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Reflection and Innovation Approach in Technology-Supported Project-Based Learning for Strengthening the Pancasila Learner Profile among Secondary School Students

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Abstract. Developing students who embody the Pancasila Learner Profile remains a central objective of Indonesia's Merdeka Curriculum, yet many schools struggle to translate these expected values into classroom practice. Meanwhile, smartphones are integral to adolescents' daily lives, though their potential to support character education remains underused. This study examined whether integrating a Reflection and Innovation approach into Technology-Supported Project-Based Learning could improve students' character development more effectively than conventional instruction. A quasi-experimental nonequivalent control-group pretest-posttest design was conducted with 384 Grade Eleven students (192 experimental, 192 control). Character development was assessed using a 60-item Pancasila Learner Profile Questionnaire with strong content validity (CVI = .89) and excellent internal consistency (Cronbach's α = .93). After eight weeks, students exposed to the intervention outperformed the comparison group ($M = 82.6$ vs. 63.4 ; $t(382) = 18.18$, $p < .001$; Cohen's $d = 1.86$), with large effect sizes across all six dimensions ($d = 1.37$ - 1.53). The intervention also produced a

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substantially higher Normalised Gain ($g = .65$) than conventional learning ($g = .27$), while students reported very positive learning experiences (91.1% positive responses). These findings indicate that combining structured reflection, authentic project work, and technology-supported learning provides an effective pathway for strengthening multidimensional character development among secondary school students.

Keywords: Reflection and Innovation approach; Technology-Supported Project-Based Learning; Pancasila Learner Profile; character education; secondary school students

1. Introduction

Character education is an important global concern: students are expected to achieve strong academic results while developing positive values and responsible behaviour, a challenge intensified by young people now spending much of their time in digital environments (Kar et al., 2025). Digital technology offers several learning opportunities, but it also exposes adolescents to misinformation, cyberbullying, and other online risks that may influence their character development if schools do not provide proper guidance (Bitto Urbanova et al., 2023; Jović et al., 2024; Vladova et al., 2023). For this reason, technology should be used to support learning through appropriate pedagogy rather than simply because it is available (UNESCO, 2023).

Indonesia has responded through the Merdeka Curriculum (Freedom to Learn Curriculum), a 2022 national reform granting schools flexibility to design competency-based, student-centred instruction, with the Pancasila Learner Profile at its centre. The framework consists of six interconnected dimensions: Faith, Piety, and Noble Character, Global Diversity, Mutual Cooperation, Self-Regulation, Critical Reasoning, and Creativity (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2022). These competencies are expected to help students become responsible citizens who are prepared for future social and professional life.

Although the policy is well established, its implementation in schools is still inconsistent. Observations conducted in 15 senior high schools in Medan City showed that learning activities supporting the Pancasila Learner Profile reached only 24.1%. Students also recorded an average baseline score of 49.6, indicating that character development remained at a low level (Kesuma et al., 2025). These findings suggest that many classrooms have not yet translated policy expectations into effective learning practices.

At the same time, smartphones have become part of students' daily lives, yet they are still used mainly for communication and entertainment rather than as tools for character learning (Widowati & Tyas, 2024). This creates an opportunity to use technology to support both academic achievement and character development. Combined with approaches such as project-based learning, technology can encourage collaboration, critical thinking, creativity and active participation

through authentic learning experiences. However, prior studies mostly examined project-based learning and mobile learning separately, and research combining both to strengthen all six dimensions remains limited (Zaenab et al., 2024; Zha et al., 2024), highlighting the need for a more integrated model.

Building on this gap, this study introduces a Reflection and Innovation approach within Technology-Supported Project-Based Learning. It combines project activities, structured reflection, a mobile application and a web dashboard that allows teachers, students, counsellors, school leaders and parents to monitor progress in real time. The study examined whether this approach produced better outcomes than conventional learning, measured its effects across all six dimensions, and explored students' perceptions after participating in the programme, providing practical evidence for strengthening Indonesian secondary character education.

2. Literature Review

2.1 The Policy Framework: Pancasila Education and the Merdeka Curriculum

The Merdeka Curriculum places Pancasila Education at the centre of character development, anchored in the Pancasila Learner Profile's six dimensions: faith, piety, and noble character, global diversity, mutual cooperation, self-regulation, critical reasoning, and creativity (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2022). These dimensions support academic competence alongside social responsibility and lifelong learning skills, consistent with international discussions on social-emotional learning and twenty-first-century competencies (von der Embse et al., 2023; Voogt & Pareja Roblin, 2023).

To strengthen these competencies, the Merdeka Curriculum introduces the Pancasila Learner Profile Strengthening Project, allocating 20–30% of instructional time to project-based learning and character-building activities (Solehuddin et al., 2024), encouraging students to solve real-world problems, work collaboratively, and apply Pancasila values in meaningful situations. Many countries have introduced character education policies with broadly similar goals, such as Singapore's Character and Citizenship Education curriculum and initiatives in parts of the United States. Yet successful implementation depends less on curriculum design than on how teachers translate these values into daily classroom practice (Brown et al., 2023), meaning the main challenge is implementation, not policy design.

The Pancasila Learner Profile therefore represents more than a national policy: it reflects Indonesia's response to a broader international challenge of strengthening character education, consistent with Brown et al.'s (2023) finding that programme success depends on consistent classroom translation. Instructional models connecting policy goals with classroom practice are needed so character development can be observed, measured, and improved.

2.2 Project-Based Learning and Mobile Technology

Project-Based Learning gives students opportunities to learn through real situations: students investigate problems, work in teams, discuss solutions, and reflect on what they have learned. This reflects social constructivist theory, where knowledge develops through interaction, collaboration, and authentic experience (Huang et al., 2024; Lee & Jung, 2025), making it suitable for developing academic competence alongside communication, responsibility, and positive character. Recent work continues to reinvent it through formats such as hackathons and collaborative learning expeditions (Chounta et al., 2023).

