



Digital Readiness, Artificial Intelligence Use, and Student Learning Outcomes in Indonesia: Evidence from PISA 2025

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Abstrak

Teknologi digital dan kecerdasan artifisial (AI) semakin mengubah praktik belajar siswa, tetapi peningkatan akses terhadap teknologi tidak selalu meningkatkan capaian belajar. Penelitian ini mengkaji hubungan antara kesiapan digital sekolah, penggunaan AI oleh siswa untuk kegiatan sekolah, kesempatan untuk mengevaluasi secara kritis informasi yang dihasilkan AI, kondisi sosial ekonomi, dan capaian belajar siswa di Indonesia berdasarkan data PISA 2025. Penelitian menggunakan pendekatan kuantitatif berbasis data sekunder dengan analisis deskriptif, komparatif, dan interpretatif yang berfokus pada Indonesia. Siswa Indonesia melaporkan keterlibatan yang relatif tinggi dalam penggunaan teknologi digital dan AI, termasuk penggunaan perangkat digital untuk belajar di sekolah selama 2,5 jam per hari dan 53% siswa yang menggunakan chatbot AI setiap minggu. Namun, capaian rata-rata tetap berada di bawah rata-rata OECD dalam sains (389 dibandingkan 482), matematika (364 dibandingkan 463), dan membaca (365 dibandingkan 461). Penggunaan AI tidak secara konsisten berkaitan dengan capaian yang lebih tinggi, sehingga manfaat pendidikannya bergantung pada tujuan dan intensitas penggunaan. Kesempatan mengevaluasi informasi secara kritis dan kesiapan digital sekolah menjadi dimensi kontekstual penting, sementara perbedaan sosial ekonomi menunjukkan ketimpangan kesempatan dalam mengembangkan kompetensi AI. Tantangan Indonesia kini bergeser dari akses teknologi menuju penguatan kapabilitas digital dan AI. Penguatan kesiapan sekolah, kapasitas pedagogis guru, literasi AI kritis, dan akses yang setara terhadap pembelajaran berbantuan AI yang berkualitas menjadi penting. Mengingat bukti bersifat potong lintang dan observasional, hubungan yang ditemukan harus ditafsirkan sebagai asosiasi, bukan hubungan sebab-akibat.

Kata kunci: Kecerdasan Artifisial; Kesiapan Digital; Pembelajaran Berbantuan AI; PISA 2025; Capaian Belajar Siswa; Literasi AI Kritis; Indonesia; Kesenjangan Pendidikan

Abstract

Digital technologies and artificial intelligence (AI) are transforming students' learning practices, yet greater access does not necessarily improve outcomes. This study examines relationships among school digital readiness, students' AI use for schoolwork, opportunities to critically evaluate AI-generated information, socio-economic conditions, and learning outcomes in Indonesia using PISA 2025 evidence. A quantitative secondary-data approach was used, applying descriptive, comparative, and interpretive analysis to Indonesia. Indonesian students reported relatively high engagement with digital technologies and AI, including 2.5 hours of digital-device use at school per day and 53% reporting weekly AI chatbot use. However, mean achievement remained below the OECD average in science (389 vs. 482), mathematics (364 vs. 463), and reading (365 vs. 461). AI use was not consistently associated with higher achievement, suggesting that its educational significance depends on purpose and intensity. Critical evaluation opportunities and school digital readiness emerged as important contextual dimensions, while socio-economic differences indicated unequal opportunities to develop AI competencies. Indonesia's challenge is shifting from technological access toward digital and AI capability. Strengthening school preparedness, teacher pedagogical capacity, critical AI literacy, and equitable access to quality AI-supported learning is essential. Given the cross-sectional, observational evidence, relationships should be interpreted as associations rather than causal effects.

Keywords: Artificial Intelligence; Digital Readiness; AI-Supported Learning; PISA 2025; Student Achievement; Critical AI Literacy; Indonesia; Educational Equity

1. Introduction

The rapid diffusion of digital technologies and artificial intelligence (AI) is reshaping how students access information, complete schoolwork, and engage with learning. Generative AI tools, particularly AI chatbots such as ChatGPT, have introduced new possibilities for supporting learning activities, including searching for information, summarising texts, drafting written assignments, and explaining concepts. At the same time, the growing availability of AI creates important educational challenges. Students may become dependent on ready-made answers, engage less deeply with learning materials, or accept AI-generated information without adequately evaluating its accuracy and credibility (Popa & Oprea, 2026). Consequently, the educational value of AI cannot be understood simply in terms of whether students have access to AI or how frequently they use it. Rather, its educational implications depend on how AI is incorporated into learning activities and whether students develop the capacity to engage critically with AI-generated information.

