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Collaborative Project-Based Hybrid Learning for Adaptive Learning in Higher Education

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Abstract

Higher education requires flexible learning models that combine digital accessibility, collaboration, and meaningful learning while accommodating differences in students' technological readiness. However, limited research has examined how collaborative project-based hybrid learning supports adaptive learning among students with different levels of technological literacy. This study developed and evaluated a Collaborative Project-Based Hybrid Learning model for higher education. Using a research and development approach based on the ADDIE framework, the model integrated synchronous and asynchronous learning, project-based activities, collaboration, and digital resources within a learning management system. Data were collected through questionnaires, interviews, observations, documentation, and learning achievement tests. Following expert validation, the model was implemented using a posttest-only control group design, with quantitative and qualitative data analyzed comparatively and descriptively. The findings showed that the model was valid and feasible for implementation. Students with higher technological literacy who participated in the developed model demonstrated better learning outcomes than those receiving conventional instruction, whereas comparable improvement was not evident among students with lower technological literacy. These findings highlight technological readiness as an important condition for successful hybrid learning implementation. The study provides an instructional framework for integrating collaborative project-based activities into hybrid higher education while emphasizing the need for differentiated digital support to foster adaptive learning across diverse learner readiness levels.

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INTRODUCTION

The world of education is changing in response to recent advancements in information and technology, both in the methods used and in the outcomes of high-quality education (Munti & Syaifuddin, 2020). Although internet access in Indonesia has increased, access to digital devices remains uneven (Padmasari et al., 2025; Rohid et al., 2026). According to Statistics Indonesia (BPS, 2025), 72.78% of Indonesia's population accessed the internet in 2024, whereas household computer ownership was considerably lower at 18.52%. This disparity indicates that internet connectivity does not necessarily guarantee access to suitable digital learning devices. Previous research has also emphasized the importance of technological access in supporting the quality of distance education (Ali et al., 2026). Globally, UNESCO (2023) highlighted persistent inequalities in access to technology-enabled education. Therefore, higher education institutions need flexible

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learning models that accommodate differences in students' technological readiness while maintaining meaningful interaction, collaboration, and continuity of learning. In addition to technological infrastructure, educator competence and preparedness are essential for addressing the challenges of digital education, implementing adaptive learning practices, and responding to the demands of Education 4.0 in higher education (Hidayat et al., 2023; Miranda et al., 2021; Ramli et al., 2026; Santoso et al., 2024). Implementing the MBKM (Merdeka Belajar-Kampus Merdeka) curriculum requires aligning learning experiences with employment opportunities (Endrawan et al., 2021; Medriati et al., 2022). Accordingly, one objective of learning management in universities is to collaborate with other universities to implement the curriculum.

Future educational demands will not only be carried out face-to-face but can also be done online, alternately or even simultaneously (hybrid) (Risdianto et al., 2025). Hybrid learning combines face-to-face and online instruction and may provide opportunities for flexible participation, interaction, and independent learning (Fajri et al., 2022; Nagrath et al., 2025; O'Byrne & Pytash, 2015; Pasaribu et al., 2022; Spanjers et al., 2015). In this context, self-regulated learning is particularly important because it enables learners to manage their learning goals, cognition, motivation, and behavior in response to different learning demands (Ritonga & Desrani, 2025). As a result, students can participate in synchronous (in person or virtually) or asynchronous (online) classrooms in an interactive setting that promotes behavioral, emotional, and cognitive engagement (Hapke et al., 2021; Wu et al., 2020; Ariza et al., 2024). Previous studies have reported that hybrid learning can support students' motivation, cognitive abilities, communication skills, learning independence, and other learning outcomes (Helsa et al., 2023; Putri et al., 2022). It has also been associated with time efficiency and positive student perceptions (Crawford et al., 2014; Juwita & Purwoko, 2022; Susilawati et al., 2026). However, in general, the hybrid technique is better suited as a complementary approach and cannot be fully utilized in quantitative classes, according to (Hendrayati & Pamungkas, 2016). Its implementation also involves challenges related to flexibility, interaction, student support, and the learning environment (Boelens et al., 2017). Therefore, hybrid learning requires appropriate instructional design, infrastructure, and implementation strategies.