Its contribution has been reported across settings: in Indonesia, Zaenab et al. (2024) found project-based learning helped schools implement the Pancasila Learner Profile Strengthening Project by connecting activities with students' daily experiences; Mutanga (2024) reported stronger collaboration and responsibility; and Kizys et al. (2025) found projects based on local community problems increased engagement and civic participation. However, simply assigning projects is not enough; quality depends on how teachers plan and guide them. Without clear direction, project work may become ordinary assignments with little impact on character. Projects with regular reflection, feedback, and authentic social experiences provide greater opportunities for positive values (Pupik Dean et al., 2023), forming the foundation of the Reflection and Innovation approach developed here.

Mobile technology further expands these opportunities: smartphones let students access materials, record progress, and receive timely feedback beyond classroom hours (Mehrfar et al., 2024), increasing participation and outcomes when supported by appropriate design (Anselmo et al., 2025). In Indonesia, mobile technology has strengthened civic education (Trisiana et al., 2024), teacher development (Susilawati et al., 2025), and twenty-first-century competencies (Mufit et al., 2023). Although both approaches have been widely studied, research combining them to strengthen all six Pancasila Learner Profile dimensions remains limited. This study responds by integrating project-based learning, structured reflection, and mobile technology into one approach expected to support character development while creating engaging, relevant learning experiences.

2.3 The Reflection and Innovation Approach

The Reflection and Innovation approach was designed to strengthen the Pancasila Learner Profile through Technology-Supported Project-Based Learning, combining authentic projects, structured reflection, formative feedback, and digital support into one process. Students complete project tasks, reflect on their experiences, collaborate, and apply Pancasila values, while teachers monitor progress and provide timely feedback. The approach includes interactive materials, authentic project assignments, a digital collaborative workspace, formative assessment, contextual civic issues, and a digital reflection portfolio, aligned across every project-based learning phase with the six Pancasila Learner Profile dimensions, as shown in Table 1.

Table 1: Alignment between project-based learning phases, Reflection and Innovation activities, and Pancasila Learner Profile dimensions

Project-Based Learning Phases	Reflection and Innovation Activity	Learning Mechanism	Pancasila Learner Profile Dimension
Driving Question	Digital exploration of social problems	Authentic problem identification	Critical Reasoning
Project Planning	Collaborative workspace and group project design	Goal setting and task division	Mutual Cooperation
Product Creation	Digital project development	Creative production and innovation	Creativity
Progress Monitoring	Formative assessment module	Self-monitoring and accountability	Self-Regulation
Reflection	Ethical reflection activities	Value internalisation	Faith, Piety, and Noble Character
Evaluation	Summative assessment and cross-cultural reflection activities	Intercultural appreciation	Global Diversity

3. Methodology

3.1 Research Design

This study used a quasi-experimental design with a nonequivalent control-group pretest-posttest format to examine the effectiveness of the Reflection and Innovation approach in strengthening the Pancasila Learner Profile (Gopalan et al., 2020). Students in the experimental group participated in Technology-Supported Project-Based Learning delivered through the Reflection and Innovation approach. In this study, “approach” refers to the overall pedagogical design combining project work, structured reflection and technology support. “Application” refers specifically to the mobile software tool, while “intervention” refers to the complete treatment experienced by the experimental group. Students accessed the approach through the Reflection and Innovation mobile application, whereas those in the control group received regular Pancasila Education through teacher explanations, classroom discussions, and written assignments. The application was not introduced in the control classes.

To reduce the risk of students sharing information about the intervention during the eight-week programme, the experimental and control groups were placed in separate, intact classes within each of the eight participating schools. Implementation fidelity was monitored in real time via the Reflection and Innovation web dashboard (16 sessions observed; inter-rater reliability substantial, Cohen's $\kappa = .82$, 82.4% agreement). Control-class teachers continued their usual practices without access to the approach. Because both conditions were delivered within the same eight schools, this design reduces between-school confounding (e.g., differences in institutional resources or student intake) relative to a design that compared entirely different schools, while the use of separate

intact classes still helped maintain a clear boundary between the two learning conditions under normal school settings.

Each class was taught by its own regular, certified subject teacher already assigned to teach Pancasila Education, rather than a specially recruited teacher. Teachers of the experimental classes received preparatory training (January–February 2026) covering project-based learning pedagogy, use of the Reflection and Innovation application, structured reflection facilitation, and the fidelity checklist; control-class teachers continued their standard practice without this training. Because individual random assignment was not feasible within intact classes, conditions were assigned to existing parallel classes per school on a non-random, convenience basis, consistent with the quasi-experimental design adopted for this study.

3.2 Participants

The study involved Grade 11 students from senior high schools in Medan City during the 2025/2026 academic year. The target population was approximately 12,500 students across 159 schools (BPS-Statistics Indonesia Medan Municipality, 2024). Two-stage cluster sampling was used. Schools were selected through convenience sampling based on willingness to participate and their ability to accommodate both study conditions during the eight-week intervention. Within each school, one existing Grade 11 class was assigned to each condition. Sample size was calculated using Slovin's formula (Yamane, 1967), $n = N / (1 + Ne^2)$: with $N = 12,500$ and a 5% margin of error, $n \approx 374.6$, rounded up to a minimum of 375.

A total of 384 students participated (192 experimental, 192 control), from both Natural and Social Sciences streams, aged 16–17 (54.7% female, 45.3% male), nested within intact classes across the eight schools (16 sessions observed), each guided by its regular subject teacher under a standardised, fidelity-monitored protocol. This study was approved by the Komisi Etik Penelitian [Research Ethics Committee], Universitas Islam Sumatera Utara (Approval No. 172A/I/E.02/V/2026) as a minimal-risk, curriculum-embedded activity for which institutional consent (obtained from each school's principal) was deemed sufficient, without separate parental consent. Student responses were recorded anonymously and accessible only to the research team.

