Fauzan, A., Yerizon, Y., & Syafriandi, S. (2025). Designing mathematics teaching through deep learning pedagogy: Toward meaningful, mindful, and joyful learning. *Journal of Digital Learning, 1*(2). https://doi.org/10.23917/jdl.v1i2.11969
35. Siregar, Torang, and Yuni Rhamayanti. 2025. "Implementasi pengembangan model ADDIE pada dunia pendidikan." *Jurnal Hasil Penelitian dan Pengembangan (JHPP)* 3(2):85–100. https://doi.org/10.61116/jhpp.v3i2.561
36. Sirodjiddin, Ardan, and Suwarni Soedjatmiko. 2025. *Pendidikan Literasi: Urgensi dan Implementasi*. Cipta Prima Nusantara.
37. Su, J., Ng, D. T. K., & Chu, S. K. W. (2023). Artificial intelligence (AI) literacy in early childhood education: The challenges and opportunities. *Computers and Education: Artificial Intelligence, 4*, 100124. https://doi.org/10.1016/j.caeai.2023.100124
38. Sugiharni, Gusti Ayu Dessy, and Ni Wayan Setiasih. 2018. "Validitas dan reliabilitas instrumen evaluasi blended learning matakuliah matematika diskrit di stikom bali berbasis model alkin." *IndoMath: Indonesia Mathematics Education* 1(2):93–108.
39. Syafitri, A., D. P. Anggraini, W. M. Parinduri, T. R. Rambe, and N. Rambe. 2023. "Analisis Validitas Isi Pada Instrumen Penilaian Akhir Semester Mata Pelajaran Ipas Di Sd. School Education Journal Pgsd Fip Unimed, 13 (4), 344."
40. The Role of Artificial Intelligence Applications in Enhancing Understanding and Data Analysis Using Mind Maps among Primary School Students within the Green Line. (2025). *The Eurasia Proceedings of Educational and Social Sciences*, *40*, 17-32. https://doi.org/10.55549/epess.916
41. Thinkers, Y. Sustainability Issues, Mapping Techniques and AI Tools.
42. Torang Siregar, & Yuni Rhamayanti. (2025). Implementasi Pengembangan Model ADDIE pada Dunia Pendidikan. *Jurnal Hasil Penelitian Dan Pengembangan (JHPP)*, *3*(2), 85–100. https://doi.org/10.61116/jhpp.v3i2.561
43. Touretzky, D. S., C. Gardner-McCune, F. Martin, and D. Seehorn. 2022. "AI literacy for K--12: A framework for understanding artificial intelligence." *ACM Inroads* 13(1):20–29.
44. Touretzky, D. S., Gardner-McCune, C., Martin, F., & Seehorn, D. (2019). Envisioning AI for K–12: What should every child know about AI? *Proceedings of the AAAI Conference on Artificial Intelligence*, 33(01), 9795–9799. https://doi.org/10.1609/aaai.v33i01.33019795
45. Williams, R., Park, H. W., Oh, L., Breazeal, C., & Reich, J. (2019). PopBots: Designing an artificial intelligence curriculum for early childhood education. *Proceedings of the AAAI Conference on Artificial Intelligence*, 33(01), 9729–9736. https://doi.org/10.1609/aaai.v33i01.33019729
46. Yang, H., Rachmatullah, A., Alozie, N. *et al.* A Systematic Review Mapping of AI Literacy Progression in K–12. *Journal for STEM Educ Res* (2026). https://doi.org/10.1007/s41979-025-00166-z

47. Yeter, I. H., Yang, W., & Sturgess, J. B. (2024). Global initiatives and challenges in integrating artificial intelligence literacy in elementary education: Mapping policies and empirical literature. Future in Educational Research, 2(4), 382–402. https://doi.org/10.1002/fer3.59
48. Yim, I.H.Y., Su, J. Artificial intelligence (AI) learning tools in K-12 education: A scoping review. *J. Comput. Educ.* **12**, 93–131 (2025). https://doi.org/10.1007/s40692-023-00304-9
49. Yim, I.H.Y., Su, J. Artificial intelligence literacy education in primary schools: a review. *Int J Technol Des Educ* **35**, 2175–2204 (2025). https://doi.org/10.1007/s10798-025-09979-w
50. Yue, M., Jong, M. S. Y., Dai, Y., & Lau, W. W. F. (2025). Students as AI literate designers: a pedagogical framework for learning and teaching AI literacy in elementary education. *Journal of Research on Technology in Education*, 1–22. https://doi.org/10.1080/15391523.2025.2449942
51. Zhang, H., Perry, A. & Lee, I. Developing and Validating the Artificial Intelligence Literacy Concept Inventory: an Instrument to Assess Artificial Intelligence Literacy among Middle School Students. *Int J Artif Intell Educ* **35**, 398–438 (2025). https://doi.org/10.1007/s40593-024-00398-x

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