

A Project-Based Hybrid Learning Model Using Artificial Intelligence to Enhance Students' Self-Regulated Learning

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ABSTRACT

Students' SRL ability in the English Literature Study Program at Universitas Wijaya Putra remains low, as shown by a preliminary survey recording a mean SRL score of 2.21. This is worsened by post-pandemic hybrid learning implemented without pedagogical design for learning independence, and by the absence of a model integrating PjBL, hybrid learning, and an AI to improve SRL. This study develops a PjBHL model assisted by an AI through a Research and Development approach using the ADDIE model. The model maps Zimmerman's three SRL phases forethought, performance, and self-reflection into project-based and hybrid learning syntax, with AI acting as metacognitive scaffolding and a cognitive interlocutor. Feasibility was tested through expert validation and a practicality questionnaire, while effectiveness was tested through a quasi-experimental non-equivalent control group design involving experimental and control groups. Results show the model is valid and practical based on expert and user assessments, and effective in improving students' SRL compared with conventional learning. This study contributes theoretically through a new, structured pedagogical model, and practically by helping lecturers foster students' learning independence in the AI era.

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1. INTRODUCTION

In the era of Industry 4.0, higher education institutions are expected to graduate students who possess not only strong academic ability but also the capacity to take charge of their own learning journey. This ability is regarded as essential, since it involves planning one's learning path, tracking personal progress, and evaluating what has been accomplished skills that align closely with the competencies demanded in the 21st century. Online learning in higher education certainly presents its own set of challenges; one of the obstacles students face during online classes is an unstable internet connection, particularly for those living in remote areas (Priyambudi, Bachri, et al., 2025). However, several studies point out that many Indonesian university students, including those enrolled in the English Literature Program at Universitas Wijaya Putra, still show limited Self-Regulated Learning (SRL). Evidence of this includes a continued dependence on lecturer instructions, poor time-management skills when studying independently, and a lack of initiative in exploring learning materials beyond what is assigned. The situation has become more challenging with the rise of hybrid learning models following the COVID-19 pandemic. These models, which blend limited face-to-face sessions with online components, are often implemented without a well-structured pedagogical design. As a result, students commonly experience confusion due to the lack of a clear learning structure, while lecturers struggle to track each student's individual progress. This dynamic further impedes the development of students' SRL competencies.

The motivation behind this research stems from a notable contradiction: although project-based learning (PjBL) has been shown to enhance SRL by engaging students in authentic, contextual project experiences, its implementation in hybrid settings is often constrained by minimal face-to-face interaction and delayed feedback. At the same time, advances in artificial intelligence (AI) including chatbots, personalized recommendation systems, and learning analytics offer promising solutions to these limitations. AI has the potential to deliver adaptive scaffolding, timely feedback, and

individualized motivational support. Despite this potential, no pedagogical model has yet been developed that fully and systematically combines PjBL, hybrid learning, and AI to strengthen students' Self-Regulated Learning (SRL) abilities.

There is a growing demand for English Literature graduates who possess not only linguistic competence but also the capacity for lifelong, self-directed learning. Research indicates that self-regulated learning (SRL) is strongly and positively associated with academic performance, long-term knowledge retention, and career readiness (Diningrat et al., 2024). This is supported by findings from a preliminary survey conducted in March 2026, which utilized an instrument based on Barnard's SRL framework (Barnard et al., 2009). The survey involved 65 English Literature students at Universitas Wijaya Putra and revealed an average SRL score of only 2.21 (SD = 0.73), indicating a low level of self-regulation. Specifically, only 24.4% of respondents reported setting learning goals, merely 17.8% engaged in self-evaluation, and 68.9% admitted to struggling to maintain focus during online learning sessions. These findings underscore the urgent need for structured interventions aimed at strengthening students' self-regulated learning capabilities.

Furthermore, no established learning model currently exists that simultaneously integrates PjBL, hybrid learning, and AI, particularly within the context of English Literature programs at Indonesian universities. This gap is significant given AI's considerable potential to function as an intelligent tutoring system, offering personalized learning experiences at scale something that would be nearly impossible for lecturers to achieve manually, especially in large hybrid classes. Moreover, prior research has typically examined the influence of PjBL or AI on SRL in isolation, without exploring how the combined, synergistic application of both within a unified learning model might produce a more comprehensive effect. Given these gaps, this study carries substantial urgency, aiming to develop an innovative learning model capable of addressing students' low SRL levels within the context of AI supported hybrid learning.

The problem-solving approach adopted in this study follows a systematic, measurable, and sustainable process based on the ADDIE development model, which has been adapted into five strategic phases. Each phase is equipped with specific objectives, methods, instruments, and indicators of success.

1. Phase 1: Problem Analysis
Thoroughly mapping students' SRL conditions, the characteristics of the Computer & Internet Applications course, and the readiness of existing AI infrastructure.
2. Phase 2: Model Design
Developing a preliminary design of the AI-assisted PjBL and Hybrid Learning model, along with its supporting instruments.
3. Phase 3: Development and Validation
Creating a model prototype validated by experts and ready for trial implementation.
4. Phase 4: Field Test Implementation
Conducting an empirical test of the model's effectiveness in enhancing students' SRL through a quasi-experimental design.
5. Phase 5: Evaluation, Analysis, and Dissemination
Analyzing collected data, drawing conclusions regarding the model's effectiveness, and refining the final version of the model.

Drawing from the background outlined above, the research questions guiding this study are as follows: 1)What is the baseline condition of students' SRL ability?; 2)In what ways can an AI-assisted Project-Based Hybrid Learning model enhance students' Self-Regulated Learning?; and 3)To what extent is the AI-assisted Project-Based Hybrid Learning model more effective in improving students' SRL compared to conventional instructional approaches?.

Accordingly, this study is intended to: 1)examine the baseline condition of students' SRL ability; 2)develop an AI-assisted Project-Based Hybrid Learning model capable of enhancing students' SRL; and 3)evaluate the model's effectiveness in producing a significant improvement in students' SRL.

