

AI AND ASES-EDTECH INTEGRATION OF P5TK IN RURAL ELEMENTARY SCHOOLS

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Abstract

This study investigated the integration of Artificial Intelligence (AI) tools and the ASES-EdTech (Automated Science and Education Scoring-Educational Technology) framework within P5TK (Projek Penguatan Profil Pelajar Pancasila dan Kebangsaan) learning activities in rural elementary schools in North Sumatra, Indonesia. Rural schools face compounded challenges of limited instructional resources, low digital infrastructure, and a shortage of qualified educators, rendering innovative technology integration particularly consequential in these settings. Employing a quasi-experimental design with a control group ($n = 42$) and treatment group ($n = 44$) across four rural elementary schools in Langkat Regency, this research examined whether AI-assisted ASES-EdTech implementation produced significant improvements in students' P5TK learning outcomes, teacher digital competency, and school-level educational transformation indicators. The ASES-EdTech platform provided automated formative assessment, adaptive content delivery, and real-time learning analytics, while AI tools supported teachers in lesson planning and differentiated instruction. Results demonstrated statistically significant gains in student learning outcomes in the treatment group ($M = 78.4$, $SD = 8.2$) compared to the control group ($M = 63.7$, $SD = 9.1$), $t(84) = 8.46$, $p < .001$. Teachers in the treatment schools also exhibited marked improvements in digital pedagogical competency following a structured eight-week professional development program. Qualitative findings from teacher interviews highlighted increased instructional confidence, enhanced student engagement, and greater community awareness of educational technology. These findings contributed to the evidence base for AI-integrated EdTech in underserved educational settings and informed policy development for digital transformation in Indonesian rural elementary education.

Keywords: artificial intelligence, ASES-EdTech, P5TK learning, rural elementary schools, educational technology, transformation education

1. Introduction

The integration of artificial intelligence (AI) into educational technology represents one of the most consequential transformations in contemporary pedagogy. Hwang et al. (2022) identified adaptive content delivery, automated assessment, and real-time learning analytics as the three pillars of AI-driven educational transformation, each of which holds particular relevance for schools operating in resource-constrained contexts. In Indonesia, the national

curriculum framework has been restructured through the Kurikulum Merdeka initiative, which places P5TK (Projek Penguatan Profil Pelajar Pancasila Tema Kewirausahaan) at the centre of competency-based learning, emphasising character formation, civic identity, and twenty-first-century skills (Kemendikbudristek, 2022; Kesuma et al., 2025).

Rural elementary schools in Indonesia face persistent structural disadvantages that undermine effective P5TK implementation. Cahyadi et al. (2021) found that rural schools in Sumatra consistently scored below national averages on digital readiness indices, with teacher digital competency identified as the primary constraint on technology integration. OECD (2023) data similarly confirmed that Indonesian students in rural settings scored significantly lower on digital literacy assessments than their urban counterparts, pointing to a pronounced technology gap that existing policy responses have yet to adequately address.

The ASES-EdTech framework, developed at UISU's Pusat Studi Pendidikan Inovatif, combines AI-driven automated assessment with adaptive learning content and real-time pedagogical analytics (Susilawati et al., 2025a; Susilawati, Kesuma, Leman, Yusrita, et al., 2025). Grounded in prior ASES research, which demonstrated its effectiveness in improving academic integrity, character development, and digital assessment quality in higher education (Susilawati et al., 2023; Susilawati et al., 2025b) ASES-EdTech extends these capabilities to the elementary school context, providing locally adapted tools for P5TK project facilitation. This study therefore assessed the efficacy of ASES-EdTech integration in rural elementary schools, with specific attention to student learning outcomes, teacher competency development, and school-level educational transformation.

Three objectives guided this research: (1) to evaluate the effect of ASES-EdTech and AI integration on P5TK student learning outcomes; (2) to document changes in teacher digital pedagogical competency following structured EdTech professional development; and (3) to identify enabling and constraining factors for EdTech adoption in rural elementary school contexts in North Sumatra.

