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THE EFFECT OF PROBLEM-BASED LEARNING INTEGRATED WITH ARTIFICIAL INTELLIGENCE ON SELF-REGULATED LEARNING TENDENCIES

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ABSTRACT
Self-regulated learning (SRL) is essential for 21st century learners, yet many junior high students struggle to regulate their learning. This study examined whether Problem Based Learning supported by AI based pedagogical scaffolding enhances students' SRL tendencies. Using a quasi experimental one group posttest only design, the intervention was implemented in Grade 7 at SMP Negeri 1 Telaga Biru in the first semester of 2025 2026 with 60 purposively selected students. SRL was measured via a questionnaire covering goal setting, strategy use, self monitoring, time and resource management, motivational control, and self reflection. After normality testing using Kolmogorov Smirnov, outcomes were compared against a predetermined reference value using a One Sample t Test or Wilcoxon Signed Rank Test as appropriate. Post intervention SRL levels were good to high and significantly higher than the reference value with p less than 0.05. The strongest tendencies appeared in forethought, motivational beliefs, and self reflection, while help seeking and collaboration remained comparatively lower. These results suggest that positioning AI as adaptive scaffolding within Problem Based Learning, not merely as technology, can strengthen SRL, provided that collaborative supports are deliberately designed.

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INTRODUCTION

The development of 21st-century skills has placed self-regulated learning (SRL) as one of the key capacities that needs to be developed from junior high school level, because SRL enables students to set goals, monitor progress, choose learning strategies, reflect on results, and actively manage motivation (Zimmerman, 1989; Zimmerman, 2008; Šašić et al., 2023). However, in practice, many junior high school students still face obstacles such as fluctuating intrinsic motivation, limited learning strategies, and a classroom environment that does not consistently support reflection and independent learning (Pintrich & Groot, 1990; Kistner et al., 2010; Yot-Domínguez & García, 2017). This condition is a crucial issue because low SRL has the potential to impact the quality of learning engagement, resilience in facing complex tasks, and academic achievement, thus requiring pedagogical interventions that are not only results-oriented but also strengthen the self-regulation process.\

One approach that is considered relevant for developing SRL is Problem-Based Learning (PBL). PBL is student-centered learning that uses real and challenging problems as triggers for learning, encouraging students to work collaboratively, conduct research, and develop critical thinking skills (Barrows, 1996; Dochy et al., 2003; Gijbels et al., 2005). The characteristics of PBL, namely active student involvement, collaborative discussion, cross-disciplinary integration, and reflection and feedback, are theoretically in line with the core components of SRL (Greeno, 1998; Belland, 2009; Sockalingam & Schmidt, 2011). Mechanistically, PBL is thought to strengthen SRL through the formulation of learning objectives when facing problems (Teng, 2021), monitoring and reflection during the problem-solving process (Soemantri et al., 2018), the development of learning strategies and metacognition (Liu et al., 2022; Šašić et al., 2023), and increased motivation due to task relevance (Aggarwal et al., 2023; Xue et al., 2024). Thus, PBL not only develops knowledge but also builds independent learning habits that form the basis of SRL (Pan & Liu, 2022).