These issues have become particularly important with the introduction of new measures of digital learning and artificial intelligence in the 2025 Programme for International Student Assessment (PISA). PISA 2025 placed science as its major assessment domain while also assessing mathematics and reading and introducing an innovative assessment of learning in the digital world. The assessment involved more than 760,000 students representing approximately 33 million 15-year-olds across 91 countries and economies. In addition to assessing academic achievement, PISA 2025 collected information on students' use of AI chatbots for schoolwork, schools' preparedness to use digital technologies for teaching and learning, and students' opportunities to assess the quality of AI-generated information. These new measures make PISA 2025 an important source of international evidence for understanding the changing relationship between digitalisation, AI-supported learning, and student achievement (Programme & Assessment, 2026).

The emerging evidence reported by the OECD suggests that the relationship between AI use and academic achievement is neither straightforward nor uniformly positive. Across OECD countries, AI chatbot use for schoolwork is already widespread, although patterns of use vary considerably across activities and intensity levels. Students who do not use AI chatbots for particular schoolwork tasks sometimes outperform those who use them. At the same time, students who use AI for the broader purpose of helping them learn may show somewhat different achievement patterns, with moderate use associated with better science performance than either very limited or intensive use (Salman et al., 2025). Such findings challenge a simple assumption that greater AI use necessarily produces better educational outcomes. Instead, they suggest that the educational implications of AI may depend on the purpose, intensity, and context of its use.

This distinction highlights the importance of school digital readiness. Digital readiness in education extends beyond students' ownership or use of digital devices. Schools require adequate digital infrastructure, reliable connectivity, access to appropriate digital resources, technical support, and sufficient teacher skills and time to integrate digital technologies effectively into teaching and learning (Nguyen et al., 2026). PISA 2025 captures this institutional dimension through measures of schools' preparedness to use digital technologies to enhance teaching and learning. The OECD evidence indicates that digital preparedness is relevant to educational performance, although its relationship with achievement can vary across education systems and may be attenuated when differences in students' socio-economic backgrounds are taken into account. Digital readiness should therefore be understood not simply as the presence of technology, but as the institutional capacity to use technology productively for educational purposes (Pratama et al., 2024).

The ability to critically evaluate AI-generated information represents another important dimension of productive AI use. AI systems can generate fluent and apparently credible responses while simultaneously producing inaccurate, incomplete, biased, or misleading information. Students therefore require more than technical access to AI tools; they need opportunities to question, verify, compare, and evaluate AI-generated content. PISA 2025 addresses this issue by asking students whether, and how frequently, they are given opportunities during school lessons to assess the quality of information generated by AI chatbots. Across OECD countries, approximately six in ten students reported receiving such opportunities (Sudaryanto et al., 2023). The OECD also reports that students who frequently use AI to help them learn and who have opportunities to assess AI-generated information tend to demonstrate somewhat higher science performance than students with less frequent use or fewer such opportunities. Importantly, these findings are correlational and should not be interpreted as evidence that AI use or critical-evaluation opportunities cause higher achievement (Harsanti et al., 2025).

The distribution of opportunities to develop critical AI-related competencies also raises an important equity concern. PISA 2025 indicates that opportunities to learn how to critically engage with AI-generated information are reported more frequently by socio-economically advantaged students. This pattern suggests that the educational implications of AI may be intertwined with broader inequalities in students' access to resources, supportive learning environments, and opportunities to develop digital competencies (Martha, 2025). Socio-economic status may therefore shape not only students' access to digital technologies but also the quality and educational purpose of their engagement with those technologies. Examining AI-related educational patterns alongside the PISA index of economic, social and cultural status (ESCS) is consequently important for understanding whether the emerging digital transformation may reinforce or reduce existing educational inequalities (Vázquez-Cano, 2023).

The Indonesian context makes these questions particularly significant. PISA 2025 shows that Indonesian students continue to face substantial challenges in science, mathematics, and reading. Indonesian 15-year-old students achieved an average score of 389 points in science, compared with 482 points across OECD countries (Maryani, 2023). The corresponding averages were 364 points in mathematics and 365 points in reading, compared with OECD averages of 463 and 461 points, respectively. Only 37% of Indonesian students reached at least Level 2 proficiency in science, compared with 74% across OECD countries, while the corresponding proportions were 17% in mathematics and 27% in reading. These results highlight the importance of examining how emerging digital and AI-supported learning practices are situated within a broader educational system that continues to face substantial learning challenges (Ekanesia, 2026).

Indonesia is also an important context for examining the educational implications of AI because the expansion of digital and AI-supported learning occurs alongside persistent differences in educational resources and student achievement. The availability of AI tools alone does not guarantee productive learning (Lo, 2023). Students may use AI as a substitute for cognitive effort, or they may use it as a tool for questioning, exploring, comparing explanations, and deepening understanding (Farizi, 2025). Likewise, schools with stronger digital preparedness may be better positioned to provide the infrastructure, teacher support, and pedagogical guidance necessary for productive technology use (Kisam et al., 2025). The coexistence of these conditions makes Indonesia a particularly relevant case for examining the opportunities and challenges associated with the emerging AI-supported learning environment.

