



The effect of blended microlearning soil analysis practicum on students' learning outcomes in Geography

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Abstract. High schools with limited instructional resources require learning approaches that are both effective and practical. This study investigated the effectiveness of a blended microlearning model in improving students' learning outcomes during a soil analysis practicum in Geography. A quasi-experimental posttest-only control-group design was used with 59 Grade XI Social Science students at SMA Diponegoro Tumpang. Two classes were selected through purposive sampling: an experimental group ($n = 30$) that received blended microlearning instruction and a control group ($n = 29$) that followed conventional practicum-based learning. Data were collected using a cognitive achievement test, a psychomotor performance rubric, and a learning motivation questionnaire. The results show that students in the experimental group achieved a higher mean score ($M = 87.3$) than those in the control group ($M = 79.3$). Analysis using the Mann-Whitney U test indicated a statistically significant difference between the two groups ($p = .019$). These findings

demonstrate that blended microlearning effectively enhances students' cognitive understanding, practical skills, and learning motivation in geography practicums. Therefore, this study recommends adopting microlearning-based blended strategies as a low-cost, feasible instructional alternative for schools with limited educational resources.

Introduction

The Industrial Revolution 4.0 era has profoundly reshaped educational systems, necessitating the systematic integration of digital technologies to enhance learning effectiveness, flexibility, and the cultivation of essential 21st-century competencies, including critical thinking, digital literacy, and adaptability (Mukul & Büyüközkan, 2023). One widely adopted innovation is blended learning, which combines face-to-face and online instruction to position students at the center of the learning process and provide flexible access to digital materials (Graham, 2006). Beyond its basic form, blended learning encompasses various instructional models (e.g., flipped classroom, station rotation) that optimize interaction and independent study while promoting learner autonomy and collaboration (Mahalli et al., 2019).

In geography education, this approach is particularly pertinent for practice-oriented topics such as soil analysis, which plays a pivotal role in fostering understanding of environmental sustainability, agricultural productivity, and sustainable natural resource management (Kopitke et al., 2021).

Ideally, geography instruction should strategically harness technological innovations to facilitate interactive, experiential, and student-centered learning environments (Jong et al., 2020).

Nevertheless, a substantial discrepancy persists between these pedagogical ideals and classroom realities, particularly in resource-limited educational settings such as SMA Diponegoro Tumpang in Malang Regency. Inadequate laboratory facilities, limited digital infrastructure, and restricted internet connectivity significantly constrain the implementation of hands-on practicums and technology-supported learning environments (Olanrewaju et al., 2021). These structural limitations are exacerbated by pedagogical practices that predominantly rely on conventional, teacher-centered approaches, where extensive geography content is delivered in large, uninterrupted segments (Krause et al., 2025).

This instructional pattern aligns with the principles of Cognitive Load Theory (Sweller, 1988), as it contributes to excessive extraneous cognitive load, thereby impairing students' capacity to effectively process, integrate, and retain complex conceptual information (Mayer, 2024). Consequently, the availability of cognitive resources for germane processing is reduced, hindering meaningful knowledge construction (Zeithofer et al., 2024). To address this pedagogical gap, blended learning has emerged as a promising approach. It strategically integrates face-to-face and online instruction to enhance flexibility, promote learner autonomy, and support collaborative knowledge construction (Graham, 2006; Sudirtha et al., 2022). This model positions students at the center of the learning process and provides flexible access to digital learning materials (Purnadewi et al., 2023), making it particularly suitable for practice-oriented topics such as geography practicums. Empirical studies in geography education have shown that blended learning can improve academic achievement and spatial thinking when aligned with disciplinary objectives (Cheng et al., 2023; Lusa et al., 2021).

The integration of these approaches can be theoretically grounded through the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the dynamic alignment of content knowledge, pedagogical strategies, and technological affordances to design context-sensitive and pedagogically coherent learning environments (Schmid et al., 2024; Widana & Laksitasari, 2023)). Within this framework, accessible technologies can be strategically combined with appropriate pedagogical models to support meaningful learning, even in settings with limited infrastructure.

