AI Usage and SRL on Academic Performance in EMag of Second Year BSED-Science Pre-Service Teachers

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Abstract

The increasing adoption of artificial intelligence (AI) in Philippine higher education has transformed teaching and learning, particularly in science education such as Electricity and Magnetism (Shi et al., 2024). However, limited empirical evidence exists on the relationship between AI tools usage and academic performance, as well as the mediating role of self-regulated learning (SRL) among pre-service science teachers (Al Darayseh, 2023; Moroianu et al., 2023). This study addressed this gap using a quantitative correlational design with mediation analysis grounded in Zimmerman's (2002) SRL theory. A total of 66 second-year BSEd-Science pre-service teachers from a university in Eastern Visayas participated through total enumeration sampling during the second semester of A.Y. 2025–2026. Data were gathered using validated and adapted questionnaires measuring AI tools usage and SRL, while academic performance was based on final grades, where lower numerical values indicate better outcomes. Results showed that AI tools usage was "Often" (M = 3.72), SRL was "Highly Self-regulated" (M = 3.36), and academic performance was "Good" (M = 1.65). Mediation analysis revealed that AI tools usage significantly predicted SRL ($\beta = 0.593$, $p < .001$), indicating that greater AI engagement was associated with higher SRL. In turn, SRL significantly predicted academic performance ($\beta = -0.436$, $p < .001$), suggesting improved performance with higher SRL. AI tools usage also had a significant direct effect on academic performance ($\beta = -0.279$, $p = .005$). The indirect effect through SRL was significant ($\beta = -0.259$, $p < .001$), accounting for 48.2% of the total effect ($\beta = -0.537$, $p < .001$), indicating partial mediation. These findings highlight that AI tools enhance academic performance both directly and indirectly by strengthening SRL. These findings provide empirical evidence to guide educators and policymakers in establishing evidence-based guidelines for AI integration, ensuring future educators are equipped for technology-driven learning environments.

Keywords: Academic performance; AI tools usage; mediation analysis; pre-service science teachers; self-regulated learning

1. Introduction

The continued evolution of Artificial Intelligence has dramatically reshaped how we access, utilize, and retain information—consequently redefining our educational landscape (Al Darayseh, 2023; Moroianu et al., 2023). AI-powered tools have transformed the traditional teaching-learning process by providing an interactive, collaborative, engaging, and more personalized learning experience for students by using them for the visualization of abstract concepts and simplifying complex scientific principles (Almasri, 2024; Alshorman, 2024; Ramnarain et al., 2024; Shi et al., 2024). AI technologies offer great promise in science education, particularly when complex and theoretical concepts, as well as mathematical calculations, are involved, such as in the Electricity and Magnetism course (Sermeus et al., 2021). However, Wang et al. (2025) emphasized that the effectiveness of AI integration in the educational process largely depends on how learners manage, control, and regulate their learning.

As future secondary science educators, the BSEd-Science pre-service teachers are expected not only to master content knowledge and pedagogy but also to be able to learn independently, which requires a relatively high level of self-regulated learning (SRL). Mirriahi et al. (2025) define SRL as an active and intentional process in which students employ various cognitive, meta-cognitive, behavioral, motivational and environmental strategies to monitor, control, and regulate their learning. It plays a pivotal role in the learning process as it directs students' motivation and acquisition of academic knowledge, thereby leading to academic achievement (Shi et al., 2025).

A recent study revealed that self-regulated learning (SRL) has a mediating effect in technology-driven learning environments, explicitly stating that students with high self-regulated learning skills can effectively and strategically use AI-powered tools and platforms to support their learning rather than use them as a shortcut and a direct substitute (Wang et al.,2025). Similarly, Wu et al. (2026) revealed that students with high SRL traits used general-purpose AI tools to foster metacognitive reflection and independent problem-solving rather than simply generating answers. These students strategically used AI for goal setting, monitoring progress, and adjusting learning strategies. The study further explained that self-regulated learners utilized task-specific AI tools as scaffolding mechanisms that encouraged incremental skill development rather than

passive consumption of information. Their interactions with AI reflected the core components of self-regulated learning, namely forethought, performance monitoring, and self-evaluation.