The model proposed in this research is intended for implementation in the Computer & Internet Applications course within the English Language Study Program at Universitas Wijaya Putra. This course was chosen due to its strong alignment with the PjBL approach, its emphasis on information and communication technology use, and its learning outcome target of strengthening SRL. Preliminary findings suggest that comparable courses at other institutions such as Learning Media &

ICT at UPI and Time Management at UNS have already begun incorporating project-based methods and digital technologies to foster students' SRL (Ana & Achdiani, 2017) (Mulyani, 2024).

1.1. MODEL PROJECT BASED HYBRID LEARNING

The Project Based Learning (PjBL) model is a pedagogical approach that places students at the heart of the learning process by actively engaging them in meaningful, real world project work. This concept was first introduced by Thomas in 2000 as a framework emphasizing investigative exploration of authentic issues (Thomas & D, 2000). Within this approach, students collaborate to design, execute, and complete projects that result in a tangible product reflecting their understanding of the subject matter. Thomas's 2000 framework outlines six core phases of PjB: formulating an essential question, designing the project, creating a schedule, monitoring progress, evaluating outcomes, and reflecting on the learning experience. Together, these phases form a learning cycle that nurtures not only conceptual knowledge but also metacognitive skills and self-regulatory capacity (Thomas & D, 2000).

Several recent studies consistently demonstrate that PjBL contributes to strengthening students' critical thinking, problem-solving abilities, and conceptual understanding, particularly when implemented through authentic, interdisciplinary projects. Doyan's 2026 systematic review of 30 articles from the Scopus and SINTA databases (2020–2026) found that PjBL implemented through a STEM approach effectively cultivates higher-order thinking skills (Doyan et al., 2026). This finding is highly relevant to the current study, as critical thinking and problem-solving are core components of SRL. This condition was further analyzed by examining the limitations of the direct instruction learning model in fostering digital literacy skills, highlighting the need to explore the potential of Artificial Intelligence in supporting the PjBHL model (Priyambudi, Setyowati, et al., 2025).

Within English literature education specifically, PjBL implementation has been shown to positively influence learners' learning autonomy. Sari's 2026 systematic review, based on 56 Scopus indexed studies from 2016–2025, found that the most effective SRL interventions in English literature instruction are themselves rooted in SRL principles especially when educators offer explicit guidance in developing responsibility, resilience, initiative, and unconstrained creativity (Sari et al., 2026a). This suggests that PjBL's impact on SRL development is heavily dependent on the quality of support provided, whether from instructors or technological tools.

Hybrid learning refers to an approach that integrates face-to-face and online instruction in a structured, cohesive manner. It combines the benefits of direct classroom interaction with convenient access to materials through digital platforms (Jingran Yang & Yahaya, 2025). Distinct from blended learning which often simply merges the two modes hybrid learning requires a more thorough pedagogical integration between them (Kristanto et al., 2024). Its defining features include flexibility in learning time and place, access to diverse digital resources, both synchronous and asynchronous interaction, learning pathways adapted to individual needs, and the use of learning analytics to track student progress. Importantly, hybrid learning designs that neglect SRL considerations tend to compromise students' depth of understanding (Jingran Yang & Yahaya, 2025), underscoring that effective hybrid learning must be intentionally designed to support SRL rather than merely blending two modes without careful planning.

The integration of PjBL and hybrid learning gives rise to a model known as Project Based Hybrid Learning (PjBHL), an innovative approach that merges the strengths of project-based learning with the flexibility of hybrid instruction (Surya Priyambudi, 2025). This model was developed to address the growing complexity of education in the digital era, with a focus on solving authentic, real-world problems. The PjBHL framework consists of several stages needs analysis, planning, implementation, assessment, and classroom management within a hybrid setting (Surya Priyambudi, 2025). Its key advantage lies in fostering a more interactive, collaborative, and meaningful learning experience through digital media that supports project-based work.

Emerging research trends point to growing interest in web-based learning models and the incorporation of deep learning techniques into PjBL frameworks. However, studies note that adaptive integration of deep learning mechanisms within PjBL remains scarce, revealing a research gap that warrants further exploration (Doyan et al., 2026). This study seeks to address that gap by incorporating AI as an adaptive element within the PjBHL framework applied to the Computer & Internet Applications course.

1.2. ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) refers to a technological system designed to replicate human cognitive functions such as learning, reasoning, problem solving, and contextual adaptation (Benfarha et al., 2025). The emergence of generative AI tools including ChatGPT, Claude, Gemini, and Llama has fundamentally reshaped the landscape of higher education. Rather than serving merely as a supplementary tool, AI now functions as a cognitive collaborator capable of engaging with students in an adaptive manner (Chen, 2023).

The pace of AI adoption has been remarkably rapid; by late 2024, close to 40% of the U.S. population aged 18–64 reported having used generative AI tools, with adoption occurring far more quickly than that of earlier technologies such as personal computers and the internet (Song et al., 2026). The global AI market is expected to reach roughly USD 1.8 trillion by 2030, reflecting a significant transformation in the nature of knowledge-based work (Song et al., 2026). In the current independent learning curriculum of the independent campus, learning in Higher Education has shifted to being based on internet digitalization. SPADA, which will be developed, is an application owned by Wijaya Putra University, which is located at olp.uwp.ac.id. The combination of project-based learning that implements hybrid learning is learning simultaneously online and offline (Surya Priyambudi, 2024).

The integration of AI into education presents two contrasting implications. On one hand, it holds substantial promise for supporting SRL through personalized learning, immediate feedback, and adaptive scaffolding. On the other hand, when used without structure, AI may actually weaken SRL and foster what has been termed metacognitive laziness (Yang, 2026). In a 2025 study at Lancaster University, Kwok empirically investigated the role of ChatGPT within PjBL for engineering students. Employing a mixed-methods approach alongside the Motivated Strategies for Learning Questionnaire (MSLQ), the study found that ChatGPT offered marginally greater support for SRL compared to conventional PjBL, yielding notable improvements in effort regulation and help-seeking behavior ($p < 0.05$), along with a moderate gain in academic performance ($p = 0.041$) (Kwok YH, 2025).

Nonetheless, other empirical findings highlight considerable risks associated with unregulated AI use. A systematic review encompassing 58 peer-reviewed studies from 2022 to 2025 found that excessive reliance on generative AI tools was linked to superficial learning patterns in 65.52% of the cases examined (Song et al., 2026). Similarly, a meta-analysis of 14 empirical studies identified a significant inverse relationship between heavy dependence on AI-generated content and students' capacity for independent problem-solving (Song et al., 2026). This concern is further supported by evidence suggesting that AI generated outputs often lack sufficient contextual sensitivity, which can diminish critical engagement and erode the authenticity and ownership students bring to their own work (Song et al., 2026).