Despite the growing body of research on blended learning and microlearning, empirical studies that integrate microlearning principles within a blended practicum-based Geography instruction, particularly in resource-constrained secondary schools, remain scarce (Wijaya et al., 2024). Existing studies tend to examine blended learning and microlearning as separate instructional approaches or focus on technology-intensive solutions such as virtual laboratories, which are often impractical for schools with limited infrastructure (Sriadhi et al., 2022). Consequently, there is a need for empirical evidence on how a low-cost, pedagogically integrated blended microlearning model can support cognitive, affective, and psychomotor learning outcomes in Geography practicums.

In response to the identified gaps, this study examines whether integrating microlearning principles within a blended learning framework through a soil analysis practicum can enhance students' learning outcomes in resource-constrained secondary school settings. Accordingly, this study aims to examine the effectiveness of a blended microlearning-based soil analysis practicum in improving the cognitive, affective, and psychomotor learning outcomes of Grade XI Social Science students in Geography. To achieve this objective, a quasi-experimental posttest-only control group design was employed to compare students exposed to the blended microlearning intervention with those receiving conventional instruction. It is hypothesized that students who participate in the blended

microlearning-based practicum will demonstrate higher cognitive, affective, and psychomotor learning outcomes than those taught using conventional instructional methods.

Method

Research Method and Design

This study employed a quasi-experimental approach using a Posttest-Only Control Group Design (Creswell, 2014). This design was considered appropriate because full randomization at the class level was not feasible due to administrative constraints and the need to preserve existing class structures, a limitation frequently reported in educational field research. The design reduces the potential for testing effects that would arise if a pretest were administered, since prior exposure to test items may sensitize students and interfere with the accurate estimation of the treatment effect (Sugiyono, 2020). By comparing posttest scores between a treatment group and a non-treated control group, the design supports valid causal inferences about the intervention's impact while maintaining adequate internal validity.

Table 1. Posttest-Only Control Group Design

Class	Treatment	Posttest
Experimental	X	Q ₁
Control	O	Q ₂

Note:

X : Treatment using blended learning integrated with microlearning based on soil analysis practicum.

Q₁ : Final observation (posttest) of the experimental group.

Q₂ : Final observation (posttest) of the control group.

Participants and Sampling Technique

The target population comprised all Grade XI Social Science students in the first semester of the 2024/2025 academic year, totaling 120 students across four classes. A purposive sampling technique was employed to select two classes with comparable academic backgrounds and demographic characteristics. Class XI IPS G, comprising 30 students, was assigned to the experimental group, whereas Class XI IPS F, comprising 29 students, served as the control group. To statistically verify the equivalence of these groups prior to the intervention, an independent samples t-test was conducted using students' midterm Geography scores from the previous semester. The results indicated no significant difference between the groups, $t(57) = 1.45, p = .153$, confirming their comparability. Demographic characteristics were also similar, with participants aged 16–17 years and a gender distribution of approximately 60% female and 40% male in both classes.

Research Setting and Timeline

The study was conducted from 8 November to 28, 2024, at SMA Diponegoro Tumpang, a public high school in Malang Regency, East Java, Indonesia. The school was purposively selected due to its resource-limited context, which is characterized by minimal laboratory facilities, including only one multipurpose science laboratory, limited digital infrastructure in the form of a single computer laboratory with 15 functional computers, and intermittent internet connectivity. These conditions represent the typical constraints encountered by many public schools in peri-urban regions of Indonesia and therefore provide an appropriate setting for testing the feasibility of technology-supported instructional innovations.

Research Procedures

The intervention was conducted over a three-week period and followed a structured, blended microlearning cycle comprising three sequential phases. To ensure consistency in implementation, the geography teacher participated in a brief preparatory training session focusing on the blended microlearning model and the use of the selected digital tools prior to the intervention. The same teacher delivered instruction to both the experimental and control groups to minimize potential teacher-related confounding. Throughout the intervention, an implementation checklist was employed to monitor adherence to the planned instructional procedures.

Phase 1, implemented on Days 1 and 2, focused on individual pre-practicum learning activities. Students accessed microlearning materials on Google Drive, including a three-minute animated video introducing soil color theory, a five-minute screencast demonstrating soil texture testing, and an interactive student worksheet (LKPD). These materials were designed to support independent learning and to develop foundational conceptual understanding prior to the hands-on practicum.