Despite the prevalent utilization and integration of AI technologies in Philippine higher education, studies exploring the relationship between AI tools usage and academic performance in science courses, particularly in electricity and magnetism among pre-service science teachers, and whether self-regulated learning plays a key role in this relationship, remain underexplored. Hence, this study aimed to bridge this gap by providing valuable insights and empirical evidence that could guide educators, curriculum planners, and educational policymakers in establishing evidence-based policies and guidelines for the integration of AI technologies in the Philippine higher education.

Specifically, this study sought to:

1. Assess the level of AI tool usage among second-year BSEd-Science pre-service teachers during A.Y. 2025–2026.
2. Assess the level of self-regulated learning (SRL) among second-year BSEd-Science pre-service teachers during A.Y. 2025–2026.
3. Determine the academic performance of second-year BSEd-Science pre-service teachers in Electricity and Magnetism based on their final grades during A.Y. 2025–2026.
4. Determine whether self-regulated learning (SRL) significantly mediated the relationship between AI tool usage and the academic performance of second-year BSEd-Science pre-service teachers in Electricity and Magnetism during A.Y. 2025–2026.

This study aimed to provide valuable insights and recommendations to teachers, administrators, stakeholders, policymakers, and curriculum developers that could serve as a basis for developing robust AI literacy programs and establishing clear guidelines, ethical standards, and policies to ensure the appropriate and responsible use of AI technologies while promoting self-directed learning among pre-service science teachers in the Philippines.

2. Methodology

2.1 Research Design

This study utilized a quantitative correlational research design with mediation analysis to examine the relationship between AI tools usage and academic performance in Electricity and Magnetism course, and self-regulated learning among second-year BSEd-Science pre-service teachers. This design is deemed appropriate for this study as it allows the systematic collection and measurement of existing conditions and the assessment of statistical relationships without manipulating the variables (Creswell & Creswell, 2018). It is also emphasized that this study does not aim to predict any causal relationship between the variables, but only focuses on determining the existence and significance of the relationships, particularly between AI tools usage and academic performance in Electricity and Magnetism (Price et al., 2015). In addition, the mediation analysis was used to investigate whether self-regulated learning acts as an intervening mechanism or mediating factor between AI tools usage and academic performance. This also allowed for a deeper understanding of the underlying processes that explained how AI tools usage may have influenced pre-service teachers' academic performance in Electricity and Magnetism.

2.2 Research Locale

This study was conducted in a higher education institution located in Eastern Visayas, Philippines. The institution is recognized as a teacher-training institution that offers various undergraduate and graduate programs. It consists of three major academic units: the College of Education (COE), the College of Arts and Sciences (CAS), and the College of Management and Entrepreneurship (CME). The study was situated within the Science Department of the College of Education. This department offers the Bachelor of Secondary Education major in Science (BSEd-Science) program, which served as the setting of the study.

2.3 Research Respondents

The respondents of the study were second-year Bachelor of Secondary Education major in Science (BSEd-Science) pre-service teachers enrolled in a higher education institution in Eastern Visayas, Philippines, during the second semester of Academic Year 2025–2026. The study employed a total enumeration sampling technique, also known as census sampling, wherein all members of the target population were included in the study (Total population sampling | Lærd Dissertation, 2012). As such, this study included all second-year BSEd-Science students who had already taken the Electricity and