Despite the growing literature on digital learning and AI in education, several gaps remain. First, much of the existing evidence on AI and learning outcomes has focused on university students, individual institutions, or relatively small samples, limiting its relevance to the broader school-age population (Besas, 2026). Second, digital readiness is frequently conceptualised at the individual level, while less attention has been given to the institutional preparedness of schools to integrate digital technologies into teaching and learning. Third, AI use is often discussed primarily in terms of access or frequency, without sufficient attention to students' opportunities to critically evaluate AI-generated information. Fourth, evidence concerning these dimensions in middle-income education systems remains comparatively limited. Finally, the release of PISA 2025 provides a timely opportunity to synthesise newly available international evidence on AI use, digital preparedness, critical evaluation of AI-generated information, and student achievement, with particular attention to the Indonesian context.

This study therefore examines Indonesia's PISA 2025 evidence on school digital readiness, students' AI use for schoolwork, critical evaluation of AI-generated information, and student learning outcomes. Science achievement is given primary attention because science is the major domain of PISA 2025, while mathematics and reading provide additional perspectives on student achievement. AI use is examined through the OECD's AIUESCH index, which captures students' frequency of using AI chatbots for school-related activities, including summarising texts, conducting preliminary research, drafting written assignments, and helping them learn. School digital readiness is examined through the PISA 2025 evidence on schools' preparedness to use digital technologies to enhance teaching and learning. The analysis also considers the reported opportunities students receive to assess AI-generated information and the role of socio-economic background in shaping these patterns.

Accordingly, the study addresses four research questions. First, what does PISA 2025 reveal about the level and educational significance of school digital readiness in relation to student learning outcomes in Indonesia? Second, what patterns of AI use for schoolwork are reported among Indonesian students, and how are these patterns situated in relation to student achievement? Third, what does PISA 2025 reveal about students' opportunities to critically evaluate AI-generated information, and how are these opportunities associated with patterns of AI-supported learning? Fourth, how do socio-economic differences contribute to the unequal distribution of digital and AI-related learning opportunities?

The study makes three contributions. First, it brings together the newly available PISA 2025 evidence on school digital preparedness, AI use, critical evaluation of AI-generated information, and student achievement within a single analytical framework. Second, it extends discussion of AI in education beyond the question of whether students use AI by emphasising the institutional and pedagogical conditions under which AI-supported learning takes place. Third, it contributes evidence from Indonesia, an education system where substantial learning challenges coexist with the rapid expansion of digital technologies and AI-supported educational practices.

The study does not assume that AI use causes higher or lower achievement. Because the PISA evidence considered in this study is observational and cross-sectional, reported relationships should be interpreted as associations rather than causal effects. The purpose is instead to identify important patterns in the latest international evidence and to consider what these patterns imply for Indonesian education. By bringing together school digital readiness, AI use, critical evaluation of AI-generated information, student achievement, and socio-economic inequality, this study moves beyond the question of whether students use AI toward a more consequential question: under what educational conditions might AI function as a productive learning resource rather than simply another source of digital information?

2. Method

This study employed a quantitative secondary-data design using evidence from the Programme for International Student Assessment (PISA) 2025 conducted by the Organisation for Economic Co-operation and Development (OECD). The analysis focused on Indonesia and examined the relationship between digital learning conditions, students' use of artificial intelligence (AI) for schoolwork, and student learning outcomes. The study used OECD-reported PISA 2025 data and results concerning school preparedness for digital learning, AI use for schoolwork (AIUSESCH), opportunities to assess AI-generated information, economic, social and cultural status (ESCS), and achievement in science, mathematics, and reading. Science was treated as the primary achievement domain because it was the major domain in PISA 2025, while mathematics and reading were examined as complementary outcomes.

The analysis employed a descriptive, comparative, and interpretive approach. Indonesia's achievement results were compared with OECD averages, while reported patterns of AI use, school digital preparedness, critical evaluation of AI-generated information, and socio-economic differences were examined to identify their educational implications. The interpretation followed the OECD PISA methodological framework, including the use of plausible values and complex survey procedures in the reported achievement estimates. Because the present study relies on officially reported OECD estimates rather than independent analysis of student-level microdata, it does not generate new regression coefficients, correlations, interaction effects, or model-fit statistics. All relationships are therefore interpreted as associations rather than causal effects, consistent with the cross-sectional nature of PISA.

3. Result and Discussion

Result

Student Achievement in Indonesia

PISA 2025 included 14,168 Indonesian students from 419 schools, representing approximately 3.995 million 15-year-old students, or around 90% of the country's population of 15-year-olds. The Indonesian PISA 2025 data met the OECD's data-quality standards and were considered fit for reporting.