Phase 2, conducted on Day 3, consisted of a ninety-minute face-to-face practicum session. Instruction began with a guided discussion to review key concepts, followed by group-based soil analysis activities supported by the digital LKPD. During this phase, the teacher actively facilitated learning by providing clarification, scaffolding student inquiry, and offering formative feedback as needed.

Phase 3, carried out on Days 4 and 5, emphasized reflection and consolidation of learning. Students uploaded their practicum results, completed LKPD files, and reflective responses to Google Drive. The teacher then provided asynchronous written feedback to reinforce conceptual understanding and support students' integration of theory and practice.

Data Collection Techniques and Research Instruments

Data were collected using three instruments: a cognitive posttest, an observation checklist (affective/psychomotor), and a motivation questionnaire. Their validity and reliability are summarized below.

Table 2. Research Instruments Grid

Variable	Indicator	Instrument	Item Type	Reliability Statistic
Cognitive	Comprehension, Application, Analysis, Evaluation	Posttest	Multiple-choice & Essay	Cronbach's Alpha = .760
Affective	Interest, Motivation, Attitude	Questionnaire	Likert scale	Cronbach's Alpha = .943
Psychomotor	Participation, Procedure, Collaboration	Observation Checklist	Rating scale	Interrater reliability (Kappa = 0.81)

Detailed Instrument Validation

Students' learning outcomes were assessed across cognitive, affective, and psychomotor domains using three validated instruments. Cognitive achievement was measured through a posttest comprising 15 items: 10 multiple-choice questions designed to assess comprehension and application, and 5 structured essay questions targeting higher-order thinking skills, specifically analysis and evaluation. The test blueprint was systematically aligned with Bloom's Revised

Taxonomy and the national curriculum learning objectives (Kemendikbud, 2020). Content validity and item clarity were established through expert review by the participating Geography teacher and pilot testing with a small group of students. The instrument demonstrated acceptable internal consistency, with a Cronbach's alpha coefficient of .760.

Students' affective responses were measured using a questionnaire adapted from the Intrinsic Motivation Inventory (IMI) (Deci & Ryan, 2000). The instrument comprised 15 items distributed across three theoretically grounded subscales: interest and enjoyment, perceived competence, and value and usefulness. Construct validity was examined through an exploratory factor analysis with Varimax rotation, which confirmed a stable three-factor solution that explained 72.3% of the total variance. The scale exhibited excellent internal consistency, with a Cronbach's alpha of .943, indicating high reliability.

Psychomotor learning outcomes were evaluated using an observation checklist comprising 8 items organized into 3 dimensions: participation in discussions, ability to follow practicum procedures, and peer collaboration. Each item was rated on a five-point Likert scale accompanied by explicit behavioral descriptors to enhance scoring objectivity. The checklist was developed in reference to standard soil analysis practicum guidelines (Benyamin et al., 2023) and refined through consultation with the geography teacher to ensure alignment with instructional objectives. To establish interrater reliability, two trained observers (the practicum's geography teacher and a research assistant) independently rated a pilot sample of 5 students prior to the main data collection, resulting in substantial agreement (Cohen's Kappa = 0.81).

Data Analysis Techniques and Criteria

Data analysis was conducted through a series of systematic procedures to rigorously evaluate the effectiveness of the blended microlearning intervention. Initially, descriptive statistics, including means and standard deviations, were computed to summarize posttest scores and affective and psychomotor assessment outcomes for both the experimental and control groups.

Prior to inferential analysis, assumption testing was performed to assess the appropriateness of parametric statistical techniques. Data normality was assessed using the Shapiro-Wilk test, and variance homogeneity between groups was assessed using Levene's test. The results indicated violations of both normality and homogeneity assumptions ($p < 0.05$), thereby precluding the use of parametric tests. Accordingly, non-parametric statistical methods were adopted for subsequent analyses.

Differences in cognitive learning outcomes between the experimental and control groups were analyzed using the Mann-Whitney U test, with $\alpha = 0.05$. To assess the practical significance of the findings, effect sizes were calculated using the formula $r = Z/\sqrt{N}$. In addition, affective and psychomotor outcomes were initially examined through descriptive mean comparisons. These observed differences were then statistically validated using the Mann-Whitney U test applied to scores derived from the motivation questionnaire and the observation checklist.