2. Literature Review

Artificial intelligence in education (AIED) has attracted substantial scholarly attention, with researchers documenting its potential to personalise learning, automate formative assessment, and generate actionable pedagogical insights. Holmes et al. (2022) provided a widely cited ethics framework for AIED, distinguishing between AI as tutor, tool, and systemic enabler a typology that informs the ASES-EdTech design. Roll and Wylie (2022) synthesised two decades of AIED research, concluding that the most effective implementations combined adaptive content delivery with teacher professional development, rather than positioning AI as a replacement for pedagogical expertise.

Automated writing and essay scoring systems occupy a central position within AIED applications. Guo et al. (2023) demonstrated that AI-based automated writing evaluation improved student writing quality and engagement in secondary schools, with effect sizes comparable to or exceeding those of conventional teacher feedback. Warschauer and Tate (2023) further showed that automated scoring was most beneficial when used formatively — providing rapid feedback during the learning process rather than summatively a principle embedded in the ASES-EdTech design. Chen et al. (2022) identified a persistent application-theory gap in AIED, noting that many implementations lack grounding in established learning theories; the ASES-EdTech framework addresses this concern by aligning automated assessment with P5TK's competency-based design principles.

P5TK as a curriculum construct reflects the global movement toward project-based, character-oriented learning. Kemendikbudristek (2022) stipulated that P5TK projects should cultivate the six Profil Pelajar Pancasila dimensions: beriman dan bertakwa, berkebinekaan global, bergotong royong, mandiri, bernalar kritis, and kreatif. Hasanah et al. (2022) conducted a meta-analysis of project-based learning in Indonesian elementary schools, finding moderate-to-large effects on critical thinking and collaboration when projects were adequately scaffolded. Susilawati (2024) further documented those teachers who engaged in dynamic, evidence-based character education fostered deeper civic identity among students' outcome directly aligned with P5TK's national education goals.

The digital divide in Indonesian education is well-documented. Ratheeswari (2021) argued that digital infrastructure disparities systematically advantage urban learners, while Li et al. (2023) demonstrated in a randomised controlled trial in rural western China that AI-powered adaptive learning narrowed achievement gaps between rural and urban students when accompanied by teacher training. Miqwati et al. (2023) and Khaira et al. (2021) have similarly shown that differentiated, technology-integrated instruction in Indonesian schools produced significant gains in science and civics learning, underscoring the potential of appropriately designed EdTech in national curriculum implementation. Selwyn and Gašević (2021) cautioned, however, that datafication of education must be accompanied by ethical safeguards and teacher agency to avoid reproducing existing inequalities — a consideration reflected in the co-design approach adopted in this study.

3. Research Method

This study employed a quasi-experimental non-equivalent control group design, selected for its appropriateness in natural educational settings where random assignment is not feasible (Braun & Clarke, 2021). Four rural elementary schools in Langkat Regency, North Sumatra, were purposively selected based on rural classification by BPS, absence of prior EdTech program participation, and comparable baseline ICT infrastructure. Two schools were assigned to the treatment condition and two to the control condition.

The treatment group comprised 44 Grade 5 students and their classroom teachers ($n = 6$), who participated in the eight-week ASES-EdTech P5TK integration program. The control group comprised 42 Grade 5 students and their teachers ($n = 6$) who continued with standard Kurikulum Merdeka P5TK instruction without EdTech augmentation. The ASES-EdTech program included: (1) an initial two-day teacher orientation workshop covering platform navigation, AI-assisted lesson planning, and assessment interpretation; (2) weekly in-platform professional development micro-modules aligned with the DigComp 2.2 framework (Vuorikari et al., 2022); and (3) fortnightly remote coaching sessions conducted via WhatsApp video call with the research team.