The Project-Based Learning (PjBL) approach can be used for hybrid learning (Pandesha et al., 2023; Ramadhan & Rumondang, 2023). Previous studies have reported that hybrid-PjBL can improve learning outcomes, creative thinking, and metacognitive awareness, while also supporting the development of twenty-first-century learning competencies (Dhieni et al., 2024; Marpaung et al., 2025; Nurwidodo et al., 2021; Rahardjanto et al., 2019; Susilowati et al., 2025). Other studies have examined its potential to address the time demands of project-based learning (Ilma et al., 2023; Sinaga et al., 2025). Integrating Hybrid Learning and PjBL may support students' adaptive capability by combining flexible learning environments with authentic problem-solving, collaboration, critical thinking, and reflection. These processes are consistent with Constructivist Learning Theory and Self-Regulated Learning Theory, which emphasize active knowledge construction, self-monitoring, and adaptation to changing learning demands. However, limited research has examined how collaborative hybrid-PjBL models develop students' adaptive capability in higher education. This gap provides the rationale for the present study.

The development of hybrid learning, particularly in collaborative online learning, is a major issue for the Belmawa Directorate as well (Sari et al., 2025; Risdianto et al., 2026). As a result, Bengkulu University partners and Muhammadiyah University of Surakarta must prepare collaborative hybrid learning programs early. MOOCs and LMSs have not been fully utilized in the context of online education (Zadeh et al., 2025). However, their implementation has not yet been optimal when it comes to execution, particularly when it comes to using the PjBL learning approach (R et al., 2025; A. Miranda et al., 2025). This is due to the lack of a common learning mechanism for applying this knowledge, particularly for collaborative hybrid learning (Risdianto et al., 2023). Based on discussions, Muhammadiyah University of Surakarta faces similar challenges; therefore, combined research activities are needed to develop a collaborative hybrid learning model. In light of this, joint research is required to create an acceptable hybrid learning model. Therefore, this study aimed to develop and evaluate a collaborative Project-Based Hybrid Learning model in higher education. Specifically, it examined the model's validity and feasibility, its effectiveness in improving learning outcomes among students with different levels of technological literacy, and students' perceived adaptive capabilities following implementation.

METHOD

This study used research and development (R&D) as the term for this type of study. According to Borg and Gall, research outcomes serve as the foundation for developing learning products, which undergo systematic field testing, evaluation, and continuous improvement processes (Arifan et al., 2026). These procedures produce learning products that meet predetermined criteria, including effectiveness, efficiency, and high quality. Accordingly, educational research and development follows an industry-adapted development model. This study's development model uses the ADDIE (Analysis, Design, Development, Implementation, Evaluation) phases. This study employs both test and non-test data collection methods. Both qualitative and quantitative data analysis techniques are used in data analysis (Sukmarani et al., 2025).

Research Design.

The study adopted a posttest-only control group design because the primary objective of the implementation stage of the ADDIE model was to evaluate the performance of the developed learning model after validation and deployment. The study emphasized comparing learning outcomes after the intervention rather than measuring individual learning gains over time. The development of the collaborative Project-Based Hybrid Learning model followed the five phases of the ADDIE framework, as illustrated in Figure 1.