Results and Discussion

Result

This study examined the effectiveness of integrating microlearning within a blended learning model through a soil analysis practicum to enhance the learning performance of Grade XI Social Science students. The results are presented across three learning domains: cognitive outcomes measured by posttest scores, affective outcomes assessed through questionnaires, and psychomotor outcomes evaluated through observation.

Table 3. Descriptive Statistics of Posttest Results

Score Type	Experimental	Control	Difference
Mean	87.3	79.3	8.0

The experimental group obtained a higher posttest mean ($M = 87.3$) than the control group ($M = 79.3$), yielding a difference of 8.0 points (Table 3). This result suggests greater conceptual understanding among students who participated in the blended microlearning intervention.

Prior to hypothesis testing, assumption checks were conducted to guide the selection of an appropriate inferential procedure. The Shapiro-Wilk test indicated non-normal score distributions in both groups ($p < 0.05$), while Levene's test revealed unequal variances ($p < .001$) (Table 4). These results supported the use of the Mann-Whitney U test for subsequent analysis.

Table 4. Normality and Homogeneity Tests

Learning Outcome	Class	Normality Test (Shapiro-Wilk) Statistic	Homogeneity Test (Levene's) Sig.
Control	0.206	0.00	0.000
Experiment	0.197	0.002	0.000

Table 5. Mann-Whitney U Test Results for Posttest Scores

Test	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
	283.500	718.500	-2.350	.019

The Mann-Whitney U test indicated a statistically significant difference in posttest scores between the experimental and control groups ($U = 283.5$, $p = .019$), with higher scores observed in the experimental group.

Table 6. Comparison of Mean Scores for Affective Aspects

Aspect/Dimension	Experimental	Control	Difference
Interest and Engagement	4.4	3.9	0.5
Learning Motivation	4.5	4.0	0.5
Attitude Toward Learning Method	4.2	3.6	0.4
Overall Mean	4.3	3.8	0.4

Table 7. Comparison of Mean Scores for Student Activity Observations

Aspect/Dimension	Experimental	Control	Difference
Participation in Discussions	4.4	3.7	0.7
Ability to Follow Instructions	4.4	3.8	0.6
Peer Collaboration	4.3	3.9	0.4
Overall Mean	4.3	3.8	0.5

The experimental group also achieved higher mean scores in both the affective (Table 6) and psychomotor domains (Table 7). In the affective domain, students reported higher levels of learning interest, motivation, and positive attitudes. In the psychomotor domain, observational data

indicated greater student engagement, improved procedural performance, and more effective collaboration during the practicum.

Discussion

Synthesis of Key Findings

The findings of this study indicate that the integrated blended microlearning model produced statistically significant improvements across the cognitive, affective, and psychomotor domains of learning. These results highlight the model's capacity to support comprehensive, balanced learning by addressing not only students' conceptual understanding but also their attitudes and practical skills. Students in the experimental group demonstrated higher achievement on cognitive assessments, stronger affective engagement throughout the learning process, and greater effectiveness in psychomotor tasks during the soil analysis practicum. This pattern of results suggests that integrating microlearning into a blended learning framework can create a more engaging and effective instructional environment, particularly in educational settings with limited resources (Widana et al., 2023).

The cognitive improvements observed in this study are consistent with previous findings on the effectiveness of blended learning in geography education (Lusa et al., 2021) as well as research highlighting the role of microlearning in improving information retention through structured content segmentation (Taylor & Hung, 2022). However, this study goes beyond existing literature by investigating the combined application of blended learning and microlearning within a single, coherent instructional design, rather than examining these approaches independently.

While earlier studies have tended to emphasize either blended learning models or standalone microlearning modules, the present findings demonstrate that their integration can serve as a complementary, mutually reinforcing pedagogical framework. This integrated approach constitutes a meaningful contribution to geography education research, particularly in under-resourced educational contexts where instructional models that are both cost-effective and cognitively efficient are critically needed.

This study operationalizes the Technological Pedagogical Content Knowledge (TPACK) framework within a low-resource educational context and demonstrates that meaningful technology integration does not necessarily depend on sophisticated digital infrastructure. Instead, the findings indicate that pedagogical creativity and the deliberate alignment of readily available tools such as digital worksheets, Google Drive, and the Munsell Soil Chart with subject content, particularly soil analysis, and instructional strategies, namely blended microlearning, can lead to substantial improvements in student learning outcomes. In this regard, the study extends existing TPACK scholarship by providing empirical evidence of its relevance and adaptability in infrastructurally constrained environments, a context that remains underrepresented in the literature.