Indonesia's achievement remained substantially below the OECD average across all three core domains. As shown in Table 1, Indonesian students achieved a mean score of 389 points in science, compared with 482 points across OECD countries, resulting in a 93-point gap. In mathematics, the Indonesian mean score was 364 points, compared with an OECD average of 463 points, representing the largest gap of 99 points. In reading, Indonesian students achieved 365 points, compared with 461 points across OECD countries, corresponding to a 96-point gap.

Table 1. PISA 2025 Achievement Scores: Indonesia and OECD Average

Achievement domain	Indonesia	OECD average	Difference
Science	389	482	−93
Mathematics	364	463	−99
Reading	365	461	−96

Source: OECD, PISA 2025 Results.

The pattern indicates that the learning challenge in Indonesia is not restricted to a single subject. The achievement gap exceeds 90 points in all three domains, with mathematics showing the largest difference. These results provide an important context for interpreting the educational implications of digital technologies and AI in Indonesia because the expansion of digital learning is occurring alongside substantial weaknesses in foundational academic achievement.

Proficiency Levels and the Learning Challenge

The distribution of students across proficiency levels provides further evidence of the learning challenge. As shown in Table 2, only 37% of Indonesian students reached at least Level 2 in science, compared with 74% across OECD countries. The difference is even more pronounced in mathematics, where only 17% of Indonesian students reached Level 2 or above, compared with 65% across OECD countries. In reading, 27% of Indonesian students reached at least Level 2, compared with 69% across OECD countries.

Table 2. Students Achieving at Least Level 2 Proficiency

Domain	Indonesia (%)	OECD average (%)	Difference (percentage points)
Science	37	74	−37
Mathematics	17	65	−48
Reading	27	69	−42

Source: OECD, PISA 2025 Results.

The proficiency distribution demonstrates that the Indonesian challenge concerns not only the average level of achievement but also the proportion of students who possess at least the baseline competencies measured by PISA. The largest difference occurs in mathematics, where the proportion of Indonesian students achieving Level 2 or above is 48 percentage points lower than the OECD average. In science, only a small proportion of Indonesian students reached the highest proficiency levels (Levels 5 and 6), compared with approximately 7% across OECD countries.

These findings are important when considering the potential contribution of AI to learning. If AI is introduced into an educational environment in which many students have not yet developed strong foundational competencies, its educational value may depend heavily on whether it supports students' reasoning and understanding rather than simply providing ready-made answers.

Digital Learning Conditions and School Preparedness

Digital technology has become a substantial component of students' school experience in Indonesia. Indonesian students reported spending an average of 2.5 hours per day using digital devices at school for learning activities, compared with 1.7 hours across OECD countries. At the same time, Indonesian students reported approximately 1.3 hours per day using digital devices for leisure at school, compared with 1.1 hours across OECD countries.

Table 3. Digital Learning Conditions in Indonesia

Indicator	Indonesia	OECD average / comparison
Digital-device use for learning at school	2.5 hours/day	1.7 hours/day
Digital-device use for leisure at school	1.3 hours/day	1.1 hours/day
Students reporting frequent peer distraction by digital devices	23%	—
Students attending schools prohibiting mobile-phone use	45%	—
Science-score difference associated with frequent peer distraction	−11 points	—

Source: OECD, PISA 2025 Results. “—” indicates that the corresponding OECD comparison is not reported in the evidence used in this study.

The relatively high amount of time spent using digital devices for learning does not, by itself, indicate that digital technologies are producing better learning outcomes. Approximately 23% of Indonesian students reported that their peers were often distracted by digital devices during most or all science lessons. Students who reported such distraction achieved science scores approximately 11 points lower than students who did not report such distraction, after accounting for students' and schools' socio-economic profiles. Furthermore, 45% of Indonesian students attended schools where mobile-phone use was prohibited on school premises. This finding illustrates the tension between the educational potential of digital technologies and concerns about distraction and inappropriate use.

At the international level, PISA 2025 indicates that school preparedness for digital learning is positively associated with average science, mathematics, and reading performance across education systems. However, these relationships are less consistent within individual education systems after socio-economic differences are taken into account. Thus, the presence of digital resources should not be interpreted as equivalent to effective digital learning capacity. The findings suggest that digital access and digital readiness represent different educational conditions. Access concerns whether technology is available, whereas readiness concerns whether schools possess the organisational, technical, and pedagogical capacity to use that technology effectively.

Patterns of Artificial Intelligence Use for Schoolwork

AI chatbot use was already widespread among Indonesian students in PISA 2025. Fifty-three percent of Indonesian students reported using AI chatbots to help them learn at least once a week, compared with 46% across OECD countries. This indicates that weekly AI-supported learning was more prevalent among Indonesian students than the OECD average.