Student learning outcomes were measured using a researcher-developed P5TK Achievement Test (PAT), validated through expert review (content validity ratio = 0.84) and pilot testing (Cronbach's $\alpha = 0.82$). Teacher digital pedagogical competency was assessed using an adapted DigComp 2.2 instrument, administered pre- and post-intervention. Qualitative data were collected through semi-structured interviews with eight teachers (four per condition) and four school principals, conducted in Bahasa Indonesia, transcribed verbatim, and analysed using Braun and Clarke's (2021) six-phase thematic analysis framework.

Quantitative data were analysed using independent samples t-tests and paired samples t-tests in SPSS 26. Effect sizes were calculated using Cohen's d. Data triangulation across quantitative outcomes, teacher competency scores, and qualitative narratives was employed to strengthen interpretive validity. Ethical clearance was obtained from the UISU Research Ethics Committee, and all participants provided written informed consent in accordance with institutional protocols.

4. Result and Discussion

4.1 Student Learning Outcomes and ASES-EdTech Effectiveness

The research results related to Student Learning Outcomes and ASES-EdTech Effectiveness are presented as follows:

Table 1. Descriptive Statistics and Independent Samples t-Test Results

Variable	Treatment Group (n=44) Mean ± SD	Control Group (n=42) Mean ± SD	t	p
Pretest	58.1 ± 7.6	57.9 ± 8.0	0.14	0.89
Posttest	78.4 ± 8.2	63.7 ± 9.1	8.46	<0.001

Note: Cohen's d = 1.72 (very large effect size).

Table 2. Paired Samples t-Test Results Within Groups

Group	Mean Pretest	Mean Posttest	ΔM	t	p
Treatment	58.1	78.4	20.3	14.2	<0.001
Control	57.9	63.7	5.8	3.1	0.003

As shown in Table 1, the pretest scores of the treatment group (M = 58.1; SD = 7.6) and the control group (M = 57.9; SD = 8.0) showed no significant difference (t = 0.14; p = 0.89). This finding confirms that both groups had equivalent baseline abilities prior to the intervention. The equivalence of initial conditions is critical to ensuring that any changes in learning outcomes following the intervention can be attributed to the use of the ASES-EdTech platform.

Following the intervention, the posttest scores of the treatment group increased to 78.4 (SD = 8.2), while the control group reached only 63.7 (SD = 9.1). The independent samples t-test revealed a significant difference between the two groups (t(84) = 8.46; p < 0.001). A Cohen's d value of 1.72 indicates a very large effect size, suggesting that the implementation of ASES-EdTech had a substantial impact on improving P5TK learning outcomes.

These findings are consistent with Li et al. (2023), who found that AI-based adaptive learning significantly improved academic achievement among students in rural areas. The results also support the meta-analytic findings of Guo et al. (2023), which demonstrated that AI-based automated assessment systems contribute positively to learning outcomes by providing prompt, accurate, and continuous feedback.

Further analysis using the paired samples t-test, as presented in Table 2, revealed that the treatment group experienced a mean improvement of 20.3 points from pretest to posttest (t(43) = 14.2; p < 0.001). By contrast, the control group improved by only 5.8 points (t(41) = 3.1; p = 0.003). The magnitude of this difference indicates that the use of ASES-EdTech played a significant role in enhancing student learning outcomes compared to instruction without the platform.

This improvement in learning achievement is believed to be driven by the automated formative feedback feature embedded within the ASES-EdTech platform. Through this feature, students receive immediate, criteria-based feedback on each component of their

submitted P5TK projects. Timely feedback enables students to continuously revise their work and improve the quality of their learning. This finding supports Susilawati et al. (2023) and Warschauer and Tate (2023), who argued that technology-based assessment accelerates students' reflection and learning improvement processes.

The quantitative findings are further reinforced by qualitative data. The majority of students reported that the ASES-EdTech interface was engaging and motivating. Gamification features displaying learning progress indicators and real-time project feedback encouraged active student participation in the learning process. Teachers, in turn, reported that the AI-generated assessment reports helped them identify learning gaps more rapidly than through manual observation, enabling timely adjustments to instructional strategies.