Rahimi and Mosalli's 2025 study draws a distinction between deep learning in AI-supported contexts characterized by comparative analysis, conceptual integration, and evaluative reasoning and surface learning, marked by the uncritical acceptance of AI outputs and avoidance of cognitive effort (Yang, 2026). This distinction reinforces the notion that the quality of AI assisted learning is largely contingent on students' self-regulatory capacity and the contextual scaffolding provided to them. Artificial Intelligence-based tools that can be utilized effectively fall into several categories including those for searching scholarly sources, writing assistance, paraphrasing, visualizing research data, office applications, and productivity enhancement giving rise to the term AIEd (AI Education) to describe the use of AI within the educational sphere (Ibrahim et al., 2025).

1.3. SELF-REGULATED LEARNING

Self-Regulated Learning (SRL) is defined as a proactive process through which students independently manage their thoughts, emotions, and actions to achieve their learning objectives (Sari et al., 2026b). This definition highlights the centrality of student agency and autonomy in overseeing their own learning process. Among the most widely referenced SRL frameworks one that has consistently underpinned successful interventions is Zimmerman's three-phase cyclical model (Schunk & Zimmerman, 2023), which consists of:

1. Forethought: Processes that take place prior to learning activities, such as task analysis and self-motivation.
2. Performance: Processes occurring during the learning activity itself, including self-control and self-monitoring.

3. Self-Reflection: Processes that follow the learning activity, encompassing self-evaluation and response to outcomes.

In his 2024 doctoral dissertation at Utah State University, Longhurst empirically examined the cyclical interplay among these three phases (Cyclical Patterns of Self-Regulated Learning in College Students Author David N. Longhurst, 2024). Employing an SRL microanalysis approach, the study explored students' SRL processes including goal setting, strategic planning, self-efficacy, interest, task value, satisfaction, and attribution in relation to their quiz performance. Results revealed a dynamic, cyclical pattern in which outcomes from the self-reflection phase carried over to shape the forethought phase of the subsequent learning cycle (Cyclical Patterns of Self-Regulated Learning in College Students Author David N. Longhurst, 2024). This suggests that effective SRL interventions must account for the ongoing continuity between phases rather than treating them as isolated stages.

The integration of SRL within hybrid learning contexts has emerged as a key area of interest in contemporary educational research. In a 2026 book chapter titled "Assessing Educational Digital Transformation in the AI Era," Yang and Yahaya examined an SRL based instructional framework designed for blended learning in higher education settings (Jingran Yang & Yahaya, 2025). Grounded in Zimmerman's SRL model, the proposed framework incorporates technological tools, cultural adaptation, and strategies for social interaction. Findings indicate that the systematic incorporation of SRL strategies into blended learning environments significantly enhances both student performance and self-regulatory competence (Jingran Yang & Yahaya, 2025). However, the study also points to a critical gap: existing blended-learning designs have yet to fully harness the potential of SRL, thereby constraining student autonomy and limiting the depth of learning achieved. This gap serves as an important foundation for the present study, which seeks to develop a model that explicitly embeds SRL principles into hybrid learning design.

Kwok's 2025 study offers empirical insight into the role of conversational AI in fostering SRL within PjBL contexts (Kwok YH, 2025). Through a mixed-methods comparative design, the research demonstrates that ChatGPT facilitates SRL by providing personalized guidance, debugging support, and opportunities for reflective review. At the same time, the study identifies several challenges including the risk of over dependence, technical constraints, and inconsistent effects on teamwork dynamics all of which point to the need for deliberate and strategic curriculum design (Kwok YH, 2025). Several studies have shown that differentiated instruction can improve learners' learning outcomes, particularly for those with differences in cognitive style, self-efficacy, motivation, and self-regulated learning. Differentiated instruction is an approach aimed at meeting the diverse learning needs of learners (Priyambudi, 2024).

1.4. STATE OF THE ART

Drawing on a review of literature published between 2024 and 2026, the following table presents a summary of research developments relevant to the topic under investigation. This mapping is essential to position the current study within the broader scholarly conversation and to clarify precisely where existing research falls short.

Table 1. Previous Research

Author (Year)	Research Findings	Limitations
Kwok (2025) (Kwok YH, 2025)	ChatGPT facilitates SRL through personalized guidance, debugging support, and reflective review, with significant gains in effort regulation and help-seeking ($p < 0.05$)	Employs a mixed-methods design but does not involve the development of a learning model
Song R, Dkk (2026) (Song et al., 2026)	Perceived ease of use, usefulness, and interactivity are strong predictors of intention to use and SRL; intention to use correlates with learning engagement, which subsequently supports SRL	Limited to testing a correlational model rather than developing a learning model; conducted with participants in China
Sari dkk. (2026) (Sari et al., 2026a)	The most effective SRL interventions are grounded in Zimmerman's cyclical model, with effectiveness contingent on explicit scaffolding	Does not incorporate AI; constitutes a review rather than model development
Yang & Yahaya (2026) (Yang, 2026)	Systematic incorporation of SRL strategies into blended learning enhances both performance and self-regulatory skills	Does not incorporate AI; not specifically focused on PjBL

Taken together, these studies demonstrate a growing scholarly interest in the intersection between AI, technology enhanced learning, and SRL. However, each study addresses only a fragment

of the puzzle: some focus narrowly on AI's correlational influence on SRL without proposing an actionable pedagogical model, while others emphasize SRL theory or blended learning design without incorporating AI as an adaptive scaffolding mechanism. This fragmentation indicates that the field has yet to produce a unified, empirically tested model that brings these elements together in a coherent instructional design.