3.3 Instruments, Validity, and Reliability

The 60-item Likert-scale instrument was validated by experts in Pancasila Education, Educational Technology and Information Technology. The Content Validity Index ranged from .80 to 1.00, with a mean of .89 (Lynn, 1986). Pilot testing with 60 respondents showed good internal consistency, with Cronbach's alpha above .80, while corrected item–total correlations were used to assess individual items (George & Mallery, 2003). These results are summarised in Table 2. Data collection also included structured classroom observations using a 30-item fidelity checklist rated independently by two trained observers (Cohen's $\kappa = .82$; 82.4% agreement) and semi-structured interviews consisting of 12 questions. Interviews were conducted with 24 experimental-group students, three from each school, purposively selected to represent differences in gender, stream and engagement.

Table 2: Validity and reliability statistics of the Pancasila Learner Profile Questionnaire by dimension

Pancasila Learner Profile Dimension	Number of Items	Corrected Item-Total Correlation (r)	Cronbach's Alpha (α)	CVI Range
Faith, Piety, and Noble Character	10	.384-.714	.880	.80-1.00
Global Diversity	10	.351-.687	.870	.80-1.00
Mutual Cooperation	10	.421-.782	.920	.80-1.00
Self-Regulation	10	.378-.698	.870	.80-1.00
Critical Reasoning	10	.402-.751	.910	.80-1.00
Creativity	10	.363-.719	.900	.80-1.00
Total	60	.351-.782	.930	.80-1.00

Note. N-Gain was calculated using Hake's (1998) formula: $g = (Post - Pre) / (Max - Pre)$. Interpretation criteria: High ($g > .70$), Moderate ($.30 \leq g \leq .70$), and Low ($g < .30$).

3.4 Research Procedure and Data Analysis

To provide a clearer overview of the study design, the overall research procedure and quantitative data analysis are presented visually in Figure 1, which summarises the sequence of activities from preparation to data analysis and reporting.

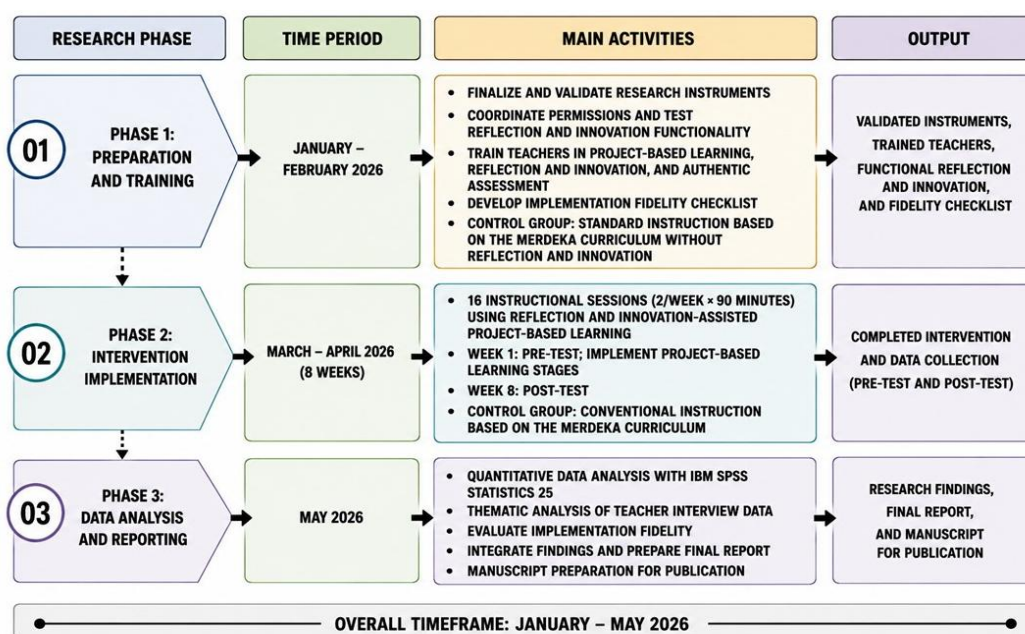


Figure 1: Overview of the research procedure and study implementation

As illustrated in Figure 1, the study was implemented through three phases: preparation (instrument refinement, institutional coordination, pilot implementation, and teacher preparation); intervention (16 Technology-Supported Project-Based Learning sessions over eight weeks with pre- and post-test assessments); and analysis (descriptive analysis and assumption testing. This was followed by hypothesis testing, learning gain analysis, effect size estimation,

and confidence interval analysis). The qualitative component complemented the quantitative findings through thematic analysis of semi-structured interviews with experimental-group students, following Braun and Clarke's (2006, 2020) procedures: iterative coding, theme development, and independent verification by two coders to enhance trustworthiness (Kiger & Varpio, 2020). Findings were integrated with the quantitative results using a sequential explanatory mixed-methods approach, providing deeper insight into how the approach supported Pancasila Learner Profile development and students' learning experiences.

4. Results

4.1 Preliminary Analysis: Normality and Baseline Comparability

Before testing the proposed hypotheses, distributional assumptions and baseline comparability were evaluated across the six dimensions and the composite score for both groups ($n = 192$ each). The Shapiro-Wilk test indicated pre-test and control post-test scores remained normally distributed ($p > .05$), while experimental post-test scores departed from normality ($p < .05$), likely reflecting a ceiling effect; given the large sample, this was not expected to compromise the t-test's robustness. Variance equality was examined using Levene's test, followed by Welch's t-test where needed, with both analyses producing the same conclusions. No significant baseline differences were found between groups ($t = -0.04$, $df = 382$, $p = .971$), confirming comparable starting conditions. Full per-dimension normality, homogeneity, and baseline-equivalence results are reported in Appendix D.