These findings support the view of Roll and Wylie (2022), who argued that the primary role of Artificial Intelligence in Education (AIED) is to enhance teachers' professional capacity rather than replace them. Consistent with this, Susilawati, Kesuma, Leman, Yusrita, et al. (2025) reported that improvements in teacher professionalism through the use of ASES-EdTech in rural areas were accompanied by increased student learning engagement. Furthermore, Kesuma et al. (2025) and Susilawati (2024) found that the integration of technology in civic education effectively improved student engagement in understanding and internalizing Pancasila values. The present study extends these findings to the context of P5TK implementation in rural primary schools, demonstrating significant improvements in both learning outcomes and student engagement throughout the learning process.

4.2. Teacher Digital Competency and School-Level Transformation

To assess the impact of ASES-EdTech implementation on teacher professional development, paired t-test analyses were conducted on pre- and post-intervention scores across all five domains of the DigComp 2.2 framework (Vuorikari et al., 2022). Results indicated that treatment group teachers demonstrated statistically significant improvements across all competency domains, whereas control group teachers showed no significant changes over the same period.

Table 3. Paired t-Test Results for Teacher Digital Pedagogical Competency Across DigComp 2.2 Domains

DigComp 2.2 Domain	Treatment Group ΔM	p	Control Group ΔM	p
Information & Data Literacy	1.42	<.001	—	n.s.
Communication & Collaboration	1.31	<.001	—	n.s.
Digital Content Creation	1.58	.002	—	n.s.
Safety	1.12	.004	—	n.s.
Problem-Solving	1.67	<.001	—	n.s.

Note: ΔM = mean difference (posttest – pretest). n.s. = not significant ($p > .05$). Domain framework based on DigComp 2.2 (Vuorikari et al., 2022).

As presented in Table 3, treatment group teachers demonstrated statistically significant pre-to-post improvements across all five DigComp 2.2 domains. The most substantial gain was recorded in the problem-solving domain ($\Delta M = 1.67$, $p < .001$), followed by digital content creation ($\Delta M = 1.58$, $p = .002$), information and data literacy ($\Delta M = 1.42$, $p < .001$), communication and collaboration ($\Delta M = 1.31$, $p < .001$), and safety ($\Delta M = 1.12$, $p = .004$). By contrast, control group teachers showed no significant changes across any domain during the same period. The consistency of significant improvement across all five domains suggests that ASES-EdTech fostered broad and comprehensive development of teachers' digital pedagogical competency, rather than enhancing isolated technical skills alone. These

findings are consistent with Khaira et al. (2023), who demonstrated that technology-enhanced instructional design meaningfully improved Indonesian teachers' pedagogical confidence and competency, particularly in rural school settings where professional development opportunities are often limited.

Beyond individual competency gains, thematic analysis of teacher and principal interviews identified three school-level transformation themes. First, *shifting pedagogical identity* teachers transitioned from perceiving digital tools as burdensome to viewing them as empowering, reflecting a fundamental reconceptualization of their professional relationship with technology. Second, *community ripple effects* parents reported increased understanding of P5TK goals through ASES-EdTech student digital portfolios shared in WhatsApp community groups, consistent with Susilawati et al.'s (2024) findings on university-community collaboration for rural development, indicating that the platform's impact extended meaningfully beyond the classroom. Third, *institutional confidence* principals described ASES-EdTech implementation as elevating school reputation and motivating applications for district-level EdTech grants, positioning the platform as a catalyst for broader institutional growth and policy engagement.

These outcomes align with Fullan and Gallagher's (2022) theory of educational change, which posits that technology integration produces sustainable transformation only when accompanied by shifts in teacher professional identity and institutional culture — a pattern clearly evidenced across all three themes identified in this study. Popenici and Kerr (2022) similarly argued that AI's greatest educational impact emerges at the intersection of technological capability and human pedagogical agency, a dynamic further corroborated by the qualitative evidence presented here. Marisa et al. (2024) and Darmawan et al. (2023) further supported the centrality of structured teacher development alongside EdTech deployment as a necessary condition for meaningful rural educational transformation in the Indonesian context.