Magnetism course during the first semester of A.Y. 2025-2026. Due to the relatively small and manageable size of the target population, which is the second-year BSEd-Science pre-service teachers, this sampling technique was deemed appropriate for the study. The essential criteria for selecting the respondents of the study were: enrollment as second-year BSEd-Science pre-service teachers during the second semester of A.Y. 2025–2026, prior completion of the Electricity and Magnetism course during the first semester, an age range of 18 to 22 years, access to and use of artificial intelligence (AI) platforms in their learning process, and expressed willingness to participate in the study through an Informed Consent Form. In the interest of inclusivity and diversity, the study involved respondents regardless of their gender, family background, or socioeconomic status, provided they meet the academic and age requirements mentioned above. These criteria ensured that the selected respondents possessed the necessary background and experiences relevant to the objectives of the study while also upholding ethical standards. Consequently, individuals who did not meet these specific requirements were excluded from the study.

2.4 Research Instruments and Validation

This study utilized two research instruments to collect the data on AI tools usage and self-regulated learning among the second-year BSEd-Science pre-service teachers. The first instrument was the *AI Tools Usage Self-Assessment Questionnaire* adapted from the study of Fabro et al. (2024). It consisted of two parts: (I) *Personal Information* and (II) the *AI Tools Usage Self-Assessment Questionnaire*. Part I gathered the respondents' personal information, including their name (optional), student identification number, year level, section, and final grade in the Electricity and Magnetism course. The final grades were interpreted based on the institution's grading scale as follows: 1.0 (*Excellent*), 1.1–1.5 (*Very Good*), 1.6–2.5 (*Good*), 2.6–3.0 (*Fair*), 4.0 (*Conditioned*), and 5.0 and below (*Failure*). Lower numerical grade values indicated higher academic performance. Part II consisted of a 10-item questionnaire designed to measure the extent to which respondents utilized AI tools in their Electricity and Magnetism course. Respondents were asked to indicate their level of agreement with each statement by placing a check mark under the appropriate response option. The instrument utilized a *5-point Likert scale*, where 5 represented "*Always*", indicating consistent and regular use of AI tools for a specified task, and 1 represented "*Never*," indicating no use of AI tools at all. The overall mean was interpreted using this scale: 4.50 - 5.00 (*Always*), 3.50 - 4.49 (*Often*), 2.50 – 3.49 (*Sometimes*), 1.50 – 2.49 (*Rarely)*, and 1.00 – 1.49 (*Never*). The second instrument was the *Self-Regulated Learning Questionnaire* adapted from the validated instrument developed by Mngomezulu et al. (2024). It was adapted to the context of the Electricity and Magnetism and AI tools usage and was composed of 29 items. The items were modified for contextual relevance but retained the original construct structure and scale. The respondents were asked to indicate their level of agreement by putting a check mark under the appropriate option for each statement. The instrument used a *4-point rating scale*, where 4 is the highest, meaning **"***Always***"** and 1 being the lowest, meaning **"***Never***".** The overall mean was interpreted using the scale indicated on table 1 below:

Table 1**.** Mean Interpretation for Self-Regulated Learning (SRL)

Mean Score Range	Interpretation	Description
3.26-4.00	Very High SRL	Consistently and effectively applies self-regulated learning strategies in AI-assisted Electricity & Magnetism tasks.
2.51-3.25	High SRL	Frequently uses SRL strategies, though application may vary across different situations or subscales.
1.76-2.50	Low SRL	Inconsistently uses SRL strategies; needs improvement in planning, monitoring, and evaluation skills.
1.00-1.75	Very Low SRL	Rarely engages in self-regulated learning behaviors; at risk of poor learning outcomes without structured guidance.

