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Students' Artificial Intelligence Use and Mathematics Proficiency in Relation to Challenges in Secondary Schools

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ABSTRACT

Students increasingly consult artificial intelligence (AI) tools when learning mathematics, with uncertain effects on their proficiency and growing consequences for their teachers. This study centered on students' AI use and mathematics proficiency in selected secondary schools in General Santos City, Philippines, during School Year 2025–2026, and examined both in relation to the challenges experienced by their mathematics teachers. Using a descriptive-correlational design informed by the Technology Acceptance Model, Constructivist Learning Theory, and Self-Determination Theory, data were collected from 256 students and 121 teachers through validated four-point questionnaires ($\alpha = 0.84$). Students' AI use was Good across all 25 indicators ($M = 3.12$), highest in reviewing AI-provided steps (3.24) and lowest in relying on AI for higher-level concepts and learning planning (2.98). Proficiency was Good ($M = 3.14$), strongest in conceptual understanding and critical thinking and weakest in problem-solving. Teachers reported high challenges ($M = 3.16$), led by academic integrity and institutional support. Students' profiles were related to proficiency in 29 of 40 pairs and to AI use in 32 of 40, with frequency, purpose and type of AI use, device access, and math average more influential than age and gender. All 25 relationships between AI use and proficiency were positive and significant ($r = .432$ to $.841$), strongest for higher-order domains and weakest for time spent and for application of mathematical concepts. AI use ($r = .421$ to $.823$) and proficiency ($r = .372$ to $.836$) were also related to all teacher challenges, most strongly academic integrity. The behaviors associated with stronger proficiency are thus those teachers find hardest to supervise. Reflective AI practices, reasoning-focused assessment, teacher training, and institutional support are recommended.

Introduction

For a growing number of secondary students, the first place to go when a mathematics problem resists solution is no longer the textbook or the teacher but an artificial intelligence (AI) tool. Chatbots, symbolic solvers, and tutoring platforms explain steps, check answers, and suggest strategies on demand, and student use of such tools for academic work has risen sharply (Kasneci et al., 2023). What this means for students' mathematical proficiency is not yet settled. AI can provide immediate feedback and adaptive practice that improve engagement (Holmes et al., 2022), and a meta-analysis of K–12 studies reported a small positive effect on mathematics achievement (Yi et al., 2025). Yet students who accept AI outputs without scrutiny may bypass the reasoning that proficiency requires (Susnjak, 2022).

Students' AI use does not stay within their own learning. It reaches their teachers, who must judge whether submitted work reflects real understanding, maintain academic integrity, and adapt lessons for learners who arrive with AI-generated solutions (Zawacki-Richter et al., 2019). In the Philippines, these demands arise where digital literacy, ethical awareness, and instructional support are still uneven (Lucas et al., 2021). Philippine studies of teachers' professional growth have shown that support works best when it starts from the barriers teachers actually face (Panela, 2025e), which makes evidence on those barriers essential.

This study centered on students' AI use and mathematics proficiency in selected secondary schools in General Santos City during School Year 2025–2026 and examined both in relation to the challenges experienced by their mathematics teachers. It determined students' and teachers' profiles, the levels of AI use, proficiency, and teachers' challenges, the relationships of profiles with these variables, and the relationships of AI use and proficiency with each other and with teachers' challenges, as a basis for an intervention plan on responsible AI use in mathematics.

Literature Review

How Students Use AI in Mathematics

Students' engagement with AI tools varies in frequency, purpose, and depth (Al Mashagbeh et al., 2025). Some use AI to verify and extend their own work; others use it to obtain answers. Reviews of AI in mathematics education show that adaptive tutoring and feedback can strengthen procedural skills and problem-solving (Ximenes, 2025; Panqueban & Huincahue, 2024), and AI can make learning more engaging when integrated responsibly (Luckin et al., 2016). The benefits depend on whether students evaluate and integrate outputs (Zawacki-Richter et al., 2019) rather than seeking quick answers (Chen et al., 2020). Generative AI requires verification to avoid errors (Kasneci et al., 2023), and students need information literacy to judge AI-generated content (Galagala & Bacarrisas, 2025). Self-efficacy shapes how effectively students engage with technology (Kauffman, 2015; Scherer & Teo, 2019), but confidence must rest on digital literacy (Wang & Tahir, 2020), and consistent, purposeful use outperforms sporadic use (Crompton & Burke, 2018; Holstein et al., 2019).