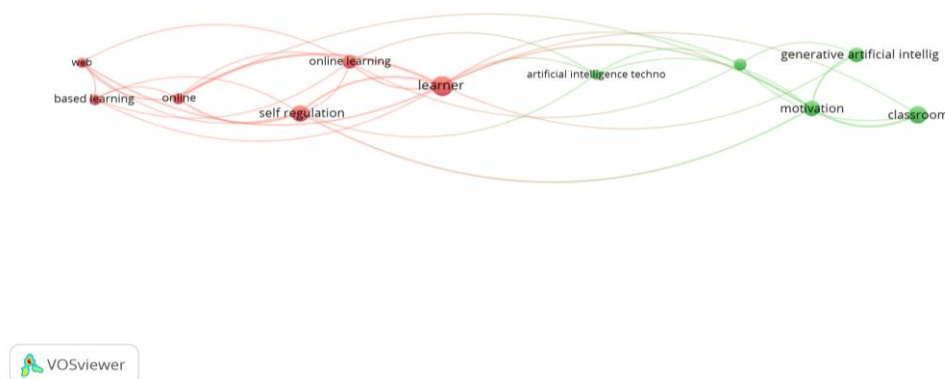
Building on this state of the art, several key research gaps can be identified as the foundation for the urgency of this study. First, no existing study has systematically combined the three components of PjBL, hybrid learning, and AI within a single pedagogical framework specifically aimed at enhancing students' SRL. Second, no prior research has developed an AI-assisted hybrid PjBL model tailored to the Computer & Internet Applications course within an English language study program. Third, no study has employed a Research and Development (R&D) approach based on the ADDIE model to design and test an AI assisted PjBHL model for SRL. Moreover, although numerous studies have positioned SRL as an outcome variable influenced by AI or PjBL, none has treated SRL as the central focus of model development with a design that explicitly incorporates Zimmerman's three SRL phases forethought, performance, and self-reflection throughout each stage of the learning process. This absence of an integrated, theory driven, and empirically validated model represents a significant gap that the present study seeks to address.

Based on the gaps identified above, the novelty of this study can be outlined as follows:

1. Novelty in Theoretical Approach
 - a. Simultaneous integration of three theoretical frameworks: Zimmerman's SRL model, Thomas's PjBL framework, and AI as adaptive scaffolding within a hybrid learning context
 - b. Explicit mapping of Zimmerman's three SRL phases forethought, performance, and self-reflection onto each stage of the model
 - c. Positioning of AI as a form of metacognitive scaffolding and a cognitive interlocutor that promotes reflection and self-regulation.
2. Novelty in Methodological Approach
 - a. Use of an R&D approach based on the ADDIE model (Analyze, Design, Develop, Implement, Evaluate), resulting in a learning model as the primary output
 - b. Field testing employing a non equivalent control group design, conducted after the model undergoes expert validation and limited-scale trials
 - c. Investigation conducted at both the individual level (SRL) and the classroom level (model implementation)

Through this combination of theoretical and methodological novelty, the present study is expected to contribute not only a conceptual advancement in understanding how PjBL, hybrid learning, and AI can jointly foster SRL, but also a concrete, field-tested instructional model that can be adopted or adapted by other English language study programs facing similar challenges. The relationships among the variables examined in this study, as visualized using VOSviewer, are presented below.

Figure 1. Relationships Between Variables Using the VOSviewer Application



To support the review presented above and visualize the conceptual research landscape linking project-based learning (PjBL), hybrid learning, AI, and self-regulated learning models, a keyword co-occurrence bibliometric analysis was conducted using VOSviewer version 1.6.20 [26]. Bibliographic

data were obtained from Scopus and Google Scholar in May 2026. The search was restricted to the title, abstract, and keyword fields using the following Boolean string: ("project-based learning" OR "PjBL") AND ("hybrid learning" OR "artificial intelligence") AND ("self-regulated learning"). The search was limited to journal articles published between 2021 and 2026. This process yielded 21 records; after excluding 17 records that did not meet the criteria, a final set of 4 records was selected for bibliometric mapping.

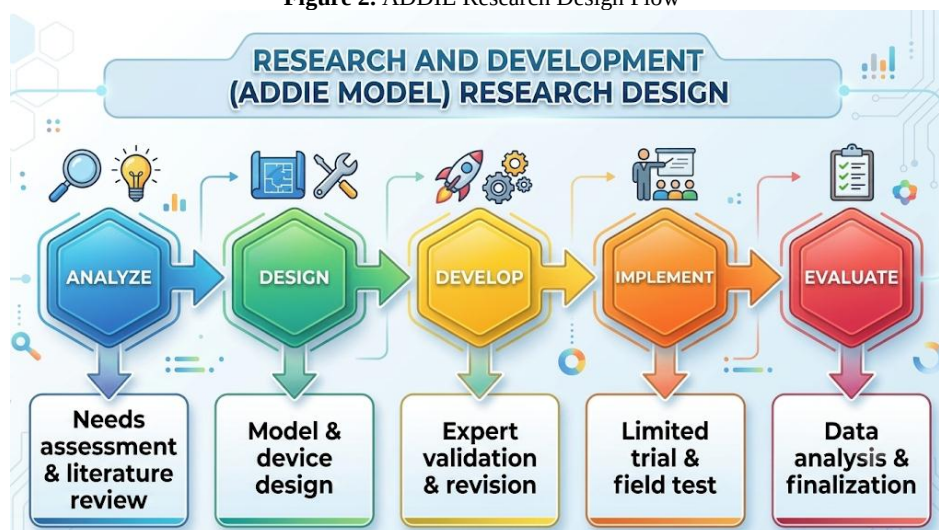
The selected data were exported in RIS/CSV format and imported into VOSviewer for co-occurrence analysis. Keywords served as the unit of analysis using the full counting method. Eleven keywords were included in the map. A thesaurus file was used to merge synonymous or nearly identical terms (e.g., "self-regulated learning" and "SRL"; "artificial intelligence" and "AI"). Relationships between terms were calculated using the association strength normalization method, and clusters were formed using VOSviewer's default resolution parameters. The resulting map (Figure 1) displays node sizes representing keyword occurrence frequencies, node colors indicating cluster membership, and line thicknesses illustrating the strength of co-occurrence between terms. As shown in Figure 1, keywords related to artificial intelligence and self-regulated learning form a well-developed cluster, while keywords associated with project-based learning and self-regulated learning form a separate, equally well-developed cluster; conversely, terms linking all three concepts project-based learning, hybrid learning, and artificial intelligence within a model focused on self-regulated learning appear only sporadically at the periphery of the map. This pattern aligns with research gaps identified in recent literature reviews: although pairwise combinations of these concepts have received significant academic attention, models integrating all three components remain underexplored within the scope of the search conducted. This bibliometric map serves as descriptive and exploratory evidence of the research landscape, complementing rather than replacing the systematic review presented in Table 1. The map is subject to limitations inherent in keyword-based mapping, meaning its coverage is restricted to a single database.