To ensure the validity and reliability of the instruments, a series of procedures were implemented. Content validity was established by having three experts in science education, language education, and research methodology evaluated the adapted instruments. They examined each item for clarity, relevance, and appropriateness within the university context, with revisions made in accordance with their recommendations. Subsequently, a pilot test was conducted with 30 BSEd-Science students who were not included in the main study but shared similar characteristics with the target population, specifically second-year BSEd-Science pre-service teachers (Creswell & Creswell, 2018). This number of respondents aligned with Cresswell & Creswell (2018) recommendation of 15 to 30 respondents for pilot testing, particularly in quantitative studies. This process ensured that the statements present in the questionnaires were clear, logically-sequenced, and easily comprehensible. The reliability of the instruments was determined using Cronbach's alpha. Specifically, the AI tools usage questionnaire yielded a Cronbach's alpha of 0.87 ($\alpha = 0.87$**)**, indicating good internal consistency. Meanwhile, the self-regulated learning questionnaire obtained a Cronbach's alpha of 0.83 ($\alpha = 0.83$**)**, also indicating good reliability. The results indicated good internal consistency for both instruments based on established reliability standards. This suggested that the items within each scale were consistent in measuring their respective constructs. Based on the results of the pilot testing, minor revisions were made to improve item clarity, readability, and alignment with the objectives of the study. These revisions ensured that the final instruments were valid, reliable, and suitable for data collection in the actual study. Overall, these

procedures helped ensure that the instruments accurately measured the intended variables and yielded consistent, reliable results when administered to the target population.

2.5 Data Gathering Procedures

This study employed a quantitative correlational design with mediation analysis to examine the relationships among AI tool usage, self-regulated learning, and academic performance among second-year BSEd-Science pre-service teachers. Prior to data collection, ethical clearance was obtained from the Research Ethics Committee to ensure compliance with ethical research standards. Content validation and pilot testing of the research instruments were also conducted. Subsequently, institutional approval to conduct the study was secured from the university administration.

Potential respondents were identified through departmental rosters and were invited to participate through institutional email and formal communication. The purpose of the study, research procedures, and informed consent process were explained to all participants. Respondents were assured of the voluntary nature of their participation, their right to withdraw at any time without penalty, and the confidentiality of their responses. Signed informed consent forms were obtained prior to participation.

Data were collected using the AI Tools Usage Self-Assessment Questionnaire and the Self-Regulated Learning Questionnaire, administered either online or in person according to respondents' preferences. In addition, respondents' final grades in Electricity and Magnetism were obtained to measure academic performance. All collected data were securely stored and managed in accordance with the Data Privacy Act of 2012 and institutional ethical guidelines, with respondents assigned alphanumeric codes to protect their identities. Following data collection and secure storage, the data were prepared and analyzed to address the objectives of the study.

2.6 Data Analysis

The quantitative data, including questionnaire responses and respondents' final grades, were analyzed using Jamovi version 2.6.26. Descriptive statistics, specifically means and standard deviations, were computed for AI tool usage, self-regulated learning, and academic performance in Electricity and Magnetism. Prior to inferential analysis, the assumptions of linear regression were evaluated to ensure the validity of results. Linearity, normality of residuals, homoscedasticity, independence of errors, and multicollinearity were assessed using appropriate diagnostic tests such as residual plots, Q–Q plots, Shapiro–Wilk test, Durbin–Watson statistic, and VIF values. Only when all assumptions were satisfactorily met did the analysis proceed to inferential testing.

Inferential analysis began with Pearson's correlation to determine the relationships among AI tool usage, self-regulated learning, and academic performance. A mediation analysis was then conducted using regression-based path analysis to examine whether self-regulated learning mediated the relationship between AI tool usage and academic performance. The analysis estimated the direct, indirect, and total effects through Paths a, b, and c′, while also determining the overall effect of the independent variable on the dependent variable. The significance of the indirect effect was tested using bootstrapping with 5,000 resamples and bias-corrected 95% confidence intervals. Effect sizes, including R^2 values and standardized beta coefficients, were reported, and statistical significance was set at $p < .05$.