AI was also used for several specific schoolwork activities. Approximately 39% of Indonesian students reported using AI chatbots to summarise a text they had to read, while 32% used AI for preliminary research on a new topic and 30% used AI to draft texts for writing assignments. Only 7% of Indonesian students reported never or almost never using AI chatbots for any of the schoolwork tasks examined, compared with 14% across OECD countries.

Table 4. AI Chatbot Use for Schoolwork

AI-related activity	Indonesia (%)	OECD (%)
Help me learn at least weekly	53	46
Summarise a text	39	—
Conduct preliminary research	32	—
Draft text for writing assignments	30	—
Never/almost never use AI for examined schoolwork tasks	7	14

Source: OECD, PISA 2025 Results. “—” indicates that a directly comparable OECD percentage is not reported in the evidence used in this study.

These findings position Indonesia as an education system in which AI-supported learning is already relatively widespread. However, the results do not support a straightforward interpretation that more frequent AI use necessarily produces better academic achievement.

Across OECD countries, students who did not use AI chatbots for particular schoolwork tasks generally outperformed students who used them. At the same time, the relationship between AI use and achievement varied according to the purpose and intensity of use. Students who used AI to help them learn showed a more complex pattern, with moderate use associated with somewhat better science performance than very limited or intensive use. Students who used AI weekly tended to perform similarly to non-users on average. The findings therefore indicate that frequency of AI use should not be treated as a direct indicator of educational effectiveness. The purpose and manner of use appear to be important dimensions of the relationship between AI and learning.

Opportunities to Evaluate AI-Generated Information

PISA 2025 also provides evidence concerning students' opportunities to evaluate information generated by AI chatbots. Across OECD countries, approximately six in ten students reported that they were given opportunities during school lessons to assess the quality of information generated by AI.

Among students reporting such opportunities, approximately 46% reported doing so sometimes, 33% often, and 22% very often. These findings indicate that critical evaluation of AI-generated information is becoming an emerging component of school-based digital learning.

The OECD further reports that students who frequently used AI to help them learn and who also reported opportunities to assess AI-generated information tended to achieve somewhat higher science scores than non-users or infrequent users. However, this pattern should not be interpreted as evidence of a causal effect. The OECD explicitly characterises the relationship as correlational.

Furthermore, after accounting for students' and schools' socio-economic profiles, the relationship between opportunities to assess AI-generated content and science performance is not consistently observed across education systems. This suggests that the educational significance of critical AI evaluation cannot be separated from broader contextual factors, including students' backgrounds and school environments.

The evidence nevertheless points to an important educational principle: AI use and critical evaluation should be considered together. Students who receive AI-generated information without learning how to question or verify it may not obtain the same educational benefits as students who are encouraged to critically examine AI outputs.

Socio-Economic Differences in Achievement

Socio-economic background remains an important dimension of student achievement in Indonesia. PISA 2025 indicates that 47% of Indonesian students were in the bottom international quartile of the socio-economic scale. Students in this group achieved an average science score of 375 points.

Within Indonesia, students in the top 25% of socio-economic status outperformed students in the bottom 25% by 47 points in science. Although this difference is substantial, it is smaller than the corresponding 85-point gap across OECD countries. Socio-economic status accounted for approximately 9% of the variation in science performance in Indonesia, compared with 12% across OECD countries.

Table 5. Socio-Economic Differences in Science Achievement

Indicator	Indonesia	OECD average
Students in bottom international ESCS quartile	47%	—
Science score of bottom ESCS group	375	—
Achievement gap: top vs. bottom ESCS group	47 points	85 points
Variation in science performance explained by ESCS	9%	12%

Source: OECD, PISA 2025 Results. "—" indicates that a directly comparable value is not reported in the evidence used in this study.

An additional finding is that approximately 15% of socio-economically disadvantaged Indonesian students achieved scores within the top quarter of science performance in Indonesia. This indicates the existence of academically resilient students who achieve relatively high performance despite socio-economic disadvantage.

The socio-economic findings are particularly relevant to the digital and AI dimensions of this study. PISA 2025 indicates that opportunities to learn how to critically evaluate AI-generated information are reported more frequently by socio-economically advantaged students. Therefore, inequality in educational outcomes may coexist with inequality in access to high-quality opportunities to develop critical AI competencies.

Integrated Findings: The Digital-Use Paradox

Taken together, the PISA 2025 findings reveal a notable digital-use paradox in Indonesia. Indonesian students report relatively high engagement with digital technologies and AI, yet this engagement coexists with substantial learning deficits.

On the one hand, Indonesian students reported spending 2.5 hours per day using digital devices for learning at school, compared with 1.7 hours across OECD countries. Similarly, 53% of Indonesian students reported using AI chatbots to help them learn at least weekly, compared with 46% across OECD countries. AI was also commonly used for summarising texts, conducting preliminary research, and drafting written assignments.