2. METHOD

2.1. RESEARCH DESIGN

This study employs a Research and Development (R&D) approach utilizing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) as its developmental framework. The ADDIE model was selected for its systematic structure, adaptability, and demonstrated effectiveness in the development of learning models (Branch, 2010). An R&D approach was deemed appropriate given that the primary aim of this study is to produce a valid, practical, and effective AI assisted PjBHL model capable of enhancing students' SRL. The overall research design flow is illustrated as follows.

Figure 2. ADDIE Research Design Flow



To evaluate the effectiveness of the developed model, this study adopts a quasi-experimental approach, specifically a non-equivalent control group design, during the implementation phase:

Table 2. Quasi-experimental Design

Group	Pretest	Treatment	Posttest
Experimental (E)	O ₁	X (AI-Assisted Hybrid PjBL Model)	O ₂
Control (K)	O ₃	C (Conventional Learning)	O ₄

Notes:

O₁ , O₃ = Pretest of students' SRL ability

O₂ , O₄ = Posttest of students' SRL ability

X = Treatment in the form of an AI-assisted Project Based Hybrid Learning model

C = Conventional learning (hybrid learning without a structured model and without AI integration)

2.2. RESEARCH SUBJECTS AND LOCATION

This research was carried out during the even semester of the 2025/2026 academic year, involving a total of 65 students enrolled in the English Language Study Program at Universitas Wijaya Putra. This location was chosen based on several considerations, including the researcher's accessibility to the study subjects, the varying levels of SRL observed among the students, and the institution's support for developing innovative learning models within the Computer & Internet Applications course.

This study utilized two pre-existing classes enrolled in a computer and internet applications course, with students randomly assigned to treatment groups. One class was designated to follow the AI-assisted PjBHL model, while the other received conventional instruction. Group assignment was based on the sequence of student ID numbers; the study was conducted across two parallel classes established by the academic department prior to the research, making it administratively unfeasible to mix the students. Both classes were taught by the same instructor using identical course materials and total time allocations to minimize instructor-related differences between the groups; the only planned difference between the two classes was the instructional model applied.

2.3. DATA COLLECTION INSTRUMENTS

Data in this study were collected through several complementary instruments designed to yield comprehensive quantitative and qualitative data. These instruments serve to measure students' SRL ability, evaluate the validity and practicality of the developed model, and monitor the model's implementation throughout the field trial process. A detailed overview of the data collection instruments used in this study is presented in Table 3 below.

Table 3. Data Collection Instruments

No	Instrument	Description
1	SRL questionnaire	Measures students' SRL ability (pretest–posttest)
2	Expert validation sheet	Validates the model and its tools
3	Student response questionnaire	Measures the practicality of the model
4	Observation sheet	Monitors model implementation
5	Interview guide	Gathers qualitative data (lecturers & students)
6	Documentation checklist	Records learning activities

2.4. SRL INSTRUMENT

The instrument designed to measure students' SRL ability was developed based on Zimmerman's theoretical framework of self-regulation, which conceptualizes the SRL process through three cyclical phases: forethought (planning), performance (execution), and self-reflection (evaluation) (Zimmerman, 2015). Each phase was further broken down into several sub-dimensions and indicators, drawing on the Online Self-Regulated Learning Questionnaire (OSLQ) developed by Barnard et al., which was adapted to fit the context of AI-assisted hybrid learning (Barnard et al., 2009). The complete blueprint of the SRL instrument is presented in Table 4, while the scoring approach employed follows the Likert scale outlined in Table 5.

Table 4. SRL Instrument

Phase	Sub-Dimension	Indicator
Forethought	Goal setting	Students set learning targets before starting
	Strategic planning	Students develop a learning strategy plan
	Self-efficacy	Students are confident in their own ability
Performance	Self-monitoring	Students monitor their own learning progress

Self-Reflection	Cognitive strategy	Students use effective learning strategies
	Resource management	Students manage their learning time and environment
	Self-evaluation	Students evaluate their own learning outcomes
	Causal attribution	Students analyze factors behind success/failure
	Strategy adaptation	Students adjust their strategies going forward

Table 5. Scoring Technique

Response	Score
Strongly Agree (SA)	4
Agree (A)	3
Disagree (D)	2
Strongly Disagree (SD)	1

2.5. MODEL VALIDITY DATA ANALYSIS

Data on model validity were obtained through expert assessments of the developed AI-assisted PjBHL model, encompassing evaluation of the model design, learning tools, and research instruments. These validation results were analyzed using descriptive quantitative techniques by calculating the percentage of the score obtained relative to the maximum possible score, using the following formula:

$$\text{Validity percentage} = (\text{Score obtained} / \text{Maximum score}) \times 100\%$$

The resulting percentage was subsequently interpreted according to the validity criteria outlined in Table 6, in order to determine the model's level of feasibility prior to its implementation in the field trial stage.

Table 6. Validity Criteria

Percentage	Category
85% - 100%	Highly valid (can be used without revision)
70% - 84%	Valid (can be used with minor revision)
55% - 69%	Sufficiently valid (requires major revision)
< 55%	Not valid (cannot be used)

2.6. MODEL PRACTICALITY DATA ANALYSIS

Data on model practicality were gathered through a response questionnaire completed by both lecturers and students following their experience with the implementation of the AI assisted PjBHL model. This assessment aims to determine the extent to which the model is practically implementable, user-friendly, and well-received by users in the field. Consistent with the analysis of validity data, practicality data were also analyzed using descriptive quantitative methods, with the score percentage calculated using the following formula:

$$\text{Practicality percentage} = (\text{Score obtained} / \text{Maximum score}) \times 100\%$$

The resulting percentage was then interpreted according to the practicality criteria presented in Table 7, in order to determine the practicality category of the developed model.