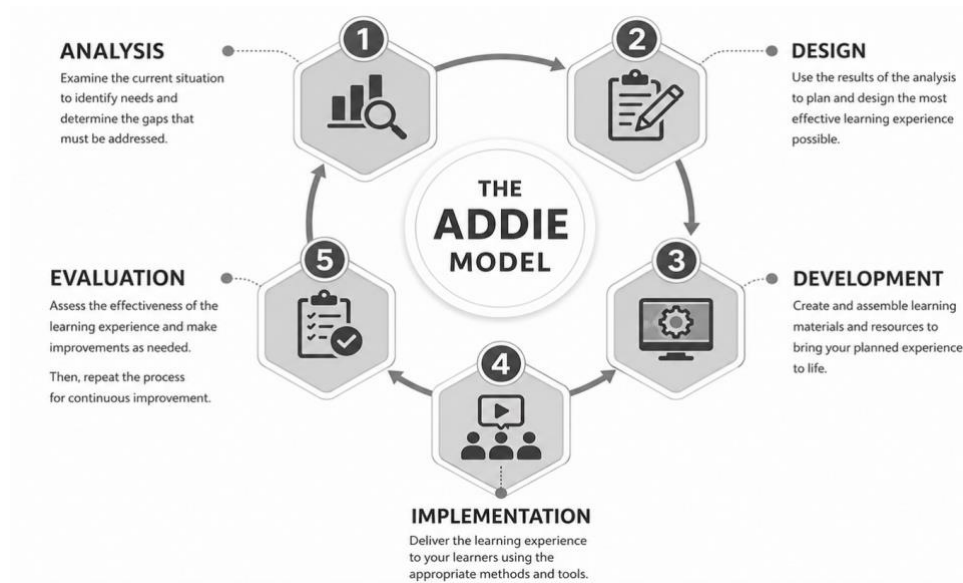


Figure 1. Development of the ADDIE Model

To enhance methodological transparency, the five ADDIE phases were operationalized into 21 sequential activities tailored to developing the collaborative Project-Based Hybrid Learning model. Table 1 presents each activity's specific procedure and expected output.

Table 1. Operational Activities

ADDIE Phase	No.	Operational Activity	Procedure / Evidence	Output
Analysis	1	Problem identification	Identification of challenges in hybrid and PjBL implementation at the partner universities	Problem statement
	2	Needs analysis	Student needs questionnaire and identification of learning requirements	Needs profile
	3	Learner analysis	Analysis of student characteristics and technological literacy	Learner profile

ADDIE Phase	No.	Operational Activity	Procedure / Evidence	Output
Design	4	Context analysis	Analysis of LMS, infrastructure, institutional collaboration, and learning environment	Context requirements
	5	Learning objectives	Formulation of model and learning objectives based on the analysis findings	Learning objectives
	6	Instructional strategy	Integration of Hybrid Learning and PjBL principles	Instructional strategy
	7	Learning activity design	Design of synchronous, asynchronous, collaborative, and project-based activities	Activity sequence
	8	Assessment design	Design of learning outcome assessment and student-response instruments	Assessment framework
	9	Model development	Development of the collaborative Project-Based Hybrid Learning model	Prototype model
Development	10	LMS development	Development/configuration of the LMS learning environment	LMS environment
	11	Learning material development	Development of RPS, SOP, PowerPoint, H5P Book, and H5P Video	Learning materials
	12	Project and task development	Development of project assignments, tasks, and quizzes	Project package
	13	Expert validation	Validation by three experts in instructional design, educational technology, and subject matter	Validation results
Implementation	14	Revision	Revision based on expert recommendations	Revised model
	15	Participant selection	Selection of two experimental classes and one control class	Research groups
	16	Model deployment	Deployment of the validated model in experimental classes	Implemented model
	17	Learning implementation	Implementation of LMS-supported synchronous, asynchronous, collaborative, and project-based activities	Implementation evidence
	18	Data collection	Collection of learning outcomes and student-response questionnaire data	Research dataset
Evaluation	19	Formative evaluation	Evaluation based on expert validation and implementation feedback	Evaluation findings
	20	Effectiveness evaluation	Statistical comparison of experimental and control groups and effect-size estimation	Effectiveness evidence
	21	Final evaluation	Analysis of students' perceived adaptive learning capabilities and final model refinement	Final model

The research was conducted through a collaboration between the Faculty of Islamic Religion at Muhammadiyah University of Surakarta and the Faculty of Teacher Training and Education at Bengkulu University. Data were analyzed qualitatively and quantitatively. Data collection used tests and non-test methods, including interviews, questionnaires, interview sheets, observation sheets, and documentation.

RESULTS AND DISCUSSION

Analysis Stage

At this stage, the researchers disseminated a survey of students' needs for the PjBL-based hybrid learning model. A student needs questionnaire consisting of four response options was developed using a modified Likert scale as a reference. The questionnaire consisted of sixteen items. The questionnaire used a four-point Likert scale, with the highest possible score of 4 and the lowest of 1. The analysis stage's findings demonstrate that students require a PjBL-based hybrid learning model.

Design Stage

Figure 2 presents the design of the developed PjBL-based hybrid learning model.