On the other hand, Indonesian students achieved mean scores of only 389 in science, 364 in mathematics, and 365 in reading, substantially below the respective OECD averages of 482, 463, and 461 points. Only 37% of Indonesian students reached at least Level 2 in science, 17% in mathematics, and 27% in reading.

The coexistence of high digital engagement and low academic achievement should not be interpreted as evidence that digital technologies or AI negatively affect Indonesian students. Rather, it indicates that technology access and frequency of use are insufficient indicators of productive educational technology integration.

The PISA 2025 evidence instead points toward several conditions that may be important for productive digital and AI-supported learning: school preparedness, appropriate intensity and purpose of AI use, teacher guidance, protection against digital distraction, opportunities to critically evaluate AI-generated information, and equitable access to high-quality digital learning experiences.

The findings therefore support a shift from an access-oriented perspective toward a capability-oriented perspective. The central issue is not simply whether students use AI, but whether students and schools possess the capabilities required to use AI in ways that support learning. The main findings can be summarised in four points. First, Indonesian students continue to perform substantially below the OECD average in science, mathematics, and reading, with achievement gaps exceeding 90 points in all three domains. Second, digital-device and AI use are relatively widespread among Indonesian students, indicating that the challenge is no longer simply one of technological access. Third, the PISA 2025 evidence suggests that the relationship between AI use and achievement is complex and depends on the purpose and intensity of use rather than frequency alone. Fourth, opportunities to critically evaluate AI-generated information and socio-economic conditions represent important contextual dimensions of AI-supported learning.

Overall, the findings indicate that the educational challenge associated with AI in Indonesia is increasingly shifting from access to effective use. The evidence suggests that schools need not only digital infrastructure but also the pedagogical capacity to guide students in using AI critically, purposefully, and responsibly. This provides the empirical basis for discussing how Indonesia can move from widespread technology adoption toward more effective and equitable digital learning.

Discussion

The findings of this study provide an important picture of the emerging relationship between digitalisation, artificial intelligence (AI), and student learning in Indonesia. The most notable finding is the coexistence of relatively high engagement with digital technologies and AI with substantially lower learning outcomes than the OECD average. Indonesian students reported relatively extensive use of digital devices for learning at school, while AI chatbot use for schoolwork was also widespread. Nevertheless, Indonesia's mean achievement remained considerably below the OECD average in science, mathematics, and reading. This pattern suggests that technological access and frequency of use alone are insufficient to ensure improved learning outcomes. Instead, the educational value of digital technologies and AI appears to depend on how these technologies are embedded within pedagogical practices, school capacity, and students' learning behaviours.

Digital Engagement Does Not Automatically Translate into Learning Gains

The Indonesian PISA 2025 results challenge a technology-deterministic view of educational digitalisation. Indonesian students reported spending more time using digital devices for learning at school than the OECD average, yet their achievement remained substantially lower across all three domains. This finding suggests that increasing students' exposure to digital technologies should not be equated with improving the quality of learning.

One possible interpretation is that digital technology functions as an educational resource rather than an educational intervention in itself. Its contribution depends on how teachers structure learning activities, how students engage with digital information, and whether digital tools are aligned with learning objectives. The finding that students in Indonesia who reported greater digital-device distraction during science lessons achieved lower science scores further illustrates that technology can have both productive and counterproductive consequences. Digital devices may facilitate access to information and interactive learning while simultaneously increasing opportunities for distraction and reducing sustained cognitive engagement.

This interpretation is consistent with the broader literature on educational technology, which increasingly emphasises the distinction between technology access, technology use, and pedagogically meaningful technology integration (Hikmah et al., 2025). Schools may possess devices and connectivity without necessarily possessing the organisational, pedagogical, and professional capacity required to transform these resources into effective learning experiences (Ismawati & Amertawengrum, 2023). Consequently, digital readiness should be understood as an institutional capability rather than simply the availability of hardware.

AI Use and the Importance of Purpose

The widespread use of AI chatbots among Indonesian students is another important finding. More than half of Indonesian students reported using AI to help them learn at least weekly, and substantial proportions reported using AI for summarising texts, preliminary research, and drafting written assignments. These figures indicate that generative AI is no longer merely an emerging technology for Indonesian students; it is already becoming part of students' learning practices.

However, the PISA 2025 evidence does not support the assumption that more frequent AI use necessarily produces better academic performance. Across OECD countries, students who use AI for particular schoolwork tasks do not consistently outperform non-users, while the relationship between AI use for learning and science performance appears more complex. Moderate use may be associated with somewhat better performance than very limited or intensive use. This pattern is important because it suggests that the educational consequences of AI depend partly on how AI is used and what cognitive role it plays in the learning process.

AI may support learning when it functions as a cognitive tool that helps students explore ideas, obtain explanations, compare perspectives, or receive feedback. Conversely, AI may become less educationally productive when students use it primarily to replace cognitive effort, generate answers without reflection, or complete assignments without developing their own understanding. From this perspective, the central educational question is not whether students use AI, but whether AI use complements or substitutes for students' cognitive engagement.