Table 7. Practicality Criteria

Percentage	Category
85% - 100%	Highly practical (can be used without revision)
70% - 84%	Practical (can be used with minor revision)
55% - 69%	Sufficiently practical (requires major revision)
< 55%	Not practical (cannot be used)

The average normalized gain for a course can be calculated based on the class average pretest and posttest scores, expressed as the ratio of the actual gain to the maximum possible gain (Hake, 1998). Based on this formula, the normalized gain (N-Gain) for each group in this study was calculated as follows: $\text{N-Gain} = (\text{posttest score} - \text{pretest score}) / (\text{maximum possible score} - \text{pretest score})$, and categorized according to the standard interpretation thresholds established by Hake (1998): high (≥ 0.70), medium (0.30–0.70), and low (< 0.30).

Hake noted that the normalized gain for a group of students can be calculated in two different ways: from the overall class average pretest and posttest scores, or as the average of individual students' normalized gain scores; these two calculations do not always yield identical values. In this study, N-Gain was calculated based on the average pretest and posttest scores of the students.

3. RESULT AND DISCUSSION

3.1. INITIAL CONDITION OF STUDENTS' SELF-REGULATED LEARNING ABILITY

Findings from a preliminary survey involving 65 students from the English Language Education Study Program at Wijaya Putra University conducted using Barnard's OSLQ instrument indicate that the students' mean Self-Regulated Learning (SRL) score was 2.21 (SD = 0.73), placing it in the low category. Specifically, only 24.4% of students reported explicitly setting learning goals, while merely 17.8% routinely engaged in self evaluation; furthermore, 68.9% acknowledged experiencing difficulty maintaining focus during online learning sessions. These findings provide the empirical basis underscoring the urgency of developing an AI-based PjBHL model, as previously discussed in the introduction.

3.2. MODEL DEVELOPMENT AND VALIDATION RESULTS

The development phase resulted in a design for the AI assisted PjBHL model that integrates Zimmerman's three SRL phases forethought, performance, and self-reflection into the syntax of project-based and hybrid learning. This model, along with its supporting tools (the semester learning plan, student worksheets, and the AI integration module), was subsequently validated by an instructional design expert. The validation results were as follows: the model design achieved a validity score of 86%, categorized as highly valid; the learning tools scored 88%, also highly valid; and the research instruments recorded a validity score of 85%, likewise falling into the highly valid category. Based on the criteria outlined in Table 6, the model is confirmed to be highly valid and suitable for use without revision prior to field implementation testing.

This Learning Management System (LMS) application was developed based on the open source Moodle which is enriched with various artificial intelligence features. One of the additions is the integration of the ChatGPT application which supports several language model providers such as Ollama, DeepSeek, and OpenAI to help the learning process. Apart from that, there is ReadSpeaker AI Voice Tools which allows learning material to be read automatically, as well as IntelliBoard which functions as an analytical and reporting tool for learning data. Not only that, this system is also equipped with Automatic Correction Tools which are able to correct assignments or exams automatically. With the combination of these features, this LMS is expected to increase effectiveness, efficiency and a more personalized learning experience for users.

The following describes the AI function in each of Zimmerman's phases (Forethought, Performance, Self-Reflection), complete with examples of commands (prompts), expected student actions, and targeted SRL indicators based on table 4.

Table 8. Zimmerman's Self-Regulated Learning Phases

Zimmerman Phase	AI Functions	Supporting AI Features	Example Command	Expected Student Actions	Targeted SRL Indicators
Forethought	Help students formulate project goals and develop strategic plans	ChatGPT (Ollama, DeepSeek, OpenAI); IntelliBoard (initial data & recommendations)	"I want to create a project involving a scientific poster. Help me set three specific goals and strategic steps to achieve them."	The student reviews the AI's suggestions, adjusts the goals to ensure they are realistic, and develops a self-directed study plan.	Goal setting; Strategic planning; Self-efficacy
Performance	Providing feedback and metacognitive scaffolding on work in progress	ChatGPT (Ollama, DeepSeek, OpenAI); ReadSpeaker AI Voice Tools (audio feedback); Automatic Correction Tools (preliminary	"Here is the draft of my second chapter. Please provide feedback on the argument structure and ask questions that prompt me to reflect on my thought process."	Students evaluate feedback, revise their work, and periodically monitor their learning progress	Self-monitoring; Cognitive strategy; Resource management

Self-Reflection	Generating reflective prompts and achievement summaries	correction) ChatGPT (Ollama, DeepSeek, OpenAI); IntelliBoard (achievement dashboards & analytics); ReadSpeaker AI Voice Tools (audio summaries)	"Create a summary of my achievements during this project and propose three reflective questions to evaluate my learning outcomes."	Students evaluate their learning outcomes, analyze factors contributing to success or failure, and adjust strategies for future projects	Self-evaluation; Causal attribution; Strategy adaptation
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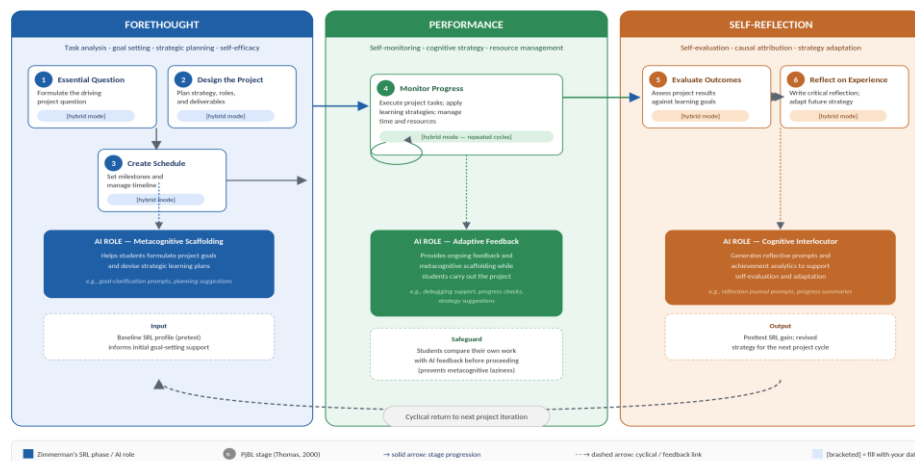
The integration of AI into the LMS which includes ChatGPT (Ollama, DeepSeek, and OpenAI), ReadSpeaker AI Voice Tools, IntelliBoard, and Automatic Correction Tools needs to be limited by a number of ethical, pedagogical, and technical principles so as not to conflict with learning objectives. From the perspective of ethics and academic integrity, AI should not be used to complete student assignments, provide final answers without stimulating thought processes, facilitate cheating, hide AI involvement in the learning process, or generate invalid claims and references. From a pedagogical and self-regulatory perspective, AI should not replace students' metacognitive role, provide feedback that is judgmental or reduces self-efficacy, take over final assessment decisions, foster excessive dependency, or ignore the differentiation of learning styles and special needs of students, because this is contrary to the nature of self-regulated learning which demands learner independence and reflection (Zimmerman, 2002).