4.2 Descriptive Statistics and Normalised Gain

After the eight-week intervention, a clear divergence between the two groups became evident. The experimental group reached a higher post-test composite mean score ($M = 82.6$) than the control group ($M = 63.4$). This difference was better understood when viewed against baseline values. The experimental group moved from 49.6 to 82.6, while the control group increased from 49.7 to 63.4. In relative terms, the gains were 66.5% and 27.6%, respectively, indicating a widening gap after the intervention. At the dimension level, the pattern remained consistent rather than isolated: Creativity showed the strongest gain (45.8 to 84.8, 85.2%), followed by Critical Reasoning (47.2 to 83.2) and Self-Regulation (49.6 to 82.6), while Faith, Piety, and Noble Character showed the smallest, though still meaningful, increase (52.3 to 81.4). Overall, improvements were distributed across all six dimensions (Table 3).

Table 3: Comparative outcomes of pre-intervention and post-intervention scores and normalized gain across six dimensions of the Pancasila Learner Profile

Pancasila Learner Profile Dimen	M (SD)	M (SD)	(g)	M (SD)	M (SD)	(g)
Faith, Piety, and Noble Character	52.3 (15.4)	81.4 (11.9)	.61 (Moderate)	51.8 (16.0)	62.1 (14.6)	.21 (Low)
Global Diversity	48.7 (14.5)	79.6 (12.3)	.60 (Moderate)	49.1 (16.4)	61.8 (13.7)	.25 (Low)
Mutual Cooperation	54.1 (14.8)	83.8 (12.7)	.65 (Moderate)	53.7 (15.5)	64.7 (13.6)	.24 (Low)
Self-Regulation	49.6 (13.7)	82.6 (11.7)	.65 (Moderate)	50.2 (15.1)	63.5 (14.7)	.27 (Low)
Critical Reasoning	47.2 (16.4)	83.2 (13.0)	.68 (Moderate)	46.9 (15.1)	62.9 (15.1)	.30 (Low)
Creativity	45.8 (14.2)	84.8 (12.6)	.72 (High)	46.3 (14.7)	65.2 (13.0)	.35 (Moderate)
Overall Mean	49.6 (11.8)	82.6 (9.3)	.65 (Moderate)	49.7 (12.5)	63.4 (11.3)	.27 (Low)

Key: Experimental Pre-test M (SD); Experimental Post-test M (SD); N-Gain (g); Control Pre-test M (SD); Control Post-test M (SD)

The pattern shown in Table 3 suggests that the impact of the intervention extended beyond individual competencies and was consistently observed across all six Pancasila Learner Profile dimensions. As the intervention progressed, the distinction between the experimental and control groups became more pronounced, indicating that integrating the Reflection and Innovation approach into Technology-Supported Project-Based Learning produced greater improvements in students' learning outcomes than conventional instruction.

Normalised Gain analysis revealed a marked difference in learning improvement between the two groups. The experimental group obtained an overall N-Gain of .65 (moderate), with Creativity reaching the high category ($g = .72$). In contrast, the control group recorded an overall N-Gain of .27 (low), with most dimensions remaining in the low category.

The variation in N-Gain scores across dimensions indicates differences in the magnitude of improvement. Dimensions associated with generative and productive activities, particularly Creativity and Critical Reasoning, showed the highest gains, whereas Global Diversity and Faith, Piety, and Noble Character showed comparatively lower, though still meaningful, improvements. This suggests that dimensions involving direct engagement in designing, creating, and problem-solving may show more observable change within an eight-week period than reflective and attitudinal dimensions. The control group showed smaller improvements across all dimensions than the experimental group.

4.3 Independent-Samples t-Test and Effect Size

Post-test comparisons demonstrated a clear advantage for the experimental group. Statistically significant differences were found for the composite score ($t(382) = 18.18, p < .001$) and for all six Pancasila Learner Profile dimensions (all $p < .001$). The magnitude of these differences was substantial, with Cohen's d ranging from 1.37 to 1.86, indicating consistently large intervention effects according to Cohen's (1988) benchmarks for small ($d = 0.2$), medium ($d = 0.5$), and large ($d \geq 0.8$) effects. A complete summary of the statistical comparisons and effect size estimates is presented in Table 4. Because students were nested within intact classes, these comparisons were re-estimated as a cluster-robust ANCOVA; adjusted estimates were virtually identical to the unadjusted values above, confirming the results are not an artefact of the nested data structure.

Table 4: Comparative post-intervention outcomes and effect size estimates

Variable	t-value	df	p	Cohen's d	95% CI of Mean Difference
Composite Score	18.18	382	< .001	1.86	[17.1, 21.3]
Faith, Piety, and Noble Character	14.19	382	< .001	1.45	[16.6, 21.9]
Global Diversity	13.39	382	< .001	1.37	[15.2, 20.4]
Mutual Cooperation	14.23	382	< .001	1.45	[16.5, 21.8]
Self-Regulation	14.03	382	< .001	1.43	[16.4, 21.8]
Critical Reasoning	14.17	382	< .001	1.45	[17.5, 23.2]
Creativity	14.98	382	< .001	1.53	[17.0, 22.2]

4.4 Student Perceptions

Students' responses after the intervention showed highly positive evaluation of the Reflection and Innovation-based learning experience, with satisfactory reliability ($\alpha = .86$). Positive responses averaged 91.1% (Excellent), highest for engaging activities (94.8%), followed by broader implementation and collaborative learning support. Qualitative interviews revealed three recurring patterns

First, students showed stronger intrinsic motivation through authentic project experiences:

"I was actually interested because the problems were real things happening in my community."