What Counts as Mathematics Proficiency

Mathematical proficiency is a set of intertwined strands that include conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning (Kilpatrick et al., 2001). Conceptual and procedural knowledge support each other bidirectionally (Rittle-Johnson et al., 2015), and teaching that attends explicitly to concepts strengthens both (Hiebert & Grouws, 2017). Critical thinking involves analysis, evaluation, and reflective judgment (Facione, 2015; Lai, 2018), and applying mathematics to real situations is a core aim of current curricula and assessments (NCTM, 2014; OECD, 2019; Boaler, 2016).

When Student AI Use Becomes a Teaching Challenge

Students' AI use creates demands for teachers in academic integrity (Bretag, 2019; Eaton & Turner, 2020), in assessment that captures reasoning (Black & Wiliam, 2018), and in instructional design that requires technological pedagogical content knowledge (Mishra &

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Koehler, 2006; Koehler & Mishra, 2019). Teachers' beliefs and confidence condition how they integrate technology (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017), and training and institutional support are necessary for responsible AI use (UNESCO, 2022a, 2022b, 2023b). In the Philippines, AI integration is uneven, with infrastructure gaps, digital divides, and training deficits (Co, 2025; Escorial & Pajo, 2025; Estrellado & Miranda, 2023; Pajo & King, 2025), and both pre-service and in-service teachers need deliberate competency development (Vera et al., 2025). Philippine research on teachers' skills shows that such development is most effective when it starts from a careful mapping of existing competencies (Panela, 2025d).

Theoretical Framework

The Technology Acceptance Model explains students' AI use through perceived usefulness and ease of use, shaped by external conditions such as access and support (Davis, 1989). Constructivist Learning Theory frames AI as a tool through which students construct understanding by testing, verifying, and reflecting (Piaget, 1967). Self-Determination Theory explains how autonomy, competence, and relatedness sustain the motivation of students using AI and of teachers managing it (Deci & Ryan, 2000). In this study, students' AI use and proficiency are the focal variables, and teachers' challenges are treated as the instructional context with which they are related.

Methodology

Research Design

The study used a quantitative descriptive-correlational design to describe students' AI use, proficiency, and teachers' challenges and to determine the strength and direction of their relationships without manipulating variables (Creswell & Creswell, 2018; Ary et al., 2014).

Respondents and Sampling

The respondents were 256 students from Grades 7 to 12 and 121 mathematics teachers in selected secondary schools of General Santos City, Philippines. Simple random and quota sampling were applied, and participation was limited to those who consented voluntarily.

Instrument

A four-part questionnaire was adapted from published instruments on students' engagement with AI tools (Al Mashagbeh et al., 2025), mathematics self-efficacy and skills, and teachers' challenges in AI use, and was modified for the local context. Part I covered students' age, gender, grade level, device access, frequency and purpose of AI use, type of AI tools, and mathematics general average, and teachers' age, gender, educational attainment, years of teaching, and AI trainings. Part II measured five dimensions of students' AI use; Part III, five domains of mathematics proficiency; and Part IV, five areas of teachers' challenges. All items used a four-point scale, interpreted as Excellent (3.26–4.00), Good (2.51–3.25), Less Satisfactory (1.76–2.50), or Least Satisfactory (1.00–1.75).

Validity and Reliability

Experts in educational technology, mathematics education, and research methodology established content validity, and the adviser and panel reviewed the final version. Pilot testing produced a Cronbach's alpha of 0.84. Philippine scale development research recommends this sequence of expert validation and reliability testing, along with checks that items function similarly for male and female respondents (Panela, 2025a).