From a privacy and data security perspective, AI needs to avoid collecting personal data without consent, sending data to third parties without clear policies, storing sensitive conversations without encryption, and excessive tracking of student behavior outside the interests of learning. From a content and bias perspective, AI should not distribute discriminatory material, present misleading information, generate illegal or harmful content, or ignore local cultural context. From a technical and operational perspective, AI should not be the only service line without alternatives when a system failure occurs, operate as a black box that cannot be audited, create dependency on one particular vendor (vendor lock-in), or be left without regular updates and evaluation. By paying attention to these limitations, it is hoped that the use of AI in LMS will not only increase learning effectiveness, but also still uphold ethics, data security and student-centered learning principles.

The PjBHL model using AI is designed based on the learning model components according to Joyce (Joyce et al., 2015) which include: (1) Syntax; (2) Social System; (3) Reaction Principle; (4) Support System; and (5) Instructional Impact and Accompanying Impact. The syntax of the AILS integrated PjBHL model consists of 6 main phases, namely: Problem Identification and Project Implementation; Learning Planning and Design; Project Development and Reflection; Peer Assessment and Feedback through AI; Presentations and Publications; and Evaluation and Reflection.

Figure 3. Diagram PjBHL Stages

Figure 3. Integration of PjBL Stages, Zimmerman's SRL Phases, Hybrid Modes, and AI Roles in the AI-Assisted Project Based Hybrid Learning (PjBHL) Model



3.3. MODEL PRACTICALITY TEST RESULTS

Practicality data were collected through a response questionnaire completed by both the teaching lecturer and students following their participation in the learning process using the AI assisted PjBHL model. The analysis revealed a practicality percentage of 80% from the lecturer and 85% from students, both of which fall into the practical category based on the criteria presented in Table 7. Additional qualitative feedback from respondents highlighted the ease of navigating the AI platform, the clarity of project instructions, and the relevance of the feedback generated by the AI system.

The learning tools designed in this research include: AILS Integrated PjBHL Model Book, which contains the theoretical basis, objectives, syntax and model implementation guidelines; A4 size PDF-based Digital Teaching Materials adapted to Computer & Internet Application material; Semester Learning Plan (RPS) which refers to Permendikbudristek No. 53 of 2023; The Self Regulated Learning Ability Assessment Instrument is based on Zimmerman's three phases.

3.4. MODEL EFFECTIVENESS TEST RESULTS

The effectiveness of the model was evaluated using a quasi-experimental non-equivalent control group design, involving an experimental group ($n = 33$) taught using the AI assisted Project-Based Hybrid Learning model, and a control group ($n = 32$) taught using conventional instruction (hybrid learning without a structured model or AI integration). SRL ability was assessed using a validated instrument ($\alpha = 0.89$), administered at both the pretest and posttest stages.

Table 9. Summary of Pretest, Posttest, and N-Gain SRL Scores

Group	n	Pretest (Mean $\pm$ SD)	Posttest (Mean $\pm$ SD)	N-Gain	Category
Experimental	33	2,23 $\pm$ 0,71	3,18 $\pm$ 0,58	0,72	High
Control	32	2,19 $\pm$ 0,75	2,87 $\pm$ 0,69	0,28	Low

As shown in Table 9, the pretest SRL scores for the experimental group (2.23) and control group (2.19) were fairly comparable, suggesting equivalent baseline conditions between the two groups. Following the treatment, however, the experimental group exhibited a substantially greater improvement (posttest = 3.18) compared to the control group (posttest = 2.87). The N-Gain score for the experimental group reached 0.72, falling into the high category, whereas the control group achieved only 0.28, classified as low.

Prior to hypothesis testing, normality (Shapiro-Wilk) and homogeneity of variance (Levene) tests were conducted on the posttest SRL data. The normality test confirmed that posttest scores for both the experimental group ($p = 0.142$) and control group ($p = 0.089$) were normally distributed, as both values exceeded 0.05. Similarly, the homogeneity test yielded $F = 1.84$ with $p = 0.180$ ($p > 0.05$), indicating that the variances between the two groups were homogeneous.

With these assumptions satisfied, hypothesis testing was conducted using an Independent Sample t-test at a significance level of $\alpha = 0.05$. The results revealed a calculated t-value of 8.47, with 63 degrees of freedom and a significance value of $p < 0.001$ ($p < 0.05$). Consequently, H_0 was rejected, confirming a statistically significant difference in SRL improvement between the experimental and control groups.

A closer examination of the SRL sub-dimensions revealed that the experimental group experienced its greatest gains in self-evaluation (N-Gain = 0.78) and goal setting (N-Gain = 0.75), while the smallest improvement was observed in resource management (N-Gain = 0.61). These results suggest that the developed model is particularly effective in encouraging students to engage in reflective practice and to independently plan their learning goals.

3.5. DISCUSSION

These effectiveness findings demonstrate that the AI assisted PjBHL model significantly outperforms conventional instruction in enhancing students' SRL ability. This result aligns with Kwok's 2025 findings, which reported that the use of conversational AI (ChatGPT) within a PjBL context significantly improved students' effort regulation and help-seeking behavior ($p < 0.05$) [21]. However, the present study extends this line of inquiry by systematically embedding AI across all three of Zimmerman's SRL phases, rather than positioning it merely as a supplementary tool.

These findings also lend support to Yang and Yahaya's 2026 argument that the systematic incorporation of SRL strategies into blended learning environments can enhance both learning

performance and self-regulatory competence (Jingran Yang & Yahaya, 2025). Within the developed model, the forethought phase is facilitated through AI features that assist students in formulating project goals and devising strategic plans; the performance phase is supported by adaptive feedback and metacognitive scaffolding provided by AI; and the self-reflection phase is reinforced through AI-generated reflective prompts and achievement analytics that prompt students to critically assess their own learning progress.