2.7 Ethical Considerations

Creswell and Creswell (2018) emphasized that the benefits of a study should outweigh its risks, and this research adhered to that principle by ensuring that all potential risks were minimal and comparable to those encountered in routine academic activities. The study was conducted within a controlled academic setting in a higher education institution in Eastern Visayas, Philippines, during the second semester of Academic Year 2025–2026, ensuring institutional supervision and minimal disruption to respondents' schedules. To further reduce any possible social or academic risks, all data were immediately de-identified upon collection. Respondents were informed through a consent process that participation was voluntary, with no penalties for withdrawal and no effect on their academic standing. While no direct financial incentives were provided, respondents received a summary of findings and snacks were given during data collection as a form of acknowledgment.

Ethical safeguards were strictly implemented through informed consent, confidentiality, anonymity, data protection, and research transparency measures. Respondents were identified using alphanumeric codes, and all identifying information was removed to ensure anonymity in data analysis and reporting. A comprehensive Data Protection Plan in accordance with the

Data Privacy Act of 2012 was employed, with all digital files stored in encrypted, password-protected systems and physical documents secured in a locked cabinet with restricted access. Data were retained for five years for verification purposes and will be securely deleted or shredded afterward to ensure continued confidentiality. The researcher also declared no conflict of interest and ensured impartiality, while results will be disseminated through peer-reviewed publications, conferences, and a plain-language summary provided to stakeholders, including full reporting of all findings to maintain scientific integrity.

3. Results and Discussion

A descriptive analysis, including the mean and standard deviation, was conducted on the responses obtained from the *AI Tools Usage, Self-Assessment Questionnaire*, *Self-Regulated Learning Questionnaire,* and the and the *final grades* of second-year BSEd-Science students in the Electricity and Magnetism course, as presented in Table 2.

Table 2. Descriptive Statistics of AI Tools Usage, Self-Regulated Learning, and Academic Performance

	f	**Mean**	**SD**	**Description**
AI Tools Usage	66	3.72	0.781	Often
Self-Regulated Learning	66	3.36	0.611	*Very High SRL*
Final Grade in Electricity and Magnetism	66	1.65	0.542	Good

3.1 Level of AI tools usage among second-year BSEd-Science pre-service teachers during A.Y. 2025-2026

As shown in Table 2, the 66 second-year BSEd-Science pre-service teachers obtained a mean score of 3.72 for AI tool usage, interpreted as "*Often*" based on the AI Tools Usage Self-Assessment Questionnaire. This indicates that respondents frequently use AI tools in their Electricity and Magnetism course, particularly for academic tasks and learning activities, suggesting that AI has become a regular component of their academic processes. The standard deviation of 0.781 further indicates variability in usage, showing that while some pre-service teachers consistently integrate AI tools into their learning, others use them less frequently. Overall, the results reflect a moderate-to-high level of engagement with AI technologies, with differing degrees of reliance among students.

The findings are supported by related literature indicating widespread but varied use of AI tools in higher education. Bancoro (2024) and Fabro et al. (2024) reported that students frequently use AI as supplementary learning aids rather than replacements for academic work, particularly to enhance understanding and access additional resources. In science education contexts, Udosen and Udoh (2024) found that pre-service teachers use AI platforms to simplify complex scientific concepts and engage in interactive learning experiences, aligning with the present study's implication that AI supports understanding of Electricity and Magnetism. Similarly, Vieriu and Petrea (2025) reported that 95.6% of students use AI technologies in academic activities, with 57.6% using them daily or weekly, while Vandana et al. (2025) noted frequent use of ChatGPT for simplifying concepts and improving learning efficiency.

However, contrasting findings highlight that AI adoption is not uniform among students. Crompton and Burke (2023, as cited in Bancoro, 2024) reported high usage among pre-service teachers, but Hanshaw and Sullivan (2025) and Downey et al. (2025) found that a significant proportion of students remain non-users or infrequent users due to lack of trust, limited training, low self-efficacy, and preference for traditional learning methods. These differences suggest that while AI tools are generally used at a moderate to frequent level among second-year BSEd-Science pre-service teachers, variability in usage may be influenced by differences in familiarity, confidence, and perceived usefulness of AI technologies. Overall, the findings indicate growing but uneven integration of AI tools in science education contexts.