On the other hand, The rapid development of Artificial Intelligence (AI) has created new opportunities to strengthen self-regulated learning (SRL), because AI-integrated learning (AI-assisted or AI-enhanced learning) enables more adaptive and personalised learning experiences through supports such as student progress analysis, learning recommendations, and scaffolded feedback (Jeon & Park, 2021; "Editorial," 2024; Zhao, 2025; Dadhich et al., 2025). In educational practice, AI can be implemented through personalisation and adaptive learning ("Editorial", 2024; Adawiyah, 2025; KHUIBUT et al., 2024), virtual tutors or chatbots (Liao et al., 2023; BenMessaoud et al., 2025), learning analytics (Dahri, 2018), simulation or VR (Adawiyah, 2025; KHUIBUT et al., 2024), and collaborative learning support (Abdullah, 2025), with commonly discussed models including Intelligent Tutoring Systems that have been shown to improve learning outcomes (Steenbergen-Hu & Cooper, 2013; Ma et al., 2014; Chen et al., 2020), automatic feedback systems (Roll et al., 2011; Walkington, 2013; Jeon & Park, 2021; Heffernan & Heffernan, 2014), and recommendation systems (Zawacki-Richter et al., 2019; Chen et al., 2020). However, the literature also highlights controversies, including the risks of overreliance and cognitive offloading that may weaken cognitive engagement and reflection (Zhai et al., 2024; Gyekye, 2025), as well as concerns about academic integrity, algorithmic bias, data privacy, and feedback quality that is not always equivalent to human feedback (Li et al., 2024; Jin et al., 2025). In parallel, although studies indicate that Problem-Based Learning (PBL) can support SRL, the results are not always consistent because the effects can be small (Wang et al., 2016) and depend on context and student characteristics (Funa & Prudente, 2021; Panadero, 2017), the quality of task design and teacher facilitation (Dignath & Veenman, 2020), and differences in SRL measurement instruments (Sitzmann & Ely, 2011; Soemantri et al., 2018). Likewise, in the AI field, some studies report positive SRL support through adaptive feedback and metacognitive scaffolding (Edisherashvili et al., 2022; Dahri et al., 2024; Sardi et al., 2025; Xu et al., 2025), yet other studies caution that dependency and reduced self-control may occur when pedagogical scaffolding is insufficient (Fan et al., 2024; Zhai et al., 2024; Gyekye, 2025). Therefore, even though research on "PBL alone" and "AI alone" has progressed, a key gap remains in the limited number of studies that explicitly

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examine AI-integrated PBL as a learning design to strengthen SRL, particularly in school contexts and junior high schools, so empirical evidence on its effects on students' SRL tendencies still needs to be strengthened (Chang et al., 2023; Järvelä et al., 2023; Thomae et al., 2024; Kavadella et al., 2024; Gu et al., 2025).

Based on this gap, this article aims to examine the effect of Artificial Intelligence-integrated Problem-Based Learning on the Self-Regulated Learning tendencies of junior high school students. The unit of analysis in this study is students as individuals, with SRL tendencies understood through the dimensions of goal setting, monitoring, strategy, reflection, and motivation (Barak, 2009; Andrade, 2019; Teng & Zhang, 2016; Metallidou & Vlachou, 2007; Šašić et al., 2023). The argument tested in this paper is that the integration of AI designed as support (e.g., prompts, scaffolding, rapid feedback, and/or learning analytics) within the PBL stages will increase SRL tendencies compared to learning that does not pedagogically integrate AI support (Afzaal et al., 2021; Park & Doo, 2024; Li & Tu, 2024; Mottaghi-Dastjerdi & Soltany-Rezaee-Rad, 2024). This article is structured as follows: introduction, research methods, results, discussion, and conclusions and implications.

METHOD

This study used a quasi-experimental method with the aim of determining the effect of implementing Problem-Based Learning (PBL) integrated with Artificial Intelligence (AI) on students' Self-Regulated Learning (SRL) tendencies. The research was conducted at SMP Negeri 1 Telaga Biru in the odd semester of the 2025/2026 academic year, during the period from September to November 2025. The research subjects were seventh-grade students who participated in learning using the AI-integrated PBL model, which is problem-based learning supported by the use of AI to help students explore information, develop problem-solving strategies, obtain feedback, and reflect on their learning.

The research design used was a One Group Posttest Only Design, in which one group of students was given treatment without initial measurement (pretest), followed by measurement only at the end of learning (posttest). The treatment given was AI-integrated PBL learning that emphasized the stages of problem orientation, investigation, solution development, presentation of results, and reflection, with AI support as a tool for guided and critical learning. This design was used to determine students' SRL tendencies after participating in AI-integrated PBL learning.

The population in this study was all seventh-grade students at SMP Negeri 1 Telaga Biru. The sampling technique used was purposive sampling, which is the selection of samples based on certain considerations relevant to the research objectives. The research sample consisted of two classes, namely class VII-1 with 30 students and class VII-3 with 30 students, bringing the total sample to 60 students.