Second, students reported greater confidence in collaborative and self-directed learning:

"I learned how to work together and manage my own tasks at the same time."

Third, students showed deeper appreciation of Pancasila values within digital environments:

"I started to think about how Pancasila applies when I use social media."

These narratives reinforce the quantitative findings, indicating that students experienced the intervention as both personally meaningful and socially relevant. Detailed survey results are presented in Table 5.

Table 5: Student perceptions of the Reflection and Innovation-based Technology-Supported Project-Based Learning intervention

Statement	Agree + Strongly Agree (n)	Positive Response (%)	Category
Engaging and enjoyable	182	94.8	Excellent
User-friendly and accessible	176	91.7	Excellent
Pancasila content easier to understand	170	88.5	Excellent
Encourages creative thinking	174	90.6	Excellent
Promotes collaboration	178	92.7	Excellent
Enhances civic value awareness	172	89.6	Excellent
Increases motivation	169	88.0	Excellent
Should be widely adopted	179	93.2	Excellent
Mean Positive Response	—	91.1	Excellent

5. Discussion

The present findings provided compelling evidence that the Reflection and Innovation approach supported meaningful improvements in students' Pancasila Learner Profile, a conclusion based not on a single statistical indicator but on the convergence of several independent sources of evidence. Large effect sizes were observed for the overall score (Cohen's $d = 1.86$) and for each of the six profile dimensions ($d = 1.37$ – 1.53), while the experimental group also demonstrated substantially greater learning gains than the control group (overall N-Gain = .65 versus .27).

Importantly, these quantitative improvements were accompanied by highly positive learner perceptions (91.1%), suggesting that students not only achieved better outcomes but also experienced the instructional process as engaging and meaningful. This convergence of evidence makes a statistical-artefact explanation unlikely; nonetheless, because students were not individually randomised, the findings are best interpreted as a strong association between participation and higher post-intervention scores, rather than definitive proof of a sole causal effect.

This improvement can be explained by the intervention's combination of collaborative inquiry, structured reflection and authentic project work. Students were required to analyse real social issues, consider different viewpoints and justify their decisions rather than simply memorise Pancasila values. The findings align with Vygotsky's (1978) sociocultural theory, which views higher-order learning as developing through guided social interaction, and Wertsch's (1991) concept of mediated action, which emphasises learning through interactions with people and cultural tools. This helps explain why Mutual Cooperation and Critical Reasoning showed particularly strong improvement, as both depend fundamentally on dialogue and collaborative knowledge construction.

The technological component should be interpreted carefully: findings do not suggest digital applications alone improve character education, but that technology enabled pedagogical processes to work more effectively. The mobile platform supported continuous communication, structured reflection, formative feedback, and documentation of project development, while the web dashboard enabled teachers to monitor progress throughout. This aligns with UNESCO (2023), which emphasises that educational technology is most effective when supported by appropriate pedagogical design. It also reflects Mayer's (2024) multimedia learning principles, which suggest that combining visual and textual materials with interactive resources can strengthen understanding of concepts such as Faith, Piety and Noble Character and Global Diversity. Technology thus functioned as a pedagogical mediator rather than the principal source of improvement.

The highest normalised gain was observed for Creativity ($g = .72$). During the product development stage, students designed multimedia civic projects addressing social issues they identified within their own communities, requiring them to generate original ideas, evaluate alternatives, revise their work, and communicate solutions through digital media. Such experiences positioned creativity as a consequence of authentic problem-solving rather than an isolated classroom activity, consistent with Pupik Dean et al. (2023), who argue that project-based learning deepens character development through meaningful real-world engagement, and with Zha et al. (2024), who found learner autonomy and authentic product creation central to creativity in project-based environments (retained as a preprint for its direct relevance to LLM-enhanced project-based learning and creativity, pending formal peer review).

The qualitative findings strengthened this interpretation by explaining how these quantitative improvements emerged during classroom implementation. Students repeatedly described collaborative discussions as opportunities to reconsider their assumptions after hearing classmates' perspectives, while structured reflection encouraged them to connect classroom learning with experiences in their families, communities, and digital environments. These accounts explained how character development occurred, rather than simply confirming improvement. This reflects a sequential explanatory mixed-methods design, in which qualitative findings help explain patterns identified through statistical analysis (Creswell & Plano Clark, 2018).

Beyond demonstrating effectiveness, the study contributes to the literature on character education, where prior work commonly examined creativity, collaboration, civic engagement, or critical thinking as separate outcomes. The findings suggest instead that an instructional architecture integrating authentic projects, structured reflection, collaborative learning, and technology-supported facilitation can promote simultaneous development across all six Pancasila Learner Profile dimensions. The findings thus extend those of Kesuma et al. (2025) and Warlim et al. (2026) by showing that technology-supported Pancasila Education can function as a coherent framework for multidimensional character development. This integrated contribution represents the principal novelty of the present study. In practice, teachers could combine project-based tasks with structured reflection prompts rather than treating reflection as optional, as this combination appeared to support character development more than project work alone. School leaders could also use the web dashboard as a low-cost tool to monitor implementation.

5.1 Limitations and Future Directions

This investigation should be considered within several methodological boundaries. The quasi-experimental design balanced experimental control with authentic classroom implementation, but cannot fully separate the intervention's effects from influences such as the Hawthorne effect or students' initial enthusiasm. Because the intervention was implemented in metropolitan Medan City, where digital infrastructure was generally adequate, whether similar outcomes could be achieved in rural or peri-urban schools remains uncertain. The eight-week duration also means the reported improvements primarily reflect short-term change, and the evaluation relied predominantly on students' self-reported responses, while implementation fidelity was inferred from structured observations rather than direct monitoring of every activity.