3.2 Level of self-regulated learning among second-year BSEd-Science pre-service teachers during A.Y. 2025-2026

The second-year BSEd-Science pre-service teachers obtained a mean score of 3.36 for self-regulated learning (SRL), interpreted as "*Very High SRL*" based on the Self-Regulated Learning Questionnaire scale. This indicates that the respondents consistently demonstrated effective use of self-regulated learning strategies in AI-assisted Electricity and Magnetism tasks and activities. The result suggests that they were generally capable of planning, monitoring, and regulating their learning processes while engaging with AI tools in academic work. The relatively low standard deviation of 0.611 further indicates minimal variability, reflecting a generally consistent level of SRL among the respondents.

Despite the overall high level of SRL, the findings suggest that the application of self-regulated learning strategies may vary depending on task demands, difficulty, and learning context. This implies that while respondents generally exhibited strong self-regulatory behaviors, the effectiveness of these strategies may fluctuate across different academic situations. The results align with Wang et al. (2025) and Shi et al. (2025), who reported that students with strong SRL are more capable of strategically integrating AI tools, engaging deeply with learning content, and adapting their learning approaches based on feedback. Similarly, studies by Persico and Steffens (2017), Liu et al. (2020), and Wu and Chiu (2025) emphasize that high-SRL learners use AI tools purposefully for goal setting, progress monitoring, and strategy adjustment, leading to more effective learning outcomes.

Further literature supports the role of SRL in enhancing AI-assisted learning environments, with Vergara et al. (2024) highlighting AI's contribution to personalized learning, engagement, and SRL development, although emphasizing the need for improved AI literacy and instructional design. Wu et al. (2026) further noted that high-SRL students use AI tools for metacognitive reflection, self-evaluation, and independent problem-solving rather than passive answer generation. In contrast, Zimmerman (2020) warned that learners with low SRL may misuse or over-rely on AI tools, particularly in cognitively demanding subjects such as Electricity and Magnetism. Overall, the findings indicate that strong self-regulated learning among the respondents likely contributes to more strategic, effective, and meaningful use of AI tools in their academic tasks.

3.3 Academic Performance in Electricity and Magnetism of Second-Year BSEd-Science Pre-Service Teachers during A.Y. 2025-2026

The second-year BSEd-Science pre-service teachers obtained a mean academic performance score of 1.65 in Electricity and Magnetism, interpreted as "*Good*" based on the institutional grading scale. This indicates that, on average, respondents achieved satisfactory to above-average final grades in the course despite its conceptual and mathematical demands. The standard deviation of 0.542 suggests low variability, indicating relatively consistent academic performance among the respondents. Since lower numerical grades reflect higher performance, the findings imply that the respondents generally demonstrated commendable academic achievement in Electricity and Magnetism.

The results suggest that the respondents' frequent use of AI tools and high level of self-regulated learning may have contributed positively to their academic performance. With an "*Often*" level of AI tool usage and "*Very High SRL*," the findings imply that students likely used AI technologies strategically to support learning, reinforce complex concepts, and regulate their study behaviors. This aligns with studies indicating that AI tools enhance learning through real-time feedback, personalized learning pathways, and improved engagement (Mabborang et al., 2025; Vieriu & Petrea, 2025). In science education contexts, AI-supported tools, simulations, and virtual laboratories have been shown to simplify abstract concepts and improve conceptual understanding in Electricity and Magnetism (Udosen & Udoh, 2024; Aini & Putranta, 2025).

However, literature presents mixed findings regarding the direct effect of AI usage on academic performance, with some studies reporting minimal or no significant relationship (Bancoro, 2024; Cubillas et al., 2025). While excessive reliance on AI may hinder critical thinking and promote cognitive dependence, strategic use guided by strong self-regulated learning appears to enhance learning outcomes. In the present study, the respondents' high SRL likely supported purposeful and independent use of AI tools, contributing to better academic performance. Overall, the findings suggest that AI tools are more effective as learning supports when combined with strong self-regulated learning strategies, particularly in conceptually demanding science courses such as Electricity and Magnetism.