Data collection was conducted using a Self-Regulated Learning (SRL) instrument in the form of a Likert scale questionnaire/survey compiled based on SRL indicators, including the ability to set learning goals, plan learning strategies, monitor the learning process, manage time and learning resources, manage motivation and self-control, and conduct self-reflection and evaluation. The data obtained were analyzed quantitatively through a normality test using Kolmogorov–Smirnov. If the data were normally distributed, hypothesis testing was performed using a One Sample t-Test with a significance level of 0.05 to determine whether the average SRL score of students differed significantly from the established reference value. If the data was not normally distributed, hypothesis testing was performed using the Wilcoxon Signed-Rank Test as a nonparametric alternative to test the difference in students' SRL scores against the reference value after the implementation of AI-integrated PBL learning.

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RESULT AND DISCUSSION

Result

This section reports quantitative findings on students' Self-Regulated Learning (SRL) tendencies after participating in Artificial Intelligence (AI)-integrated Problem-Based Learning (PBL) in classes VII-1 and VII-3 at SMP Negeri 1 Telaga Biru. SRL was measured through a posttest Likert-scale questionnaire covering goal setting and strategy planning, self-monitoring, time and learning resource management, motivational control, and self-reflection/evaluation. Data analysis began with the Kolmogorov–Smirnov normality test, followed by hypothesis testing against a predetermined reference value using a One-Sample t-Test for normally distributed data and a Wilcoxon Signed-Rank Test for non-normally distributed data. The results indicate whether AI-integrated PBL is associated with students' SRL tendencies overall and across SRL indicators.

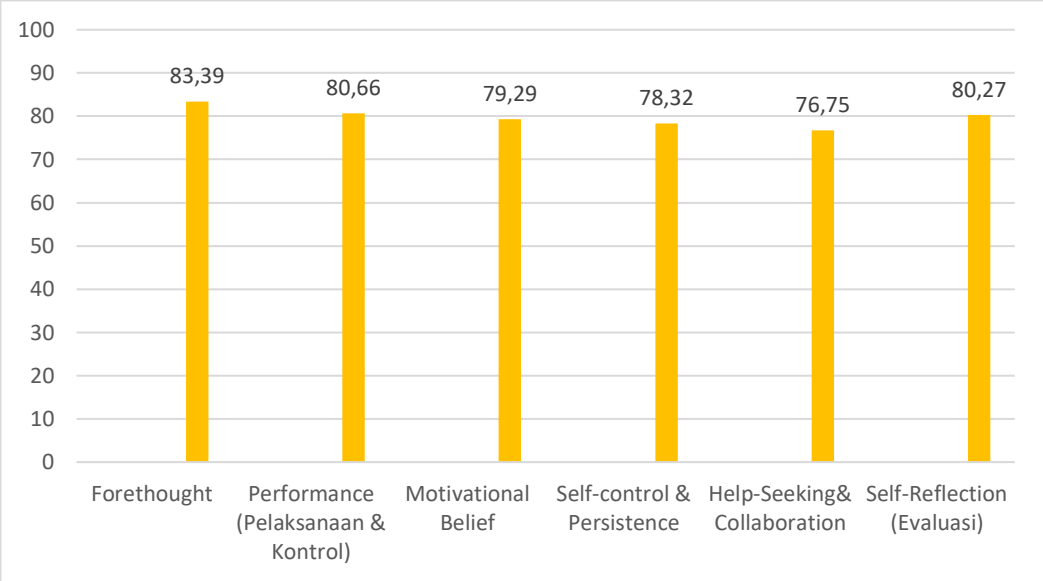

Figure 1. SRL Results by Indicators for Class VII-1

Based on Figure 1, Class VII-1 shows relatively even SRL indicator scores (76.75–83.39). Forethought is the highest (83.39), followed by Performance/Implementation & Control (80.66) and Self-Reflection/Evaluation (80.27). Motivational Belief (79.29) and Self-control & Persistence (78.32) are also in the good category, while Help-Seeking & Collaboration is the lowest (76.75), indicating a need to strengthen help-seeking and collaboration.