These boundaries point to future priorities: longitudinal designs, cross-cultural replication, structural equation modelling of mediators such as teacher digital competence, and design-based research on AI-supported personalisation and adaptive feedback. Although these boundaries should be recognised, the convergence of large effect sizes, favourable N-Gain scores, positive perceptions, and qualitative evidence supports the educational value of the Reflection and Innovation approach. Additional validation across countries with comparable character education initiatives, particularly within Southeast Asia, would clarify whether the model reflects a context-specific innovation or has broader international relevance.

6. Conclusion

The present investigation demonstrated that integrating the Reflection and Innovation approach into Technology-Supported Project-Based Learning offered a practical pathway for strengthening the Pancasila Learner Profile. Compared with conventional instruction, the intervention produced better outcomes across all six profile dimensions after eight weeks. This improvement was supported by normalised gain scores, independent-samples *t*-tests, large effect sizes, positive

student perceptions and interview findings, indicating a consistent pattern across the different forms of evidence.

An important contribution of this study lies in showing that technology alone was not the primary driver of character development. Meaningful improvement resulted from combining authentic projects, structured reflection, collaborative inquiry and continuous digital support within one instructional framework. This approach supported the simultaneous development of cognitive, social, ethical and creative competencies. The findings also extend Technology-Supported Project-Based Learning to Indonesia's Merdeka Curriculum by showing how the Reflection and Innovation approach can translate the Pancasila Learner Profile into observable and measurable classroom outcomes. This represents the study's main contribution to technology-supported character education. Although the evidence is encouraging, further investigation remains necessary. Longitudinal evaluation, implementation in schools with different technological capacities, and cross-cultural replication would clarify the sustainability and broader applicability of the model across diverse learning environments and educational systems.

Conflict of Interest

The authors confirm that no commercial, financial, or personal interests influenced this research; no conflicts of interest are declared.

7. Data Availability Statement

The complete research instruments (Pancasila Learner Profile Questionnaire, classroom observation checklist, and interview guide), together with the individual-level dataset for all 384 participants and pilot-sample psychometric data, are provided in the Supplementary Material as part of the research documentation.

8. Acknowledgements

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9. References

- Anselmo, C. T., Prudente, M. S., Aquino, J. L. R., Dumelod, D. A., & Cabrera, F. R. (2025). A systematic review of the effectiveness of mobile learning tools in enhancing physics education. *International Journal of Learning, Teaching and Educational Research*, 24(1). <https://ijlter.org/index.php/ijlter/article/view/11850>
- Bitto Urbanova, L., Madarasova Geckova, A., Dankulincova Veselska, Z., Capikova, S., Holubcikova, J., van Dijk, J. P., & Reijneveld, S. A. (2023). "I could do almost nothing without digital technology": A qualitative exploration of adolescents' perception of the risks and challenges of digital technology. *Frontiers in Psychology*, 14, Article 1237452. <https://doi.org/10.3389/fpsyg.2023.1237452>
- BPS-Statistics Indonesia Medan Municipality. (2024). *Number of schools, teachers, and pupils in senior high schools under the Ministry of Education, Culture, Research, and Technology by district in Medan Municipality, 2023/2024*. BPS-Statistics Indonesia. <https://medankota.bps.go.id>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Braun, V., & Clarke, V. (2020). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, 18(3), 328–352. <https://doi.org/10.1080/14780887.2020.1769238>
- Brown, M., McGrath, R. E., Bier, M. C., Johnson, K., & Berkowitz, M. W. (2023). A comprehensive meta-analysis of character education programs. *Journal of Moral Education*, 52(2), 119–138. <https://doi.org/10.1080/03057240.2022.2060196>
- Chounta, I. A., Hoppe, H. U., Nolte, A., & Spikol, D. (2023). Editorial: Re-inventing project-based learning: Hackathons, datathons, devcamps as learning expeditions. *Frontiers in Education*, 8, Article 1182264. <https://doi.org/10.3389/feduc.2023.1182264>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates. <https://doi.org/10.4324/9780203771587>
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.
- George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference, 11.0 update* (4th ed.). Allyn & Bacon.
- Gopalan, M., Rosinger, K. O., & Ahn, J. B. (2020). Use of quasi-experimental research designs in education research: Growth, promise, and challenges. *Review of Research in Education*, 44(1), 218–243. <https://doi.org/10.3102/0091732X20903302>
- Hake, R. R. (1998). Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, 66, 64–74. <https://doi.org/10.1119/1.18809>
- Huang, L., Wang, R., & Han, J. (2024). Regulation of emotions in project-based collaborative learning: An empirical study in academic English classrooms. *Frontiers in Psychology*, 15, Article 1368196. <https://doi.org/10.3389/fpsyg.2024.1368196>
- Jović, J., Čorac, A., Stanimirović, A., Nikolić, M., Stojanović, M., Bukumirić, Z., & Ignjatović Ristić, D. (2024). Using machine learning algorithms and techniques for defining the impact of affective temperament types, content search and activities on the internet on the development of problematic internet use in adolescents' population. *Frontiers in Public Health*, 12, Article 1326178. <https://doi.org/10.3389/fpubh.2024.1326178>
- Kar, S. S., Dube, R., Goud, B. K. M., Gibrata, Q. S., El-Balbissi, A. A., Al Salim, T. A., & Fatayerji, R. N. M. A. K. (2025). *Impact of screen time on development of children*. *Children*, 12(10), 1297. <https://doi.org/10.3390/children12101297>
- Kesuma, S., Susilawati, E., Tanjung, J. P., Fadhillah, C. R., Admiral, R. D., Mardiansyah, M., Lubis, H. T., Nasution, I. R., Purnomo, T. A., & Harahap, E. S. (2025).