3.4 Mediating Effect of Self-Regulated Learning on AI Tools Usage and Academic Performance of second-year BSEd-Science pre-service teachers in Electricity and Magnetism during A.Y. 2025-2026

The study tested whether self-regulated learning (SRL) significantly mediates the relationship between AI tool usage and academic performance in Electricity and Magnetism among second-year BSEd-Science pre-service teachers during A.Y. 2025-2026. Prior to mediation analysis, regression assumptions were assessed and found to be reasonably satisfied, including linearity, normality of residuals (KS = 0.124, $p = .265$), homoscedasticity (BP = 5.80, $p = .055$), independence of errors (DW = 1.97), and absence of multicollinearity (VIF = 2.35). Pearson's correlation results showed significant relationships among variables: AI tool usage was strongly positively correlated with SRL ($r = .758$, $p < .001$), while both AI tool usage ($r = -.775$, $p < .001$) and SRL ($r = -.797$, $p < .001$) were strongly negatively correlated with final grades, indicating better academic performance with higher AI usage and SRL. Mediation analysis, as shown in table 3, further revealed that AI tool usage significantly predicted SRL ($\beta = 0.593$, $p < .001$), SRL significantly predicted academic performance ($\beta = -0.436$, $p < .001$), and AI tool usage had a significant direct effect on academic performance ($\beta = -0.279$, $p = .005$). The indirect effect was also

significant (β = −0.259, p < .001), confirming that SRL significantly mediated the relationship between AI tool usage and academic performance with partial mediation, explaining 48.2% of the total effect.

Table 3. Results of the Mediation Analysis

Mediation Estimates

Effect	Label	Estimate	SE	Z	p	% Mediation
Indirect	a × b	-0.259	0.0563	-4.60	<.001	48.2
Direct	c	-0.279	0.0986	-2.82	0.005	51.8
Total	c + a × b	-0.537	0.0743	-7.23	<.001	100.0

Path Estimates

			Label	Estimate	SE	Z	p
AI-Tools Usage	→	**Self-Regulated Learning**	a	0.593	0.0559	10.61	<.001
Self-Regulated Learning	→	**Final Grade**	b	-0.436	0.0976	-4.47	<.001
AI-Tools Usage	→	**Final Grade**	c	-0.279	0.0986	-2.82	0.005

The findings imply that AI tools enhance academic performance both directly and indirectly by strengthening students' self-regulated learning skills. The significant partial mediation suggests that while AI tools independently contribute to improved learning outcomes, their effectiveness is amplified when students actively regulate their own learning processes. This indicates that pre-service teachers who use AI tools strategically are more likely to engage in planning, monitoring, and evaluating their learning, leading to better academic achievement in Electricity and Magnetism. However, the results also suggest that AI tools alone are not sufficient; their impact is maximized when combined with strong self-regulation, emphasizing the importance of fostering metacognitive and self-directed learning skills in AI-enhanced educational environments.

These findings are supported by related literature emphasizing the mediating role of SRL in technology-enhanced learning. Zimmerman (2000) and Persico and Steffens (2017) highlighted that learners who actively regulate their cognition and behavior achieve better academic outcomes, particularly in digital learning environments. Similarly, Zhou et al. (2024), Urbina et al. (2021), and Liu (2026) reported that SRL serves as a key mechanism through which AI tools translate into improved academic performance, with SRL accounting for substantial proportions of total effects. Recent studies by Wang et al. (2025), Shi et al. (2025), and Di and Gu (2024) further demonstrated that self-regulated learners use AI tools more strategically for planning, monitoring, and reflective learning, resulting in deeper understanding and improved achievement. Conversely, Zimmerman (2020) cautioned that low SRL may lead to overreliance on AI tools and superficial learning, particularly in complex subjects like Electricity and Magnetism. Collectively, these studies reinforce the present finding that SRL is a critical mediating factor that determines how effectively AI tools influence academic performance.