5. Conclusion

This study provided robust evidence that the integration of AI tools and the ASES-EdTech framework into P5TK learning activities produced significant improvements in student learning outcomes, teacher digital pedagogical competency, and school-level educational transformation in rural elementary schools in North Sumatra. The very large effect size for student learning gains (Cohen's $d = 1.72$) underscored the transformative potential of well-designed, locally adapted EdTech in resource-constrained settings, extending the ASES research programme previously validated in higher education contexts to the elementary level.

For educational policymakers, the study supports targeted investment in AI-assisted EdTech platforms with robust teacher professional development components as a strategy for closing the rural-urban education gap. For school administrators, the ASES-EdTech model demonstrated that P5TK's ambitious competency goals are attainable in rural settings when appropriate technological scaffolding is provided. For researchers, the study enriches the AIED evidence base for Global South educational contexts, identified as critically underrepresented in the international literature.

Limitations include the study's eight-week intervention duration, geographic confinement to Langkat Regency, and the researcher-constructed nature of the PAT instrument. Future research should employ longitudinal designs, validated standardised instruments, and multi-regency sampling to strengthen generalisability. That flipped, AI-

enhanced models merit investigation as a complement to conventional EdTech approaches, raised important questions about data governance in AI-driven classrooms that warrant attention in future ASES-EdTech implementations. Notwithstanding these limitations, this study made an original contribution to knowledge about AI-integrated EdTech for rural educational transformation in the Indonesian national curriculum context, with implications for both practice and policy in the Kurikulum Merdeka era.