In addition, the results highlight the applicability of the Community of Inquiry (CoI) framework at the upper-secondary education level. Indicators of cognitive presence were observed through students' analytical reasoning and problem-solving during the practicum activities. Social presence was reflected in peer collaboration and sustained interaction within online learning spaces, while teaching presence was maintained through purposeful instructional design, facilitation, and timely feedback. Although the CoI framework has predominantly been examined in higher education settings, these findings suggest that its core dimensions are equally relevant for technology-enhanced geography instruction at the secondary level, particularly when learning activities are carefully structured and pedagogically grounded.

While previous studies have introduced low-cost practicum tools for use in resource-constrained educational settings (Sriadhi et al., 2022). There is still limited empirical evidence regarding their effectiveness when implemented within digitally structured pedagogical frameworks. This study addresses this gap by showing that digitally scaffolded practicum activities, even when supported by minimal physical resources, can effectively foster procedural accuracy and collaborative skills when embedded within a well-designed blended microlearning approach. In this context, the digital LKPD or student worksheet functioned not merely as a digital replacement for paper-based materials but as an integral pedagogical tool that guided inquiry, organized data collection, and encouraged students to engage in reflective thinking.

Theoretical and Practical Implications

This study contributes to geography education by offering both theoretical and practical insights. From a theoretical perspective, the findings support the applicability of the Technological Pedagogical Content Knowledge (TPACK) framework in low-resource educational settings and illustrate how Cognitive Load Theory and Self-Determination Theory can be meaningfully integrated within a blended microlearning approach. The use of short, focused learning segments helps reduce extraneous cognitive load, while the blended learning structure fosters key motivational components, including learner autonomy, perceived competence, and social relatedness.

From a practical standpoint, this study presents a low-cost and readily implementable instructional model that enables teachers to enhance students' cognitive, affective, and psychomotor learning outcomes without relying on advanced technological infrastructure. The integration of digital LKPD and the Munsell Soil Chart provides scalable, context-appropriate tools to facilitate hands-on learning in laboratories with limited resources. Furthermore, the proposed model offers schools and policymakers a viable strategy for addressing infrastructural constraints while simultaneously promoting essential 21st-century skills, such as critical thinking, collaboration, and digital literacy, within secondary geography education.

Implications, Limitations, and Recommendations

The findings of this study provide significant insights with wide-ranging implications for educational practice, theoretical development, and future research in technology-enhanced Geography education. This section presents these contributions while clearly outlining the study's limitations.

Implications for Educational Practice

Beyond improving conceptual understanding, the integrated blended microlearning model supports the development of key twenty-first-century competencies. Students demonstrated enhanced critical thinking through hypothesis testing in soil analysis, improved collaboration through peer discussions and group practicums, and stronger digital literacy through navigation of online platforms and digital worksheets (AlAli, 2024). For educators, this model offers a practical and scalable framework that can transform traditional practicums in settings with limited resources.

From an instructional design perspective, the successful implementation highlights the central role of teacher competence within the Technological, Pedagogical, and Content Knowledge (TPACK) framework. Teachers are required to shift from knowledge transmitters to designers who integrate Geography content knowledge, blended microlearning pedagogy, and appropriate technological tools such as digital worksheets and the Munsell Soil Chart (Putra et al., 2021). This shift underscores the need for targeted professional development programs to strengthen TPACK competencies among in-service Geography teachers.

The digital student worksheet, or LKPD, emerged as an essential pedagogical innovation. It functioned as more than a digital substitute for traditional worksheets by providing structured guidance for exploration, facilitating systematic data recording, and prompting reflective thinking (Susilawati et al., 2023). Its use offers a cost-effective means of addressing laboratory constraints and supports inquiry-based learning without heavy investment in infrastructure (Utaminingsih et al., 2024). Policymakers and school administrators are therefore encouraged to promote the development and dissemination of open-access digital LKPDs across Geography topics.

Theoretical Implications

This study advances several theoretical perspectives. First, it provides empirical support for Cognitive Load Theory within blended practicum environments. The microlearning approach assisted in managing intrinsic load by segmenting complex soil analysis procedures, while the structured LKPD reduced extraneous load through guided learning sequences, allowing cognitive resources to be allocated to germane processing and schema construction (Sweller, 1988).