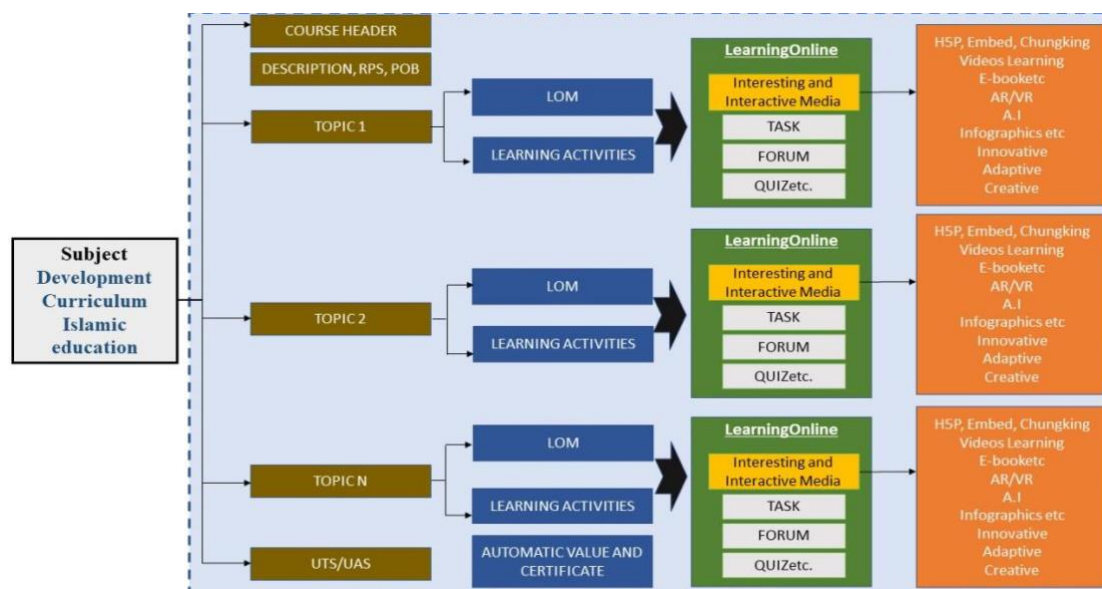


Figure 2. Design of the Developed PjBL-Based Hybrid Learning Model

Figure 2 illustrates the overall design of the developed PjBL-based hybrid learning model, which integrates course topics, LMS-supported learning activities, and interactive digital resources within a structured learning process.

Development Stage

During the development stage, the course lesson plan (RPS) and Standard Operating Procedures (SOP) were integrated into the LMS to provide structured guidance for the learning process, as shown in Figure 3.

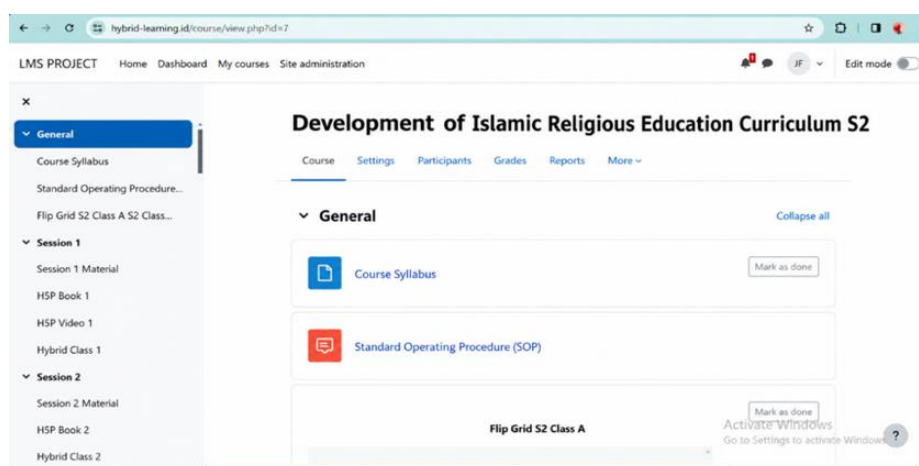


Figure 3. Course RPS and Course Standard Operational Procedures

Figure 3 shows how the course RPS and Standard Operational Procedures (SOP) are integrated into the LMS as the main instructional guidelines for implementing the developed model. These components provide students with structured information regarding the learning process and serve as a reference for participating in the subsequent hybrid and project-based learning activities. Figure 4 presents the digital learning materials and activities integrated into the LMS.