Procedure

Approval was obtained from the research adviser and from the participating schools' administrators. Respondents were informed of the study's purpose and the confidentiality of their answers, were given adequate time to respond, and returned the questionnaires to the researchers, who checked, cleaned, and encoded the data.

Data Analysis

Frequency and percentage described profiles, and weighted mean and standard deviation described levels. Normality was evaluated using the Shapiro-Wilk test, skewness and kurtosis, and Q-Q plots. Pearson's *r* or Spearman's rho was used for relationships between continuous variables depending on normality, point-biserial correlation for dichotomous variables, and eta for categorical variables, with the Kruskal-Wallis H test for multi-group comparisons. Significance was set at $p \leq .05$.

Ethical Safeguards

Participation was voluntary, informed consent was obtained, and respondents could withdraw without consequence. Data were anonymized, identifying information was stored separately, and records were kept in encrypted files or locked cabinets and later destroyed, in compliance with the Data Privacy Act of 2012.

Results and Discussion

Who the Students and Teachers Were

The 256 students averaged 15.33 years of age (*SD* = 1.39), with 15-year-olds the largest group (28.13%). Female students made up 53.91%, male students 40.23%, and LGBT students 5.86%. Grade 9 was the most represented level (22.27%), followed by Grade 10 (20.31%). Smartphones with internet access were the main device for 51.56%, laptops or desktops for 18.75%, tablets for 14.06%, and shared devices for 11.33%, while 4.30% had no regular access. Most used AI a few times a week (31.64%) or several times a day (26.17%), primarily chatbots and virtual assistants (37.50%) and AI problem solvers (27.73%). The mean mathematics average was 84.87, with 68.36% of students between 80 and 89.

The 121 teachers averaged 39.12 years of age and 14.62 years of teaching. Most were female (61.16%), and 57.02% held or were pursuing a master's degree, while 24.80% had doctoral units or a doctorate. AI training was limited, with 42.98% reporting one to three trainings and 9.09% more than ten.

The student profile reflects mobile-first access to AI and frequent, answer-oriented use. Mobile dependence can restrict the depth of digital learning (OECD, 2020), and frequent use for quick

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answers risks dependency (Chen et al., 2020). These learners also passed through the pandemic's abrupt move to remote, device-based schooling, which left a documented imprint on the mental health of Filipino students (Panela, 2025b), and adolescents generally integrate technology into both their academic and social lives (UNESCO, 2023a). The teacher profile points to strong academic preparation but limited AI-specific training, with implications for differentiated professional support (OECD, 2021b; UNESCO, 2022b; Holmes et al., 2019).

Students' AI Use in Mathematics

Table 1

Item-Level Means of Students' AI Use in Mathematics

Dimension and Indicator	Mean	SD
Accuracy verification behavior (M = 3.16, SD = 0.71)		
Reviews AI-provided steps for correctness	3.24	0.66
Checks AI answers before submitting	3.21	0.69
Verifies AI results with reliable resources	3.16	0.70
Corrects AI answers that appear wrong	3.11	0.75
Compares AI solutions with own calculations	3.08	0.73
Complexity of tasks assisted by AI (M = 3.11, SD = 0.75)		
Uses AI to solve advanced problems	3.20	0.69
Relies on AI for multi-step problems	3.18	0.72
Applies AI to challenging exercises	3.12	0.74
Uses AI for complex calculations	3.05	0.78
Depends on AI for higher-level concepts	2.98	0.81
Integration with independent learning (M = 3.11, SD = 0.75)		
Studies mathematics with AI without teacher help	3.20	0.69
Relies on AI to guide independent learning	3.18	0.72
Integrates AI suggestions into study routines	3.12	0.74
Completes exercises independently with AI support	3.05	0.78
Plans learning tasks with AI guidance	2.98	0.81
Time spent using AI tools (M = 3.10, SD = 0.73)		
Spends significant time using AI tools	3.18	0.70
Dedicates daily sessions to AI-assisted study	3.14	0.72
Uses AI for extended study periods	3.10	0.73
Allocates consistent time to AI activities	3.06	0.75
Frequently engages AI while doing math tasks	3.02	0.76
Confidence in using AI tools (M = 3.12, SD = 0.73)		
Feels capable of integrating AI into study	3.18	0.69
Feels confident solving problems with AI	3.15	0.71
Comfortable relying on AI for exercises	3.12	0.72
Trusts own ability to apply AI	3.08	0.74
Uses AI independently to complete work accurately	3.05	0.77
Overall AI use	**3.12**	**0.73**