- Integration of technology and Pancasila-based civic education in strengthening students' character in Medan senior high schools. *Edelweiss Applied Science and Technology*, 9(11), 1027–1039. <https://doi.org/10.55214/2576-8484.v9i11.11050>
- Kiger, M. E., & Varpio, L. (2020). Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical Teacher*, 42(8), 846–854. <https://doi.org/10.1080/0142159X.2020.1755030>
- Kizys, D., Lotter, C., Perez, L., Gilreath, R., & Limberg, D. (2025). Integrating community assets, place-based learning, and career development through project-based learning in rural settings. *Frontiers in Education*, 10, Article 1577093. <https://doi.org/10.3389/feduc.2025.1577093>
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174. <https://doi.org/10.2307/2529310>
- Lee, A., & Jung, E. (2025). University students' subjective experiences with problem-based learning and associated generic skills. *Frontiers in Psychology*, 16, Article 1618997. <https://doi.org/10.3389/fpsyg.2025.1618997>
- Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing Research*, 35(6), 382–386. <https://doi.org/10.1097/00006199-198611000-00017>
- Mayer, R. E. (2024). The past, present, and future of the cognitive theory of multimedia learning. *Educational Psychology Review*, 36, Article 8. <https://doi.org/10.1007/s10648-023-09842-1>
- Mehrfar, A., Zolfaghari, Z., Bordbar, A., & Mohabbat, Z. (2024). Influencing factors on the success of mobile learning: A systematic review and meta-analysis. *Investigación y Educación en Enfermería*, 42(3), Article e09. <https://doi.org/10.17533/udea.iee.v42n3e09>
- Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia. (2022). *Keputusan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 56/M/2022 tentang Pedoman Penerapan Kurikulum dalam Rangka Pemulihan Pembelajaran* [Decree of the Minister of Education, Culture, Research, and Technology Number 56/M/2022 on guidelines for curriculum implementation in the context of learning recovery]. <https://bpmkaltara.kemendikdasmen.go.id/2022/02/20/keputusan-mendikbudristek-nomor-56-m-2022-tentang-pedoman-penerapan-kurikulum-dalam-rangka-pemulihan-pembelajaran>
- Mufit, F., Hendriyani, Y., Usmeldi, Dhanil, M., & Tanjung, M. R. (2023). The effectiveness of smartphone-based interactive multimedia integrated cognitive conflict models to improve 21st-century skills. *International Journal of Information and Education Technology*, 13(11), 1793–1801. <https://doi.org/10.18178/ijiet.2023.13.11.1991>
- Mutanga, M. B. (2024). Students' perspectives and experiences in project-based learning: A qualitative study. *Trends in Higher Education*, 3(4), 903–911. <https://doi.org/10.3390/higheredu3040052>
- Pupik Dean, C. G., Grossman, P., Enumah, L., Herrmann, Z., & Schneider Kavanagh, S. (2023). Core practices for project-based learning: Learning from experienced practitioners in the United States. *Teaching and Teacher Education*, 133, Article 104275. <https://doi.org/10.1016/j.tate.2023.104275>
- Solehuddin, M., Budimansyah, D., & Dahliyana, A. (2024). Tracing Pancasila: Unveiling the impact of the Pancasila student profile strengthening project on student well-being in Indonesia. *Cakrawala Pendidikan: Jurnal Ilmiah Pendidikan*, 43(3), 773–787. <https://doi.org/10.21831/cp.v43i3.78328>
- Susilawati, E., Kesuma, S., Leman, D., Yusrita, Y., Fauzan, A., Habil, H., Viona, D., & Hummairah, C. A. (2025). The economic potential of using the AI-based ASES-EdTech platform to improve the professionalism of elementary school teachers in rural areas of Indonesia. *Edelweiss Applied Science and Technology*, 9(11), 827–838. <https://doi.org/10.55214/2576-8484.v9i11.11009>

- Trisiana, A., Priyanto, A., & Sutoyo, S. (2024). Analysis of developing anti-corruption education in Indonesia through media-based citizenship education learning smart mobile civic. *Cakrawala Pendidikan: Jurnal Ilmiah Pendidikan*, 43(1), 166–175. <https://doi.org/10.21831/cp.v43i1.60261>
- UNESCO. (2023). *Global education monitoring report 2023: Technology in education – A tool on whose terms?* UNESCO Publishing. <https://doi.org/10.54676/UZQV8501>
- Vladova, G., Ullrich, A., Sloane, M., Renz, A., & Tsui, E. (2023). Editorial: New teaching and learning worlds – Potentials and limitations of digitalization for innovative and sustainable research and practice in education and training. *Frontiers in Education*, 8, Article 1175498. <https://doi.org/10.3389/educ.2023.1175498>
- Von der Embse, N., Kilgus, S., Oddleifson, C., Way, J. D., & Welliver, M. (2023). Reconceptualizing social and emotional competence assessment in school settings. *Journal of Intelligence*, 11(12), Article 217. <https://doi.org/10.3390/jintelligence11120217>
- Voogt, J. M., & Pareja Roblin, N. N. (2023). Curriculum and 21st century skills. In *International encyclopedia of education* (4th ed., pp. 49–55). Elsevier. <https://doi.org/10.1016/B978-0-12-818630-5.03007-4>
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Warlim, W., Effendi, R., Fitria, R., Ibrahim, M. M., & Hadiati, D. N. (2026). Cross-faculty analysis of AI-enhanced civic character education on digital citizenship development. *Frontiers in Education*, 10, Article 1690799. <https://doi.org/10.3389/educ.2025.1690799>
- Wertsch, J. V. (1991). *Voices of the mind: A sociocultural approach to mediated action*. Harvard University Press.
- Widowati, A., & Tyas, R. A. (2024). Mobile-based learning in science trends: A systematic review (2015–2023). *Cogent Education*, 11(1), Article 2303563. <https://doi.org/10.1080/2331186X.2024.2303563>
- Yamane, T. (1967). *Statistics: An introductory analysis* (2nd ed.). Harper & Row.
- Zaenab, S., Chamisijatin, L., Wahyudi, M. D. R., & Pratama, D. C. (2024). Characteristics of project-based learning models on the project to strengthening the Pancasila student profiles at Muhammadiyah school. *Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika*, 8(2), 260–279. <https://doi.org/10.36312/esaintika.v8i2.1820>
- Zha, S., Qiao, Y., Hu, Q., Li, Z., Gong, J., & Xu, Y. (2024). *Designing child-centric AI learning environments: Insights from LLM-enhanced creative project-based learning*. arXiv. <https://doi.org/10.48550/arXiv.2403.16159>