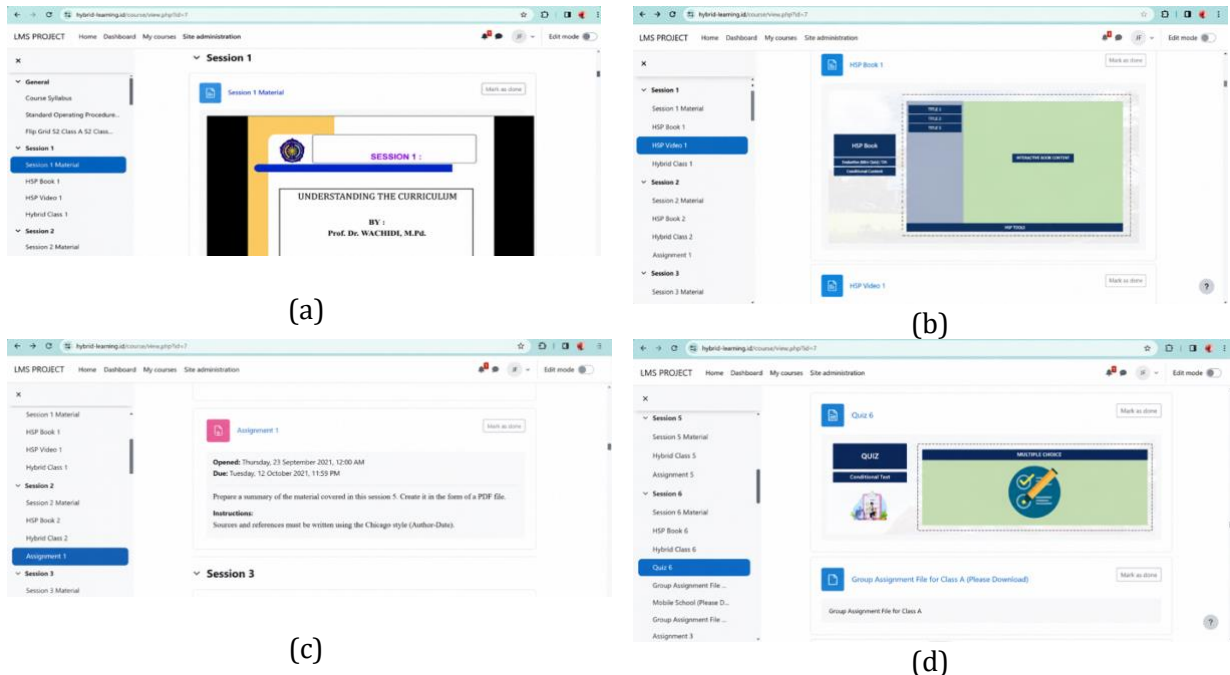


Figure 4. Digital Learning Materials and Learning Activities: (a) PowerPoint Learning Materials, (b) H5P Book and H5P Video, (c) Project-Based Learning Task, (d) Quiz Activity

The developed Learning Management System (LMS) integrates various digital learning materials and learning activities to support the implementation of the collaborative project-based hybrid learning model. The learning materials are organized by learning session, enabling students to access relevant course content throughout the learning process. PowerPoint presentations serve as structured learning resources, while interactive materials, including H5P Book and H5P Video, extend the learning experience through digital content within the LMS.

In addition to learning materials, the LMS incorporates project-based learning tasks that facilitate student engagement with course content and collaborative learning activities. These tasks support the implementation of Project-Based Learning (PjBL) within the hybrid learning environment. The quiz component is also integrated into the LMS to assess students' understanding of the learning materials. The synchronous learning component was implemented through the hybrid class feature, which combined face-to-face and online learning activities. Figure 5 presents an example of the first hybrid class meeting.