Note. 3.26–4.00 = Excellent (very high level); 2.51–3.25 = Good (high level); 1.76–2.50 = Less Satisfactory (low level); 1.00–1.75 = Least Satisfactory (very low level). All indicators were rated Good.

Table 1 shows that students' AI use was Good on all 25 indicators (*M* = 3.12). The item-level data reveal how students use AI rather than merely how much. The highest-rated behaviors were reviewing AI-provided steps for correctness (3.24), checking answers before submission (3.21), and using AI to solve advanced problems or to study without teacher assistance (3.20 each). The lowest were depending on AI for higher-level concepts and planning learning tasks with AI guidance (2.98 each), followed by frequent engagement during math tasks (3.02) and using AI independently to complete work accurately (3.05). Students therefore treat AI as something to check and consult while still keeping it at some distance from core conceptual work and from the planning of their own learning.

Accuracy verification was the strongest dimension (*M* = 3.16), although comparing AI answers with one's own calculations (3.08) lagged behind simply reviewing AI steps, which suggests that students trust AI's internal logic more than they test it against independent work. Confidence (*M* = 3.12) was highest for integrating AI into study routines (3.18). Task complexity and integration with independent learning (*M* = 3.11 each) and time spent (*M* = 3.10) completed the profile. These results agree with research showing that AI benefits learning when students evaluate and integrate outputs (Zawacki-Richter et al., 2019), that AI should support rather than substitute for thinking (Holmes et al., 2019), and that verification skills are essential with generative AI (Kasneci et al., 2023). They also align with work on self-efficacy in digital learning (Kauffman, 2015; Scherer & Teo, 2019; Wang & Tahir, 2020) and on the value of consistent, purposeful engagement (Crompton & Burke, 2018; Holstein et al., 2019; OECD, 2021a).

Students' Mathematics Proficiency and Teachers' Challenges

Table 2

Levels of Mathematics Proficiency and Teachers' Challenges

Dimension	Mean	SD	Rank
Mathematics proficiency (overall M = 3.14)			
Conceptual understanding	3.15	0.71	1.5
Procedural skills	3.14	0.71	3.5
Problem-solving ability	3.11	0.73	5
Critical thinking skills	3.15	0.70	1.5
Application of mathematical concepts	3.14	0.71	3.5
Teachers' challenges (overall M = 3.16)			
Monitoring students' AI use	3.15	0.72	3.5
Ensuring academic integrity	3.18	0.70	1.5
Designing assessments	3.15	0.71	3.5
Instructional adaptation and strategy	3.14	0.72	5
Institutional support and resources	3.18	0.70	1.5

Note. 3.26–4.00 = Excellent (very high level); 2.51–3.25 = Good (high level); 1.76–2.50 = Less Satisfactory (low level); 1.00–1.75 = Least Satisfactory (very low level). All dimensions were rated Good. Tied dimensions share an averaged rank.

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Students' proficiency was Good overall (*M* = 3.14), with conceptual understanding and critical thinking jointly highest (3.15) and problem-solving lowest (3.11) (Table 2). Students were most confident in grasping the meaning behind formulas (3.22) and verifying solutions critically (3.21), and least confident in solving unfamiliar problems (3.05) and explaining ideas in their own words (3.09). Their proficiency is solid in understanding and procedure but less secure in novel problems and mathematical communication, consistent with research on the interplay of proficiency strands (Kilpatrick et al., 2001; Rittle-Johnson et al., 2015; Hiebert & Grouws, 2017) and on critical thinking and application (Facione, 2015; Lai, 2018; NCTM, 2014; Boaler, 2016; OECD, 2019).