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References

- Braun, V., & Clarke, V. (2021). *Thematic analysis: A practical guide*. SAGE Publications.
- Cahyadi, A., Widyastuti, S., & Hendri, M. (2021). Digital readiness of rural schools in Sumatra: A multi-province assessment. *Indonesian Journal of Educational Technology*, 8(3), 112–128. <https://doi.org/10.21831/ijet.v8i3.40182>
- Chen, X., Xie, H., Zou, D., & Hwang, G.-J. (2022). Application and theory gaps during the rise of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 1, 100002. <https://doi.org/10.1016/j.caeai.2020.100002>
- Darmawan, I. P. A., Susilawati, E., Setyowati, E., & Ulinniam. (2023). *Desain sistem pembelajaran*. CV Widina Media Utama.
- Fullan, M., & Gallagher, M. J. (2022). *The devil is in the details: System solutions for equity, excellence, and student well-being*. Corwin Press.
- Guo, K., Zhong, Y., Li, D., & Huang, R. (2023). Effects of artificial intelligence-based automated writing evaluation on students' writing quality and engagement. *Studies in Educational Evaluation*, 78, 101267. <https://doi.org/10.1016/j.stueduc.2023.101267>
- Hasanah, U., Nulhakim, L., & Wardana, M. W. (2022). The effectiveness of project-based learning in improving students' critical thinking in elementary schools: A meta-analysis study. *International Journal of Elementary Education*, 6(3), 345–357. <https://doi.org/10.23887/ijee.v6i3.48921>
- Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, 32(3), 504–526. <https://doi.org/10.1007/s40593-021-00239-1>
- Hwang, G.-J., Xie, H., Wah, B. W., & Gašević, D. (2022). Vision, challenges, roles, and research issues of artificial intelligence in education. *Computers and Education: Artificial Intelligence*, 1, 100001. <https://doi.org/10.1016/j.caeai.2020.100001>
- Kemendikbudristek. (2022). *Panduan proyek penguatan profil pelajar Pancasila dan Kebangsaan (P5TK)*. Badan Standar, Kurikulum, dan Asesmen Pendidikan.
- Kesuma, S., Susilawati, E., Tanjung, J. P., Fadhillah, C. R., & Admiral, R. D. (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/10.55214/25768484.v9i11.4512>
- Khaira, I., Susilawati, E., & Harahap, E. S. (2023). Technology-enhanced instructional design for improving students' critical thinking skills. *Journal of Educational Technology*, 12(1), 1–12. <https://doi.org/10.5281/zenodo.10491827>
- Khaira, I., Susilawati, E., Renaldi, & Refli. (2021). Implementasi rancangan pembelajaran berbasis TPACK sebagai integrasi pembelajaran di era Society 5.0. *Jurnal Teknologi Pendidikan*, 14(2), 111–119. <https://doi.org/10.24114/jtp.v14i2.25783>
- Li, W., Gao, M., & Wei, X. (2023). Effects of AI-powered adaptive learning on rural student achievement: Evidence from a randomized controlled trial in western China. *Educational Technology Research and Development*, 71(4), 1183–1209. <https://doi.org/10.1007/s11423-023-10214-z>
- Marisa, S., Susilawati, E., & Gunawan. (2024). Global education development plan to build sustainable education based on artificial intelligence. *Qubahan Academic Journal*, 4(2), 38–46. <https://doi.org/10.48161/qaj.v4n2a407>
- Miqwati, M., Susilawati, E., & Moonik, J. (2023). Implementasi pembelajaran berdiferensiasi untuk meningkatkan hasil belajar ilmu pengetahuan alam di sekolah dasar. *Pena Anda: Jurnal Pendidikan Sekolah Dasar*, 1(1), 30–38. <https://doi.org/10.59686/pena.v1i1.9>
- OECD. (2023). *PISA 2022 results: Factsheets — Indonesia*. OECD Publishing. <https://www.oecd.org/pisa/pisa-2022-results-indonesia>
- Popenici, S. A. D., & Kerr, S. (2022). Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and Practice in Technology Enhanced Learning*, 12(22), 1–13. <https://doi.org/10.1186/s41039-017-0062-8>
- Ratheeswari, K. (2021). Information communication technology in education. *Journal of Applied and Advanced Research*, 3(1), S45–S47. <https://doi.org/10.21839/jaar.2018.v3iS1.169>
- Roll, I., & Wylie, R. (2022). Evolution and revolution in artificial intelligence in education. *International Journal of Artificial Intelligence in Education*, 26(2), 582–599. <https://doi.org/10.1007/s40593-016-0110-3>
- Selwyn, N., & Gašević, D. (2021). The datafication of higher education: Discussing the promises and problems. *Teaching in Higher Education*, 25(4), 527–540. <https://doi.org/10.1080/13562517.2019.1689388>
- Susilawati, E. (2024). Dinamika guru dan siswa dalam membangun karakter: Studi literatur. *Journal of Education Technology and Civic Literacy (JET CIVIL)*, 5(1), 13–20. <https://doi.org/10.51544/jetcivil.v5i1.4108>
- Susilawati, E., Kesuma, S., Leman, D., & Yusrita. (2025). *Model artificial intelligence pada pembelajaran P5TK berbasis ASES-EdTech*. UISU Press.
- Susilawati, E., Kesuma, S., Leman, D., Yusrita, A., Fauzan, H., Habil, D., & Viona, D. (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/10.55214/25768484.v9i11.4491>
- Susilawati, E., Lubis, H., Kesuma, S., Pratama, I., & Khaira, I. (2023). Exploring the antecedents of student academic integrity: The impact of using digital technology ASES assessment models in learning. *Eurasian Journal of Educational Research*, 103, 145–164. <https://doi.org/10.14689/ejer.2023.103.009>

- Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The digital competence framework for citizens*. Publications Office of the European Union. <https://doi.org/10.2760/115376>
- Warschauer, M., & Tate, T. (2023). Automated writing evaluation: Current and future approaches. *Journal of Writing Research*, 14(3), 403–432. <https://doi.org/10.17239/jowr-2023.14.03.01>