Appendix A : Pancasila Learner Profile Questionnaire (60 Items)

The Pancasila Learner Profile Questionnaire comprised 60 items rated on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), with 10 items per dimension across six dimensions. Illustrative items for each dimension are presented below; the complete 60-item instrument, together with item-level corrected item-total correlations and CVI values, is provided in the Supplementary Material (Supplementary Table S1).

Pancasila Learner Profile Dimension	Example Items (of 10 per dimension)
Faith, Piety, and Noble Character (Items 1–10)	Item 2: Acts with moral integrity in all situations. Item 8: Upholds honesty in academic and social contexts.
Global Diversity (Items 11–20)	Item 11: Appreciates cultural differences among classmates. Item 20: Recognises the richness of Indonesia's cultural diversity.
Mutual Cooperation (Items 21–30)	Item 22: Shares responsibilities fairly within a team. Item 29: Resolves conflicts constructively within the group.
Self-Regulation (Items 31–40)	Item 31: Sets clear goals for personal learning. Item 37: Shows accountability for personal actions and outcomes.
Critical Reasoning (Items 41–50)	Item 42: Evaluates the credibility of sources. Item 48: Constructs well-reasoned arguments.
Creativity (Items 51–60)	Item 51: Generates original ideas to solve civic problems. Item 57: Produces innovative digital civic projects.

Appendix B: Classroom Observation Checklist (30 Items)

The structured classroom observation checklist comprised 30 items (five per project-based learning phase), each rated on a four-point scale (1 = Not observed to 4 = Fully observed). Inter-rater reliability was Cohen's $\kappa = .82$ (82.4% agreement), indicating almost perfect agreement (Landis & Koch, 1977). One illustrative item per phase is presented below; the complete 30-item checklist is provided in the Supplementary Material (Supplementary Table S2).

PjBL Phase	Example Observation Item (Scale: 1–4)
Driving Question (Items 1–5)	The teacher introduces a real civic or social problem drawn from the Reflection and Innovation application's social-problem database to open the session.
Project Planning (Items 6–10)	Groups use the Reflection and Innovation application to set project goals and divide tasks among members.
Product Creation (Items 11–15)	Students use the Reflection and Innovation application's multimedia tools to develop their project product.
Progress Monitoring (Items 16–20)	Students submit progress updates through the Reflection and Innovation automated formative assessment module.
Reflection (Items 21–25)	Students complete structured ethical reflection prompts within the Reflection and Innovation application.
Evaluation (Items 26–30)	The teacher conducts a summative assessment of each group's final product using the Reflection and Innovation rubric.

Appendix C: Semi-Structured Interview Guide (12 Questions)

The semi-structured interview guide comprised 12 open-ended questions organised into three thematic blocks (four questions each), administered to a purposive sample of experimental-group students following the intervention. One illustrative question per thematic block is presented below; the complete 12-question guide is provided in the Supplementary Material (Supplementary Table S3).

Thematic Block	Example Interview Question
Authentic Project Experience and Motivation (Q1–4)	Can you describe the social problem your group chose to work on, and why your group chose it?
Collaboration, Self-Regulation, and Use of the Reflection and Innovation Application (Q5–8)	How did your group divide tasks and responsibilities while planning and carrying out the project?
Pancasila Values and Digital Social Life (Q9–12)	In what ways, if any, did this project change how you think about Pancasila values such as cooperation, tolerance, or honesty?

Appendix D: Per-Dimension Normality, Homogeneity, and Baseline-Equivalence Tests

Table D1 reports per-dimension tests summarised in Section 4.1

PLP Dimension	SW p (Exp. Post)	Levene's p	Baseline t(382)	Baseline p
Faith, Piety, and Noble Character	.001	.049	0.31	.757
Global Diversity	.000	.189	-0.25	.799
Mutual Cooperation	.000	.906	0.26	.797
Self-Regulation	.000	.012	-0.40	.687
Critical Reasoning	.000	.157	0.19	.853
Creativity	.000	.548	-0.34	.736
Composite Total	.028	.018	-0.04	.971

Table D2 reports the cluster-robust ANCOVA re-analysis referenced in Section 4.3 (pre-test as covariate; standard errors clustered on the 16 intact classes)

PLP Dimension	Adj. Mean Diff (SE)	95% CI (cluster-robust)	p	Adj. Cohen's d
Faith, Piety, and Noble Character	19.28 (1.20)	[16.91, 21.64]	<.001	1.45
Global Diversity	17.83 (1.39)	[15.10, 20.56]	<.001	1.37
Mutual Cooperation	19.14 (1.27)	[16.65, 21.63]	<.001	1.45
Self-Regulation	19.11 (1.28)	[16.60, 21.63]	<.001	1.43
Critical Reasoning	20.36 (1.59)	[17.24, 23.47]	<.001	1.45
Creativity	19.64 (1.38)	[16.94, 22.33]	<.001	1.53
Composite Total	19.22 (1.00)	[17.25, 21.19]	<.001	1.85

Note. ICC attributable to class/school clustering was negligible ($\approx .00-.01$).