Teachers reported a high level of challenges (*M* = 3.16), led by academic integrity and institutional support (3.18 each). Preventing AI misuse in assessments (3.24), limited institutional support (3.23), and monitoring students' AI use during lessons (3.22) were the most difficult items. These pressures are added to existing teaching loads, and Philippine research has documented how such accumulating demands become a source of workplace stress for educators (Panela, 2026). The findings correspond with research on academic integrity and assessment (Bretag, 2019; Eaton & Turner, 2020; Black & Wiliam, 2018) and on the institutional conditions for technology integration (Tondeur et al., 2017; Ertmer & Ottenbreit-Leftwich, 2010; UNESCO, 2022a).

Students' Profile in Relation to AI Use and Proficiency

Table 3

Correlations Between Students' Profile and Mathematics Proficiency

Profile Variable	CU	PS	PSA	CT	AMC
Age	.182	.205*	−.176	.198*	.121
Gender	.132	−.241*	.276*	.214*	−.130
Grade level	.328*	.295*	−.214*	.341*	.118
Access to digital devices	.512*	.438*	−.402*	.591*	.105
Frequency of AI use	.721*	.684*	.742*	.615*	.092
Purpose of AI use	.612*	.538*	.667*	.441*	.087
Type of AI tools used	.504*	.468*	.612*	.397*	.081
Math general average	.504*	.468*	.612*	.397*	.081

Note. CU = conceptual understanding; PS = procedural skills; PSA = problem-solving ability; CT = critical thinking skills; AMC = application of mathematical concepts. *p ≤ .05.

Students' profiles were significantly related to proficiency in 29 of 40 pairs (Table 3). Frequency of AI use showed the strongest relationships, with problem-solving (*r* = .742), conceptual understanding (*r* = .721), and procedural skills (*r* = .684). Purpose of AI use and type of AI tools showed moderate to strong relationships, and device access related positively to conceptual understanding and critical thinking but inversely to problem-solving (*r* = −.402). Grade level related to four domains, gender to three, and age to two, mostly with modest coefficients. No profile variable was related to application of mathematical concepts.

A similar pattern held for AI use, where 32 of 40 profile pairs were significant. Frequency of AI use related strongly to task complexity (*r* = .801), accuracy verification (*r* = .782), and

independent learning (r = .743); math general average related to all five AI dimensions, most strongly to independent learning (r = .945); type of AI tools related to all five; and device access related to verification (r = .612) and independent learning (r = .594) but inversely to task complexity (r = −.421). Age was related only to independent learning and confidence. Students' technology habits and academic standing, rather than demographic characteristics, are the profile features most closely tied to both their AI use and their proficiency, as the Technology Acceptance Model would predict (Davis, 1989; Luckin et al., 2016; Crompton & Burke, 2023; UNESCO, 2023b; Holmes et al., 2019; Zawacki-Richter et al., 2019).

AI Use and Mathematics Proficiency

Table 4

Correlation Coefficients (p Values) Between Students' AI Use and Mathematics Proficiency

AI Use Dimension	CU	PS	PSA	CT	AMC
Accuracy verification behavior	.742 (<.001)	.684 (.001)	.801 (<.001)	.836 (<.001)	.592 (<.001)
Complexity of tasks assisted by AI	.718 (<.001)	.633 (.001)	.824 (<.001)	.781 (<.001)	.574 (.004)
Integration with independent learning	.764 (<.001)	.692 (.001)	.841 (<.001)	.808 (<.001)	.603 (.002)
Time spent using AI tools	.641 (.001)	.582 (.003)	.714 (<.001)	.688 (.001)	.432 (.006)
Confidence in using AI tools	.738 (<.001)	.682 (.001)	.806 (<.001)	.791 (<.001)	.618 (.002)

Note. Abbreviations as in Table 3. All coefficients are significant at $p \leq .05$.