Second, the positive affective outcomes observed in the study reinforce the relevance of Self-Determination Theory. Students' needs for autonomy were addressed through self-paced access to microlearning materials. Their sense of competence was strengthened through step-by-step practicum mastery, and their relatedness needs were supported through collaborative face-to-face sessions and online interactions (Deci & Ryan, 2000). The findings affirm that well-designed technology-mediated learning environments can play a substantial role in enhancing intrinsic motivation.

Finally, the study operationalizes and validates the TPACK framework within a low-resource educational context. The results demonstrate that effective technology integration does not depend on advanced digital tools. Instead, it arises from a purposeful alignment of content, pedagogy, and accessible technology, offering a useful model for applying TPACK principles in diverse and resource-constrained settings.

Limitations of the Study

While this study provides empirical evidence on the effectiveness of a blended microlearning model for soil analysis practicums, several limitations must be acknowledged to appropriately interpret the findings and inform future research directions.

First, the study was conducted in a single public senior high school in Malang Regency with a relatively small sample size ($n = 59$). Although purposive sampling and group equivalence testing were applied, the contextual specificity of the setting limits the generalizability of the results to other educational environments, such as private or vocational schools, different regions, or international contexts. School-level factors, including classroom culture, teacher engagement, and students' prior exposure to digital learning, may have influenced the observed outcomes.

Second, methodological constraints should be considered. The use of a posttest-only control group design, while administratively efficient, did not allow for direct measurement of individual learning gains relative to baseline performance. Although prior academic records were used to establish group equivalence, the absence of a pretest limits causal attribution of posttest differences to the intervention alone. In addition, the relatively short intervention period may not sufficiently capture long-term knowledge retention or the progressive development of advanced psychomotor competencies.

Third, limitations related to instrumentation and data depth were evident. Despite employing validated assessment instruments, the study did not incorporate qualitative data sources such as

interviews, reflective journals, or focus group discussions. Consequently, insights into students' learning experiences, perceptions, and contextual challenges remain limited. Moreover, although interrater reliability was established for the psychomotor assessment, observations were conducted by trained teachers who were aware of group assignments, which may have introduced observer bias.

Fourth, several extraneous variables were not systematically controlled. Factors such as students' prior subject-specific knowledge, disparities in access to digital devices and internet connectivity outside school, and variations in implementation fidelity across instructional sessions were not formally measured. Additionally, the facilitating teacher's technological pedagogical content knowledge (TPACK), which plays a critical role in blended learning environments, was not explicitly assessed and may have influenced both instructional quality and student engagement.

Finally, although the model was designed as a low-cost instructional strategy, it nonetheless depended on minimal digital infrastructure and teacher readiness to adopt innovative pedagogical practices. Schools facing more severe resource constraints or lower levels of digital competence may encounter implementation challenges beyond the scope of this study.

Recommendations

Based on the study's findings, several practical implications can be drawn. First, geography teachers working in schools with limited laboratory infrastructure are encouraged to implement blended microlearning models complemented by simple, low-cost practicum activities to support the development of students' cognitive, procedural, and affective competencies. Second, school leaders and local education authorities should prioritize professional development programs focused on digital pedagogy and ensure the availability of essential technological resources, including digital worksheets and microlearning platforms. Third, curriculum developers and policymakers are advised to integrate flexible blended microlearning frameworks into official geography teaching guidelines, particularly to address the needs of under-resourced educational settings. Finally, future studies should examine the longitudinal effects of this instructional model and assess its applicability across different geography topics and diverse educational contexts.

Conclusion

The integration of microlearning within the blended learning model through a soil analysis practicum using the Munsell Soil Chart and texture by feel test has proven effective in improving the learning abilities of Grade XI social science students on the topic of Natural Resources. This model resulted in significant improvements across cognitive, affective, and psychomotor aspects compared to conventional methods. The blended microlearning strategy effectively reduced cognitive load by presenting content in small, structured units while also serving as an innovative learning solution for schools with limited facilities. The combination of flexible online learning and simple practicum activities created an engaging and meaningful learning experience. This study offers an adaptive technology-based learning model suitable for secondary schools and theoretically strengthens the application of blended learning and microlearning in Geography education, as well as the relevance of the TPACK framework in designing effective digital learning. Based on the findings, geography teachers in resource-limited schools are encouraged to adopt blended microlearning models supported by low-cost practicum activities. School leaders and education authorities should prioritize teacher training in digital pedagogy and ensure access to essential technological resources. In addition, curriculum developers are advised to integrate flexible blended microlearning frameworks into official geography teaching guidelines, while future studies should examine the long-term effects and broader applicability of this model across diverse educational contexts.