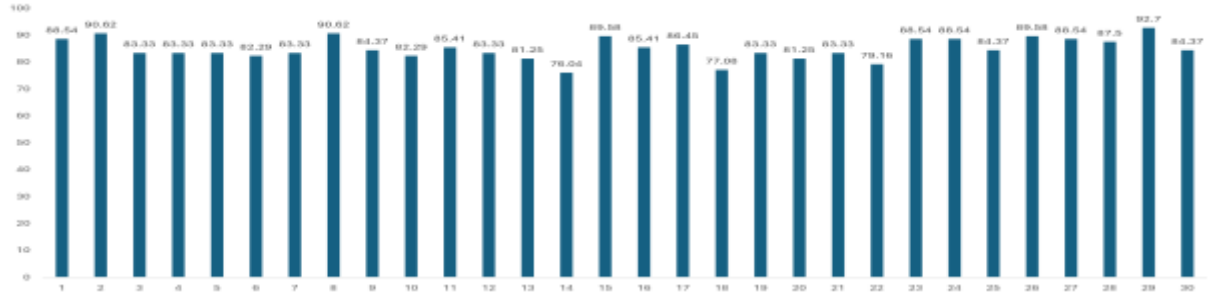

Figure 2. SRL Results by Students in Grade VII-1

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Based on Figure 2, the Self-Regulated Learning (SRL) scores per student in Class VII-1 show a fairly high and relatively stable trend, with values ranging from around 76.04 to 94.62. The highest score was achieved by one student with a score of 94.62, followed by other high scores such as 92.7, while the lowest score was 76.04 (and several other students scored below 80, such as 77.08 and 79.16). In general, the majority of students were in the 80–90 range, indicating that most students had good self-regulation skills after participating in AI-integrated PBL learning, although there were still some students who needed special reinforcement to improve their SRL evenly.

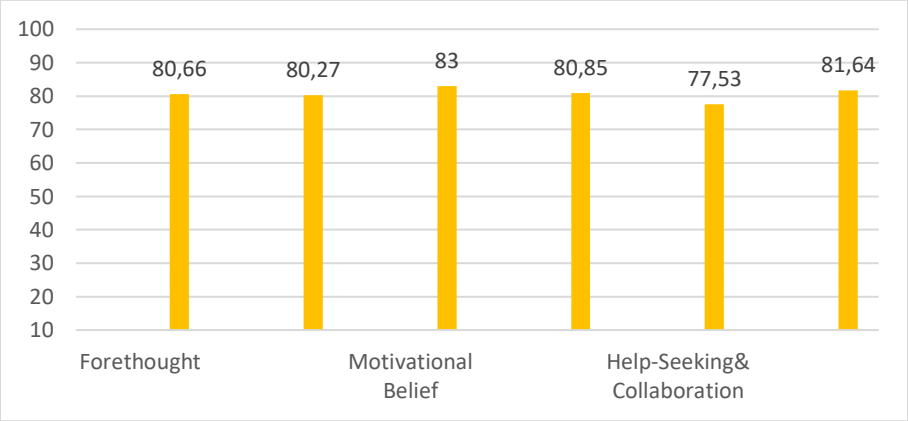

Figure 3. SRL Results by Indicators for Class VII-3

Based on Figure 3, the SRL results per indicator in Class VII-3 show fairly even scores in the range of 77.53–83.00, with the highest score in Motivational Belief (83.00), indicating that students' beliefs and motivation to learn are relatively strong. The next highest scores were seen in Self-Reflection/Evaluation (81.64) and Self-control & Persistence (80.85), indicating that self-evaluation and learning persistence abilities were in the good category. Meanwhile, Forethought (80.66) and Performance/Implementation & Control (80.27) were also at a good level, while the lowest score was in Help-Seeking & Collaboration (77.53), which indicates that the aspects of seeking help and collaboration still need to be strengthened compared to other indicators.