4.Conclusion

The study concludes that AI tools usage and self-regulated learning significantly contribute to the academic performance of second-year BSEd-Science pre-service teachers in Electricity and Magnetism. The findings indicate that respondents frequently utilized AI tools and demonstrated high levels of self-regulated learning, which were associated with good academic performance in the course. Results further show that both variables play important roles in supporting students' achievement in a conceptually demanding science subject. This suggests that students benefit academically when they actively engage with AI tools while applying effective learning strategies. Overall, the study highlights the combined importance of technology use and self-regulatory skills in improving learning outcomes.

More importantly, the study confirmed that self-regulated learning significantly and partially mediates the relationship between AI tool usage and academic performance. This indicates that AI tools function not only as academic aids but also as mechanisms that enhance learners' metacognitive and self-regulatory capacities. Students who effectively regulate their learning are more likely to use AI technologies strategically, critically, and purposefully in complex learning tasks. The findings address a research gap by explaining how AI tools influence academic performance through an internal learning process rather than direct effects alone. Thus, self-regulated learning serves as a key explanatory mechanism linking AI usage and academic achievement.

The study further extends Zimmerman's Self-Regulated Learning Theory by showing that AI technologies can support the development of autonomous, reflective, and strategic learning behaviors. It reinforces the idea that AI tools are most effective when students actively engage in self-monitoring, goal-setting, reflection, and adaptive learning strategies. The findings also emphasize that the educational value of AI tools depends not only on access and frequency of use but also on learners' ability to regulate their learning processes. Accordingly, integrating AI in higher education should be paired with instructional strategies that strengthen self-regulated learning competencies. Overall, the study underscores the need for a balanced approach that combines AI integration with the development of lifelong learning skills among future science educators.

5. Recommendations

In light of the findings and conclusions, higher education institutions are recommended to strengthen the integration of AI-supported learning strategies in science education while simultaneously enhancing students' self-regulated learning (SRL) skills, including goal-setting, self-monitoring, reflection, and strategic learning behaviors. Institutions should provide structured AI literacy training for both educators and students to ensure responsible, ethical, and effective use of AI tools in academic tasks. Clear institutional policies, including validation protocols for AI-generated outputs, should be established to safeguard academic integrity, alongside strict ethical standards and data privacy measures to protect student information. In addition, an AI-Assisted Self-Regulated Learning Support Program is recommended for pre-service science teachers, particularly in Electricity and Magnetism, consisting of AI orientation sessions, guided AI-assisted problem-solving activities, reflection journals, goal-setting worksheets, instructor feedback focused on learning strategies, and peer discussions evaluating AI outputs. Teacher education programs and curriculum developers are likewise encouraged to integrate AI literacy, ethical AI use, and SRL strategies into training and instructional design while ensuring alignment with institutional standards and responsible data practices.

Future research is recommended to replicate this study using larger and more diverse samples across multiple institutions to improve generalizability and further validate the mediating role of self-regulated learning in AI-enhanced learning contexts. Longitudinal and experimental research designs are also encouraged to establish stronger causal evidence regarding the relationships among AI tool usage, SRL, and academic performance over time. Researchers may further explore additional variables such as motivation, self-efficacy, digital literacy, cognitive engagement, and critical thinking skills to provide a more comprehensive explanation of AI's impact on academic achievement. Moreover, qualitative studies are suggested to examine students' lived experiences, challenges, and perceptions in using AI tools, particularly in relation to institutional policies and ethical considerations. Overall, these recommendations aim to strengthen evidence-based practices and enhance the effective and responsible integration of AI in science education.

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