The Indonesian context makes this distinction particularly important. Given the relatively low proportion of students achieving baseline proficiency in science, mathematics, and reading, AI should not simply be promoted as an additional source of answers (Kurnianto, 2025). Instead, its use should be connected to foundational learning, reasoning, problem-solving, scientific inquiry, reading comprehension, and independent thinking. AI-supported learning policies should therefore prioritise productive use rather than maximum use.

School Digital Readiness as an Enabling Condition

The findings also reinforce the importance of considering AI use within the broader context of school digital readiness. PISA 2025 conceptualises school preparedness for digital learning in terms of schools' capacity to use digital technologies to enhance teaching and learning, including the availability of digital resources, relevant skills, and sufficient time. This perspective moves the discussion beyond the assumption that students' individual access to technology is sufficient.

For Indonesia, strengthening school digital readiness may therefore require more than providing devices or improving connectivity. Schools need teachers who can integrate digital technologies into subject-specific pedagogy, mechanisms for technical support, sufficient planning time, and clear instructional strategies for the responsible use of AI. Without these conditions, AI may simply increase the quantity of information available to students without improving their ability to evaluate or use that information effectively.

This finding has particular implications for school leadership. Digital transformation should be treated as an organisational and pedagogical process rather than solely as an infrastructure programme. School leaders need to consider how technology is incorporated into curriculum planning, classroom assessment, teacher professional development, and student guidance (Hikmah et al., 2025). In this sense, digital readiness can be viewed as an enabling condition that determines whether technological resources are converted into meaningful educational opportunities.

Critical Evaluation as a Core AI Literacy

One of the most important contributions of PISA 2025 is its attention to students' opportunities to evaluate AI-generated information. The finding that approximately six in ten OECD students reported receiving such opportunities indicates that critical engagement with AI is becoming an emerging component of contemporary schooling (Ismawati & Amertawengrum, 2023). This is particularly important because generative AI systems can produce responses that appear authoritative while containing factual errors, incomplete explanations, or misleading information.

The association reported by the OECD between AI use for learning, opportunities to assess AI-generated information, and somewhat higher science performance provides an important direction for educational practice. Although the evidence cannot establish causality, it suggests that AI use accompanied by critical engagement may represent a more productive learning pattern than AI use without guidance.

This finding supports a shift from an access-based model of AI literacy toward a critical AI literacy model. Students need to know not only how to operate AI tools but also how to interrogate their outputs. In classroom practice, this could involve asking students to compare AI-generated explanations with textbooks or scientific sources, identify errors or unsupported claims, verify evidence, recognise bias, and revise AI-generated responses based on reliable information. Such activities transform AI from an answer-generating mechanism into an object of inquiry and evaluation.

For science education in particular, this approach is highly relevant. Scientific literacy requires students to evaluate evidence, distinguish claims from evidence, and assess the credibility of information. AI-generated content can therefore become a useful pedagogical resource if students are explicitly taught to evaluate it rather than accept it uncritically.

Socio-Economic Inequality and the Risk of a Digital Divide 2.0

The findings concerning socio-economic status raise a further concern. PISA 2025 indicates that opportunities to learn how to evaluate AI-generated information are more frequently reported by socio-economically advantaged students. This suggests that the emerging AI transformation may create a new form of educational inequality. The issue is no longer simply whether students have access to digital devices or the internet; it increasingly concerns whether students have access to high-quality opportunities to learn how to use and critically evaluate AI.

This distinction can be conceptualised as a shift from a traditional digital divide toward a digital capability divide. Students from more advantaged backgrounds may have greater exposure to supportive learning environments, digitally capable teachers, parental guidance, and educational resources that enable them to use AI more strategically. Disadvantaged students may have access to the same AI tools but fewer opportunities to learn how to question, verify, and critically engage with AI-generated information.

The Indonesian findings are particularly relevant in this regard. Although the socio-economic achievement gap reported by PISA is smaller than the OECD average, socio-economic background still explains a meaningful proportion of variation in science performance (Sudaryanto et al., 2023). Therefore, policies promoting AI in

education should explicitly address equity. Simply providing universal access to AI tools may not reduce educational inequality if the quality of AI-related learning opportunities remains uneven.

Implications for Indonesian Education

Taken together, the findings suggest that Indonesia should approach AI in education through a capability-building strategy rather than an access-expansion strategy alone. Three priorities emerge.

First, schools should strengthen their digital preparedness by investing not only in infrastructure but also in teacher professional development, technical support, and pedagogical capacity. Teachers need practical guidance on how AI can be incorporated into subject-specific learning without replacing students' cognitive work.

Second, AI literacy should be integrated into classroom learning. Students should be explicitly taught how to verify AI-generated information, identify errors, compare multiple sources, recognise uncertainty, and use AI outputs as material for analysis rather than as unquestioned answers. Such competencies are relevant across science, mathematics, reading, and other subjects.