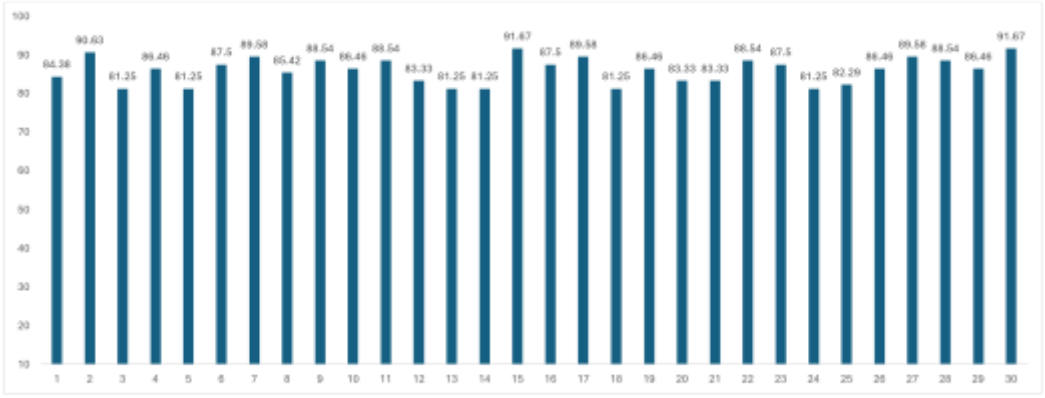

Figure 4. SRL Results by Students in Grade VII-3

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Based on Figure 4, the Self-Regulated Learning (SRL) scores per student in Class VII-3 showed a high and relatively consistent trend, with scores ranging from around 81.25 to 91.67. The highest score reached 91.67 (appeared in several students), while the lowest score was around 81.25, and only a few students were in the range of 81–83. In general, most students scored in the range of 85–90, indicating that the majority of students had good self-regulation skills after participating in AI-integrated PBL learning, although there were still some students who needed reinforcement in order to achieve more consistent SRL scores.

Table 1. Normality Test of SRL Data for Classes VII-1 and VII-3

Class	Statistik	df	Sig.	Description
VII-1	0.972	30	0.591	**Normal**
VII-3	0.921	30	0.029	**Abnormal**

(Source: IBM SPSS Statistics 27)

Based on Table 1, the results of the SRL data normality test show that class VII-1 has a Sig. value of 0.591 ($p > 0.05$), indicating that the data is normally distributed, while class VII-3 has a Sig. value of 0.029 ($p < 0.05$), indicating that the data is not normally distributed. Therefore, hypothesis analysis for class VII-1 can use parametric tests, while for class VII-3, it is more appropriate to use nonparametric tests.

Table 2. One-Sample T-Test Hypothesis Test for SRL Data for Grade VII-1

One-Sample Test						
	Test Value = 75					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Class VII-1	15.777	29	.000	11.56267	10.0638	13.0616

(Source: IBM SPSS Statistics 27)

Based on Table 2, the results of the One-Sample t-test on the SRL data for class VII-1 with a reference value of 75 show a t value of 15.777, df = 29, and Sig. (2-tailed) = 0.000 ($p < 0.05$), indicating a significant difference between the average SRL scores of students and the reference value. The Mean Difference value = 11.56267 indicates that the average SRL of students is about 11.56 points higher than 75, and this is reinforced by the 95% confidence interval ranging from 10.0638 to 13.0616. so it can be concluded that the SRL of students in class VII-1 after the implementation of AI-integrated PBL is above the specified criteria.

Table 3. Wilcoxon Sign-Rank Test Hypothesis Test for SRL Data for Grade VII-3

One-Sample Wilcoxon Signed Rank Test Summary				
Total N	**Test Statistic**	**Standard Error**	**Standardized Test Statistic**	**Asymptotic Sig.(2-sided test)**
30	465.000	48.518	4.792	0.000

(Source: IBM SPSS Statistics 27)

Based on Table 3, the results of the Wilcoxon Signed-Rank test on the SRL data for class VII-3 show N = 30 with a test statistic value = 465.000 and Z = 4.792, as well as an Asymptotic Sig. (2-sided) value = 0.000 ($p < 0.05$). These findings indicate that the SRL scores of students in class VII-3 differ significantly from the reference values used in the test, so it can be concluded that the SRL tendencies of students after the implementation of AI-integrated PBL learning show statistically significant results.