Table 4 presents the central relationship of the study. All 25 coefficients between AI use and proficiency were positive and significant, ranging from .432 to .841. Three features stand out. First, the strongest coefficients involved higher-order domains: integration with independent learning and problem-solving (r = .841), accuracy verification and critical thinking (r = .836), and task complexity and problem-solving (r = .824). Second, time spent was the weakest AI dimension for every domain, suggesting that the quality of use matters more than its quantity. Third, application of mathematical concepts was the least related domain for every AI dimension (r = .432 to .618). Students who verify, integrate, and apply AI to demanding tasks also report stronger reasoning, while the transfer of mathematics to real situations appears to depend on factors beyond AI use. The results support constructivist accounts of AI as a learning mediator (Piaget, 1967) and research showing that AI helps when it supports cognitive effort (Zawacki-Richter et al., 2019; Holmes et al., 2019; Chen et al., 2020). Because the data are correlational, more proficient students may also be the ones best able to use AI well.

AI Use and Proficiency in Relation to Teachers' Challenges

Students' AI use was related to every challenge area (r = .421 to .823), and so was their proficiency (r = .372 to .836). In both cases, academic integrity showed the strongest relationships: confidence in using AI correlated .823 with integrity, integration with independent learning .802, and task complexity .781, while critical thinking correlated .836 and problem-solving .801 with integrity. Instructional adaptation followed, with coefficients up to .756 for AI use and .754 for proficiency. Institutional support showed the weakest relationships for both (r = .421 to .492 for AI use and .372 to .468 for proficiency).

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Seen from the student side, these results indicate that the very behaviors associated with stronger proficiency, namely confident, integrated, and verifying use of AI, are also those that teachers find hardest to supervise and assess. A student who integrates AI skillfully into independent study produces work whose authorship is difficult to establish, and a student with strong critical thinking may use AI in ways that standard assessments do not capture. This creates a tension between encouraging productive AI use and protecting academic integrity, which research and policy on AI in schools have identified as a central issue (Holmes et al., 2019; UNESCO, 2023b; Bretag, 2019).

Teachers' own characteristics were related to 16 of 25 challenge pairs, weakly to modestly (r = .201 to .356). Educational attainment related to four challenges, most strongly instructional adaptation (r = .356), while age, gender, experience, and AI trainings related to monitoring, integrity, and instructional adaptation. None related to institutional support. This is consistent with research on teacher knowledge and beliefs in technology use (Koehler & Mishra, 2019; Tondeur et al., 2017).

Conclusion

Students in General Santos City secondary schools use AI in mathematics regularly and at a Good level, more for checking and consulting than for planning learning or tackling higher-level concepts, and they show Good mathematics proficiency with non-routine problem-solving as the weaker domain. Their AI use and proficiency are related more closely to their technology habits and academic standing than to their age or gender. AI use and proficiency are strongly and positively related, especially for higher-order skills, while application of mathematics to real situations is least connected to AI use. Both are strongly related to teachers' challenges, particularly academic integrity, and teachers already face a high level of difficulty with limited AI training and institutional support.

Schools should help students move from checking AI outputs to testing them against their own reasoning, and from consulting AI to using it for planning and self-regulated study. Assessment should be redesigned to reveal students' thinking, supported by clear academic integrity policies on AI. Teachers need sustained training in monitoring, integrity, and AI-responsive instruction, and schools need better infrastructure, tools, and technical support. Instruction should give explicit attention to mathematical communication and real-world application. Finally, because many students' reliance on digital tools took shape during a period that left lasting effects on Filipino learners' well-being (Panela, 2025c), AI integration should be accompanied by guidance on balanced and healthy technology use. Future studies should link students directly to their own teachers and adopt designs capable of testing causal direction.

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