The success of this model is closely tied to its demonstrated validity and practicality. Expert validation scores, which fell within the highly valid category (85–88%), coupled with practicality ratings from lecturers (80%) and students (85%), indicate that the model's syntax developed through the ADDIE framework is both feasible and straightforward to implement in real classroom settings. Key contributors to this practicality include the clarity of project instructions, the ease of navigating the AI platform, and the relevance of feedback generated by the system.

That said, implementation of the model was not without its challenges. Several students in the experimental group reported a tendency toward excessive reliance on AI recommendations when completing project tasks a pattern that raises concerns about potential metacognitive laziness or surface-level learning. To address this issue, the model places strong emphasis on the self-reflection phase, requiring students to independently compare their own work against AI-generated feedback and to compose a critical reflection journal before accessing the system's final solution. This strategy has proven effective in preserving a healthy balance between AI utilization and the cultivation of student learning autonomy.

3.6. LIMITATIONS AND FUTURE RESEARCH

Although the research results indicate that the AI-supported PjBHL model enhances students' SRL compared to conventional instruction, there are several limitations in the study's design that must be acknowledged, as they constrain the scope of the claims made herein. First and foremost, the experimental treatment combined two components simultaneously the PjBHL syntax—structured according to Zimmerman's three phases of SRL and AI based support integrated into that syntax. Since the control group did not receive these components, and there was no condition isolating the AI from the PjBHL structure, the study design cannot determine whether the observed improvement in SRL was attributable to the AI, the PjBHL structure, the interaction between the two, or a combination of all three. Consequently, the findings are interpreted as evidence of the effectiveness of the integrated model as a whole, rather than as proof that the AI component specifically caused the SRL improvement.

Second, participants were not randomly assigned to the experimental and control groups. This non-random assignment raises the possibility of pre-existing differences between the groups—beyond the aspects measured by the pretest—that could influence the results. Although pretest scores were used to refine the analysis and mitigate this risk, the possibility of selection bias cannot be entirely ruled out.

Third, this study was conducted within a single "Computer and Internet Applications" course in the English Study Program at Wijaya Putra University, utilizing a relatively small sample size. The specific characteristics of the course, the instructor, and the student population limit the extent to which these findings can be generalized to other courses, disciplines, institutions, or student populations.

Fourth, SRL was measured using a self-report questionnaire. Self-report instruments are susceptible to social desirability bias and rely on students' ability to accurately assess their own regulatory behaviors, which may not fully reflect their actual conduct during the project. This study's design did not incorporate behavioral measures or activity traces that could corroborate the improvements reported by participants.

To address the previously identified confounding variables associated with AI and the PjBHL structure, future research should employ a four-group experimental design that disentangles these two components; such a design would allow for the statistical estimation of the main effects of the PjBHL structure and AI support as well as their interaction while directly testing whether the integrated model yields synergistic effects that exceed the mere sum of the individual components' effects. Future studies are also encouraged to utilize random assignment where feasible, replicate the model across various courses and institutions, incorporate behavioral or activity-trace measures of SRL alongside

self-report instruments, and extend the observation period with follow-up post-intervention assessments to examine the durability and transferability of the observed SRL improvements.

4. CONCLUSION

This study was driven by the persistently low SRL ability observed among students in the English Literature Study Program at Universitas Wijaya Putra, as evidenced by a preliminary survey that placed students' SRL within the low category (mean score of 2.21 on a 4-point scale). This condition is further compounded by the implementation of hybrid learning that has not been pedagogically structured to foster learning independence, as well as by the absence of a learning model that comprehensively integrates AI assisted PjBHL specifically for the purpose of enhancing SRL.

To address this gap, the present study developed an AI assisted PjBHL model through a Research and Development approach grounded in the ADDIE framework. The resulting model explicitly maps Zimmerman's three SRL phases onto every stage of project-based learning. Within this framework, AI functions as a form of metacognitive scaffolding and a cognitive interlocutor, offering adaptive feedback, personalized guidance, and reflective support tailored to each individual student.

Expert validation confirmed that the model is highly valid, with validity percentages of 86% for the model design, 88% for the learning tools, and 85% for the research instruments. The practicality assessment likewise yielded positive responses from lecturers (80%) and students (85%), indicating that the model is readily implementable in authentic learning settings. The effectiveness test, conducted through a quasi-experimental non-equivalent control group design, revealed that the model significantly outperforms conventional instruction in improving students' SRL ability. The experimental group recorded an N-Gain of 0.72 (high category), markedly surpassing the control group's N-Gain of 0.28 (low category). Results from the Independent Sample t-test further confirmed a statistically significant difference ($t = 8.47$, $p < 0.001 < 0.05$), affirming that the developed model exerts a meaningful and positive influence on students' SRL.

The novelty of this study lies in its simultaneous integration of three theoretical frameworks within a single, systematically designed AI assisted PjBHL model aimed at enhancing SRL an approach not yet found in prior research, which has tended to examine these elements in isolation (Kwok; Sari; Yang & Yahaya). Furthermore, this study introduces a novel conceptualization of AI not merely as a task-completion aid, but as a cognitive partner that actively fosters students' reflective practice and self-regulation through a structured self-reflection phase. As such, this study offers both a theoretical contribution in the form of a new, structured, theory-grounded pedagogical model and a practical contribution, in the form of an instructional product that can be adopted by lecturers teaching the Computer & Internet Applications course, as well as by educators more broadly within hybrid-learning-based higher education, to cultivate students' SRL in the era of artificial intelligence.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in this article.

DATA AVAILABILITY

No new data were generated or analyzed in this study. Data sharing is not applicable to this article.

AUTHOR CONTRIBUTIONS

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Surya Priyambudi: Conceptualization; Data Curation; Methodology; Writing-Original Draft; Visualization; and Project administration. **Yulis Setyowati:** Data Labelling; Resources; Supervision;

Writing-Review & Editing. **Alven Safik Ritonga**: Software; Validation; Data Curation; Writing-Review & Editing; Funding Acquisition.

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