Discussion

This discussion interprets the findings on the effect of AI integrated Problem Based Learning (PBL) on seventh grade students' self regulated learning (SRL) tendencies using a posttest only, criterion referenced approach, where the

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key inference is whether students' SRL scores exceed the predetermined cut off score used in the hypothesis test. Overall, the results indicate that SRL tendencies fall in the good to high category and are statistically significant in both the class that met parametric assumptions and the class that did not meet normality, supporting the conclusion that SRL after the AI integrated PBL intervention surpassed the reference criteria. This pattern is consistent with evidence that PBL can create an active learning environment that increases engagement and supports independent learning even when the design does not include a pretest comparison (Aji & Kusumadani, 2024; Duman & Özçelik, 2018). Thus, the research question can be answered explicitly: the implementation of AI integrated PBL is associated with SRL outcomes that exceed the minimum expected standard, aligning with prior reports that PBL effects on SRL can vary in magnitude across contexts (Wang et al., 2016).

Methodologically, because the study relies on posttest only evidence, interpretive validity depends heavily on the justification of the reference value and the appropriateness of the criterion test for Likert scale data. Prior work notes that one sample t tests for normally distributed scores and Wilcoxon signed rank tests for non normal scores are widely used to examine whether observed scores are significantly higher than a specified benchmark, such as a scale midpoint or cut off derived from earlier research (Meek et al., 2007; Karim & Roslan, 2020). The Wilcoxon signed rank test is particularly suitable for nonparametric distributions and remains sensitive in detecting departures from the reference value (Hopcan & Tokel, 2021). The present findings reinforce this rationale: despite different distributional properties between classes, both tests produced significance that supports the same substantive conclusion (Hopcan & Tokel, 2021; Meek et al., 2007).

Viewed by SRL indicators, the profile reflects the cyclical conception of self regulation across forethought, performance, and self reflection. Stronger forethought can be explained by the core structure of PBL, which requires learners to analyse problems, set goals, and plan strategies at the outset, intensifying planning demands in students' learning experience (Panadero, 2017; Schunk & Ertmer, 1999). In addition, PBL's investigative decision making encourages metacognitive monitoring and adjustment, consistent with the view that metacognition is central to self regulation and is strengthened when tasks and facilitation promote strategic control (Veenman et al., 2006; Dignath & Veenman, 2020). This interpretation is also consistent with claims that SRL gains in PBL should be visible not only in outcomes but in the patterning of indicators, including self monitoring and reflection processes (Panadero, 2017; Cleary et al., 2020). The high motivational belief dimension likewise aligns with theory linking SRL to self efficacy and goal orientation, where beliefs about competence shape persistence, strategy choice, and the depth of cognitive engagement (Pintrich & Groot, 1990; Zimmerman, 2008). Empirical work also suggests that SRL improvements often co occur with strengthened self efficacy when learning environments provide meaningful tasks, progress signals, and opportunities for learners to manage challenges (Demirören et al., 2020; Teng, 2021). In this context, feedback and progress cues supported during learning can plausibly contribute to motivational regulation, as feedback is a known mechanism for supporting learning regulation and reflection cycles (Hattie & Timperley, 2007; Azevedo et al., 2022).

However, the lowest scores in help seeking and collaboration point to a gap in social regulation: students appeared stronger in planning, motivation, and reflection than in seeking support and coordinating learning with peers. At the junior high level, lower help seeking can be shaped by classroom norms of independence, embarrassment, fear of negative judgement, and learning designs that do not explicitly require interaction and role sharing (Eccles et al., 1993; Deci & Ryan, 2008; Abdullah, 2016). Although collaboration is often positioned as a strength of PBL, its benefits are not automatic and may depend on the presence of explicit social structures, including accountable peer roles and shared regulation routines (Kritikos et al., 2011; Li et al., 2022). Without deliberate social design, learners may rely on safer individual strategies, and when an additional support source is available during learning, help seeking may shift away from peers and teachers toward non social sources, potentially suppressing collaborative regulation practices (Li et al., 2022; Kritikos et al., 2011).