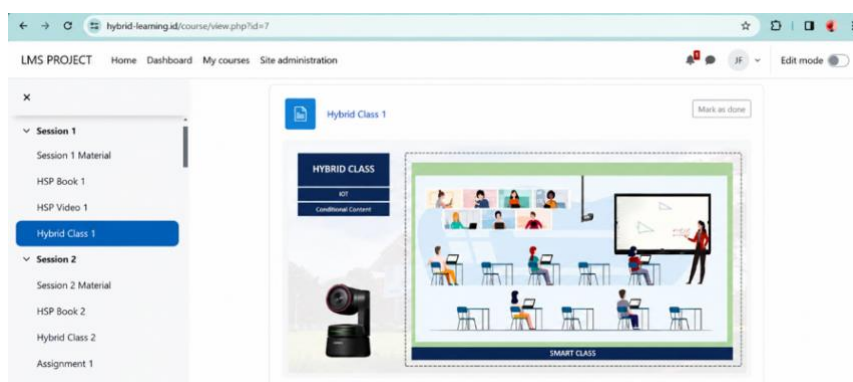


Figure 5. Hybrid Class Meeting 1

The Hybrid class feature constitutes the synchronous part of the developed learning model, as it involves combining face-to-face and online learning activities in the same learning environment. The task component facilitates collaborative learning by allowing students to engage in learning activities using various learning modes. The hybrid class functionality serves as the synchronous element of the learning approach, linking face-to-face and online learning processes within the same learning context. This element is designed to facilitate collaborative learning while offering flexible participation through different learning approaches.

Before implementation, experts validated the developed collaborative hybrid learning model to confirm the validity of its content, instructional quality, and technical feasibility. Three experts, who were representatives of the field of instructional design, educational technology, and subject-matter knowledge, evaluated the developed model using a validation tool that included criteria of learning objectives, instructional design, integration of PBL, hybrid learning implementation, learning activities, evaluation procedures, and usability of the system. The validation findings showed that the developed model demonstrated high validity and was appropriate for implementation with slight modifications. The experts generally agreed that integrating collaborative hybrid learning with the Project-Based Learning approach provided a coherent learning process, promoted student engagement, and supported the development of adaptive learning capabilities in higher education. The experts' suggestions were incorporated to improve the clarity of learning activities, navigation within the LMS, and alignment between project tasks and learning outcomes before field implementation.

Implementation Stage

The implementation stage aimed to determine the effectiveness of the PJBL-based higher education hybrid learning model in increasing creativity and adaptive learning capability in the digital era. The implementation was carried out at Muhammadiyah University of Surakarta (UMS). Three classes participated in the study. Two classes (classes A and C) were experimental groups, and one class (class B) was the control group. The experimental groups were divided into two categories: Class A included younger students with high technological literacy, while Class C included older students with lower technological literacy. Table 2 presents the results of the independent-samples t-test comparing Class A (experimental group) and Class B (control group).

Table 2. Descriptive Statistics of Learning Outcomes for Class A and Class B

Class	N	Mean	Std. Deviation	Std. Error Mean
Class A	11	87.7273	6.73930	2.03198
Class B	12	64.4167	3.82476	1.10411

As shown in Table 2, Class A achieved a higher mean learning outcome ($M = 87.73$, $SD = 6.74$) than Class B ($M = 64.42$, $SD = 3.82$). The descriptive findings show a difference of about 23 points between the two groups, suggesting that Class A had better learning achievements. Statistical analysis then tested whether this difference was statistically significant. An independent-samples t-test compared learning outcomes between Classes A and B (Table 3).

Table 3. Independent-Samples t-Test Results for Class A and Class B

Variance Assumption	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Equal variances assumed	5.636	.027	10.318	21	.000	23.31061	2.25912	18.61251	28.00871
Equal variances not assumed	—	—	10.080	15.545	.000	23.31061	2.31257	18.39648	28.22473

Levene's test violated the equality-of-variance assumption ($F = 5.636, p = .027$). Therefore, we used the results from the equal variances not assumed row, following the recommendation for Welch's t-test. There is a significant difference in performance between the experimental group (Class A) and the control group (Class B), $t(15.545) = 10.080, p < .001$. The experimental group performed better than the control group, with a significantly higher mean score ($M = 87.73, SD = 6.74$) than the control group ($M = 64.42, SD = 3.82$). The mean difference is 23.31. Table 4 presents the results from an independent t-test of Class C (Experimental Class) and Class B (Control Class).