Third, AI-related educational opportunities should be distributed equitably. Schools serving students from disadvantaged backgrounds should not receive only access to technology but also stronger support for teacher training, digital infrastructure, instructional resources, and critical AI literacy (Ekanesia, 2026). Otherwise, differences in the quality of AI-supported learning may reinforce existing educational inequalities.

These priorities also suggest that policymakers should be cautious about evaluating AI initiatives primarily through indicators such as the number of devices distributed, internet connectivity, or the percentage of students using AI. More meaningful indicators would include whether students can independently evaluate AI-generated information, whether teachers can integrate AI into effective pedagogy, and whether AI use is associated with deeper learning and improved foundational competencies.

Theoretical Implications

The findings contribute to an emerging conceptualisation of AI-supported learning in which educational outcomes are shaped by the interaction of technology, institutional capacity, and human agency. The results suggest that AI should not be conceptualised as an independent technological input that automatically generates educational benefits. Rather, its potential value is embedded within a broader socio-technical environment.

School digital readiness represents the institutional dimension of this environment, AI use represents students' engagement with the technology, and critical evaluation represents an important dimension of human agency. Socio-economic background further influences the distribution of these opportunities. This framework provides a useful basis for future empirical studies that can directly test whether these dimensions interact to shape student achievement.

Limitations and Directions for Future Research

Several limitations should be considered when interpreting the findings. First, the present study relies on officially reported PISA 2025 evidence rather than independent analysis of the underlying student-level microdata. Consequently, the study does not estimate new regression coefficients, correlations, or interaction effects. Second, PISA is cross-sectional, meaning that reported associations cannot establish temporal ordering or causal relationships. Third, AI use measures are based primarily on students' self-reports and therefore may be affected by differences in interpretation or reporting behaviour. Finally, opportunities to evaluate AI-generated information should not be interpreted as a direct measure of students' actual competence in evaluating AI outputs.

Future research should use the PISA 2025 microdata to conduct multilevel and survey-weighted analyses that explicitly examine the relationships among school digital readiness, AI use, critical evaluation, socio-economic status, and achievement. Longitudinal and experimental research would also be valuable for determining whether particular forms of AI-supported learning actually improve student learning outcomes. Such research could move beyond identifying associations toward establishing which pedagogical approaches to AI produce meaningful and equitable learning gains.

Overall, the PISA 2025 evidence suggests that the educational challenge facing Indonesia is not simply to expand students' access to digital technologies and AI. The more fundamental challenge is to ensure that students and schools possess the capacity to use these technologies productively, critically, and equitably. AI has the potential to support learning, but its educational value depends on the conditions under which it is used. For Indonesia, the priority should therefore be to develop schools, teachers, and students that are not merely AI-enabled, but AI-capable, AI-critical, and learning-oriented.

4. Conclusion

This study examined the PISA 2025 evidence on school digital readiness, students' use of artificial intelligence (AI) for schoolwork, critical evaluation of AI-generated information, and student learning outcomes in Indonesia. The findings reveal a clear tension between the growing use of digital technologies and AI and the persistently low levels of student achievement. Indonesian students reported relatively extensive engagement with digital devices and AI chatbots, yet their average performance in science, mathematics, and reading remained substantially below the OECD averages. This indicates that access to and frequency of technology use alone are insufficient to produce meaningful learning improvements. The findings further suggest that the educational value of AI depends on how it is used, the learning environment in which it is embedded, and students' ability to critically evaluate AI-generated information. AI should therefore not be regarded simply as a tool for producing answers or completing schoolwork. Its greater educational potential lies in supporting inquiry, reasoning, explanation, comparison, feedback, and deeper engagement with learning. Schools consequently need sufficient digital preparedness and pedagogical capacity to guide students toward productive and responsible AI use. An important implication concerns educational equity. The unequal distribution of opportunities to critically engage with AI may create a new form of digital inequality in which students differ not only in access to technology but also in their capacity to use technology effectively. Indonesian education policy should therefore move beyond an access-oriented approach and prioritise teacher capacity, school digital readiness, critical AI literacy, and equitable access to high-quality AI-supported learning opportunities. Overall, the PISA 2025 evidence suggests that the central challenge for Indonesia is not whether students should use AI, but under what educational conditions AI can contribute to meaningful learning. Building digitally prepared schools, strengthening teachers' pedagogical capacity, and developing students' ability to critically evaluate AI-generated information are essential for ensuring that AI functions as a learning resource rather than a substitute for learning. Because the evidence is cross-sectional and observational, these conclusions should be interpreted as associations rather than causal effects. Future research using PISA 2025 microdata and longitudinal or experimental designs is needed to determine which forms of AI-supported learning can produce sustainable and equitable improvements in student achievement.

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