Taken together, the findings suggest that the integration of AI within PBL is most clearly beneficial for SRL dimensions tied to planning, monitoring, and reflection, but it does not automatically strengthen social regulation. Research on AI supported learning highlights that AI can support SRL through metacognitive prompts, adaptive feedback, and data driven guidance that helps learners monitor their learning trajectories (Chang et al., 2023; Ng et al.,

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2024; Engeness et al., 2025; Lai, 2025). At the same time, the literature warns that if students mainly use AI as a shortcut for answers, they may experience cognitive offloading and automation bias, which can reduce deep processing and reduce interactional effort (Jin et al., 2023; Taub et al., 2014; Liang et al., 2024). Therefore, the low help seeking indicator can be interpreted as a signal that AI supported PBL should be paired with co regulation and socially shared regulation structures so SRL development extends beyond the individual to the classroom's social dimension (Lodge et al., 2024; Dignath & Veenman, 2020).

Differences in data characteristics between classes, such as one normal distribution and one non normal distribution, also need to be read as implementation signals rather than merely statistical artefacts. Classroom climate, heterogeneity of student composition, and differences in task enactment and facilitation can produce more balanced or more skewed SRL distributions (Rubie-Davies, 2010). Variation in how students use available supports during learning, whether for reflection and monitoring or mainly for rapid answers, may further shape SRL score patterns, reinforcing the need to interpret statistical outputs alongside classroom process realities (Panadero, 2017; Zimmerman, 2008). This aligns with the view that teacher readiness, facilitation quality, and motivational classroom conditions influence how learners engage with PBL and regulate their learning (Lee & Blanchard, 2018).

In practical terms, the results imply that successful AI integrated PBL requires more than tool availability and should be supported by teacher development and school level governance. Teacher training remains crucial for designing PBL tasks that balance structured inquiry, responsible use of learning supports, and collaboration routines that prevent dependency while strengthening SRL (Siadaty et al., 2016; Azevedo et al., 2022). Schools also need clear guidance and monitoring procedures for student use of learning tools, alongside routines that normalise asking for help, peer feedback, and shared accountability, so help seeking and collaboration can increase through structured practice (Fan et al., 2024; Nguyen & Ikeda, 2015). Ethical and data governance is also essential because classroom adoption of AI related tools is connected to privacy, transparency, and potential bias, requiring policy safeguards that protect students while guiding responsible use (Lupton & Williamson, 2017; Bahroun et al., 2023; Alé-Silva et al., 2025; Black et al., 2024).

Overall, the discussion reinforces the established claim that PBL can strengthen SRL through problem ownership, strategy development, monitoring, and reflection (Bahri & Corebima, 2015; Wang et al., 2023; Gu et al., 2025; Dignath & Veenman, 2020), while adding a focused implication: SRL gains are likely strongest when learning supports function to prompt metacognition and regulation rather than substitute for thinking. The consistently lower help seeking and collaboration indicators provide the empirical basis for refining the implementation framework toward explicit social regulation supports such as structured peer assistance, assigned roles, peer feedback protocols, and collaboration accountability rubrics, which are known to shape help seeking behaviours and collaborative regulation (Wei et al., 2015; Gholami et al., 2022; Li et al., 2010; Ryan et al., 2005).

CONCLUSION

This study concludes that the application of Problem-Based Learning (PBL) integrated with Artificial Intelligence (AI) has a positive effect on the Self-Regulated Learning (SRL) tendencies of seventh-grade students at SMP Negeri 1 Telaga Biru. This is demonstrated by SRL scores that are generally in the good to high category and are proven to be significantly different from the established reference values; in class VII-1, the data is normally distributed, so the One-Sample t-test shows significance ($p < 0.05$), while in class VII-3, the data is not normal, so the Wilcoxon signed-rank test also shows significance ($p < 0.05$). In terms of indicators, the strength of students' SRL was evident in the aspects of planning (forethought), motivational belief, and self-reflection, while the indicators of help-seeking and collaboration tended to be lower and therefore needed to be strengthened through a more structured PBL social design (e.g., role sharing, peer feedback protocols, and collaboration rubrics) so that self-regulation could develop more evenly. In the future, further research could use a stronger design (e.g., adding a comparison group or pretest–posttest), report effect sizes, and add supporting data such as observations, reflection journals, or AI usage logs to explain the mechanism of AI-integrated PBL's influence on SRL while formulating more effective strategies for improving help-seeking and collaboration.

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