Table 4. Effect Size Analysis

Comparison	Cohen's <i>d</i>	Hedges' <i>g</i>	Interpretation
Class A vs Class B	4.31	4.15	Extremely Large
Class C vs Class B	0.36	0.34	Small

To further investigate the intervention's effect, we estimated the effect size using Cohen's *d*. This calculation yielded a Cohen's *d* of 4.31, which is interpreted as an extremely large effect size based on Cohen's (1988) standards. Because the sample size was small, Hedges' *g* was calculated, yielding an effect size of 4.15, again suggesting a very large effect. Thus, the Project-Based Hybrid Learning collaboration provided an intervention effect that was not only statistically significant but also practically valuable. The effect size analysis further quantified the intervention effect. The comparison of Class C and the control group produced a Cohen's *d* value of 0.36 and a Hedges' *g* value of 0.34, suggesting a small practical effect. These results align with the independent-samples t-test output, which showed no statistical significance ($p = .628$). The collaborative Project-Based Hybrid Learning model did not appear to have much impact among students with low technological literacy, underscoring the need for digital preparedness to implement the model. We also calculated descriptive statistics for Class C, the experimental group with lower technological literacy, and Class B, the control group. Table 5 presents the results.

Table 5. Independent-Samples t-Test Results for the Experimental Group (Class C) and the Control Group (Class B)

Class	N	Mean	Std. Deviation	Std. Error Mean
Class C	5	66.2000	7.32803	3.27719
Class B	12	64.4167	3.82476	1.10411

As shown in Table 5, Class C obtained a slightly higher mean learning outcome ($M = 66.20, SD = 7.33$) than Class B ($M = 64.42, SD = 3.82$). The descriptive results indicate a mean difference of approximately 1.78 points between the two groups. We then tested whether this difference was significant. An independent-samples t-test compared learning outcomes between Classes C and B (Table 6).

Table 6. Independent-Samples t-Test Results for Class C and Class B

Variance Assumption	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Equal variances assumed	7.275	.017	.669	15	.513	1.78333	2.66400	-3.89484	7.46150
Equal variances not assumed	—	—	.516	4.936	.628	1.78333	3.45819	-7.14075	10.70741

Levene's test also showed that the assumption of equal variances was not met across the groups ($F = 7.275, p = .017$). The findings indicated no statistically significant difference in learning outcomes between Class C and the control group, $t(4.936) = 0.516, p = .628$. These findings suggest that the developed model did not produce significantly better learning outcomes among students with lower technological literacy.

Disparities emerged after an independent t-test comparing class A (experimental) with class B (control) and class C (experimental) with class B (control). This disparity in technology literacy between classes A and C explains the discrepancy. While Class C consisted of older students with lower technological literacy, Class A consisted of younger students with strong technical literacy and was better suited to the PJBL-based hybrid learning approach. With low technological literacy, implementing the PJBL-based hybrid learning approach presents certain challenges.

Evaluation Stage

Student responses to the developed PJBL-based hybrid learning model were collected using a questionnaire consisting of 23 statements measured on a four-point Likert scale. To present the findings concisely, Table 7 reports six selected questionnaire items. The table presents students' responses to the selected items and does not represent the complete results of all 23 questionnaire statements. The findings are therefore interpreted as descriptive evidence of students' perceptions of the learning model rather than as a comprehensive representation of the entire questionnaire response distribution.

Table 7. Students' Adaptive Capability Based on Questionnaire Responses

Dimension	Item	SA	A
Learning flexibility	5	7	4
Adaptation to changing situations	16	4	7
Adaptive problem-solving	17	3	8
Continuous learning	19	5	6
Working in changing environments	20	4	7
Technological adaptation	21	6	5

Students' Adaptive Capability

To examine the model's contribution beyond learning outcomes, the students' responses were analyzed using adaptive capability indicators. Six questionnaire items (Items 5, 16, 17, 19, 20, and 21) were identified as representing the dimensions of adaptive capability, including learning flexibility, technological adaptation, problem-solving, continuous learning, and responsiveness to changing learning environments. All respondents strongly agreed or agreed with these statements, reflecting their positive perceptions of their ability to adapt after completing the Project-Based Hybrid Learning framework.

Item 5 revealed that all learners felt that the hybrid learning approach helped them adapt to various types of learning (7 SA; 4 A). In addition to this, Item 16 revealed that students felt that the model facilitated faster adaptation to changes in the learning environment (4 SA; 7 A), whereas Item 17 revealed the students' confidence in coming up with creative solutions in difficult situations (3 SA; 8 A). Continuous learning and knowledge update were also viewed favorably by the students, which is reflected in Item 19 (5 SA; 6 A), thereby showing that the model encouraged the students to develop themselves in line with the changing learning demands continuously. Additionally, Item 20 (4 SA; 7 A) showed students' ability to work effectively in changing learning environments, while Item 21 (6 SA; 5 A) showed that the model improved students' adaptation to new educational technologies.

The findings extend previous studies on the benefits of integrating Hybrid Learning and Project-Based Learning. While Rahardjanto et al. (2019) primarily demonstrated its effects on learning outcomes and creative thinking, Nurwidodo et al. (2021) emphasized metacognitive awareness, and Ilma et al. (2023) and Sinaga et al. (2025) highlighted its potential to address the time limitations of project-based learning. Similarly, Dhieni et al. (2024) and Marpaung et al. (2025) positioned hybrid-PjBL as an alternative approach for meeting twenty-first-century learning demands. However, this research adds to the literature by showing that the effectiveness of collaborative Project-Based Hybrid Learning depends on learners' technological literacy, with effectiveness more pronounced when technological literacy is high. The model was also found to be positively accepted in promoting learning flexibility, technological adaptation, lifelong learning, and adaptability in problem-solving skills. Hence, this research's innovation comes not only from

integrating the two models of Hybrid Learning and Project-Based Learning, but also from the contribution of technological readiness to its effectiveness.

Overall, these results provide empirical evidence of the adaptive capabilities enabled by collaboration within the Hybrid Learning Model Based on Project-Based Learning. The learning model not only enhanced the students' academic performance but also fostered learning flexibility, technology readiness, continuous learning, and adaptive problem solving, all of which are crucial abilities in the modern era of higher education. These results support the statistically significant increase in learning outcomes discovered in the experimental group. Thus, the suggested learning model helps improve academic performance and adaptive learning abilities.

LIMITATIONS

Several limitations of this research need to be considered to interpret the results correctly. First, the implementation stage used a post-test-only control group design that did not allow comparison of participants' baseline competencies or assessment of their progress over time. Second, the sample size was quite small, especially in the experimental group, which had a lower level of technological literacy; thus, the results may be less generalizable to higher education settings. Third, although the study measured participants' adaptive capability through factors such as learning flexibility, technological adaptation, problem-solving, and continuous learning, it did not use an adaptive capability scale. Finally, the study tested the established collaborative hybrid learning framework in only two Indonesian institutions of higher learning, and differences in institutions, technology, and culture may affect its transferability to other environments. Future studies should use a broader sample, a pretest-posttest design, standardized measures of adaptive capacity, and evaluation across different universities to strengthen the external validity of the results.

CONCLUSION

This study emphasized developing and evaluating the collaborative PBLH model to extend learning opportunities, support adaptive learning, and help achieve higher education KPIs. The model was developed using the ADDIE R&D method, validated by experts, and implemented in a collaborative learning environment comprising two institutions of higher education. The results showed that students with high technological literacy who used the proposed learning model performed much better in terms of achievement than students in traditional teaching, with a very large effect size. In contrast, for students with low technological literacy, the learning model produced only moderate effects. This suggests that digital readiness is an important condition for ensuring the effectiveness of hybrid learning. Finally, the analysis of students' adaptability proved that the model contributes to the formation of adaptive learning skills in higher education. In sum, the proposed Collaborative Project-Based Hybrid Learning approach has both theoretical and practical implications by integrating collaborative hybrid learning and Project-Based Learning into a comprehensive instructional design approach for adaptive learning in technology-enhanced higher education. Further research should confirm the model through experiments with more cases, measurement instruments for adaptive capabilities, and pretest-posttest research designs.

AUTHOR CONTRIBUTIONS

WW originated the idea of the study, designed the collaborative Project-Based Hybrid Learning method, carried out the research, collected and analyzed the data, and created the first manuscript draft. ER contributed to conceptualization, methodology, supervision, validation, project administration, formal analysis, and critical review and revision of the manuscript. JS and AHA contributed to methodology, validation, data interpretation, and manuscript review and editing. MP was responsible for data collection, implementing the learning method, and coordinating the research. DAD participated in validating the learning method, improving its methodology, and critically reviewing the manuscript. NPN contributed to data curation, visualization, and manuscript editing.

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