Bibliography

- AlAli, R. (2024). Enhancing 21st century skills through integrated stem education using project-oriented problem-based learning. *GeoJournal of Tourism and Geosites*, 53(2), 421–430. <https://doi.org/10.30892/gtg.53205-1217>
- Benyamin, P., Sulaeman, L. H., Anggria, L., Usman, H. E. T., Prihatini, R., & Wuningrum, P. (2023). *Petunjuk teknis analisis kimia tanah, tanaman, air, dan pupuk* (Technical Instructions, 3rd ed., pp. 1–266). Kementerian Pertanian Republik Indonesia.
- Cheng, Y., Yang, M., Tao, Z., Kong, J., & Liu, Z. (2023). Access and cost of primary educational services in plateau areas: A case study in Tibet, China. *Applied Geography*, 152, 102874. <https://doi.org/10.1016/j.apgeog.2023.102874>
- Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th Edition). Sage.
- Deci, E. L., & Ryan, R. M. (2000). The “what” and “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/10.1207/s15327965pli1104_01
- Graham, C. R. (2006). Blended Learning Systems: Definition, Current Trends, and Future Directions. In C. J. Bonk & C. R. Graham (Eds.), *The handbook of blended learning: Global perspectives, local designs* (pp.3–21). Pfeiffer.
- Jong, M. S. Y., Tsai, C. C., Xie, H., & Kwan-Kit Wong, F. (2020). Integrating interactive learner-immersed video-based virtual reality into learning and teaching of physical geography. *British Journal of Educational Technology*, 51(6), 2063–2078. <https://doi.org/10.1111/bjet.12947>
- Kementerian Pendidikan dan Kebudayaan. (2020). *Buku panduan merdeka belajar kampus merdeka (Independent learning guide book independent campus)*. Direktorat Jenderal Pendidikan Tinggi.
- Kopittke, P. M., Menzies, N. W., Dalal, R. C., McKenna, B. A., Husted, S., Wang, P., & Lombi, E. (2021). The role of soil in defining planetary boundaries and the safe operating space for humanity. *Environment International*, 146. <https://doi.org/10.1016/j.envint.2020.106245>
- Krause, U., Rawlings Smith, E., Flajšhans Nedbalova, R., He, X., He, Y., Ito, N., Milaras, M., Yang, J., Hanus, M., & Béneker, T. (2025). The barriers and enablers of curriculum thinking and teacher agency in geography education: A multinational study. *International Research in Geographical and Environmental Education*, 34(3), 220–236. <https://doi.org/10.1080/10382046.2025.2466160>
- Lusa, H., Adnan, A., & Yurniwati, Y. (2021). Effect of blended learning on students’ learning outcomes: A meta-analysis. *Jurnal Pendidikan Progresif*, 11(2), 309–325. <https://doi.org/10.23960/jpp.v11.i2.202113>
- Mahalli, Nurkamto, J., Mujiyanto, J., & Yuliasri, I. (2019). The implementation of station rotation and flipped classroom models of blended learning in efl learning. *English Language Teaching*, 12(12), 23. <https://doi.org/10.5539/elt.v12n12p23>
- Mayer, R. E. (2024). The past, present, and future of the cognitive theory of multimedia learning. *Educational Psychology Review*, 36(1), Article 37. <https://doi.org/10.1007/s10648-023-09842-1>
- Mukul, E., & Büyüközkan, G. (2023). Digital transformation in education: A systematic review of education 4.0. *Technological Forecasting and Social Change*, 194, 122664. <https://doi.org/10.1016/j.techfore.2023.122664>
- Olanrewaju, G. S., Adebayo, S. B., Omotosho, A. Y., & Olajide, C. F. (2021). Left behind? The effects of digital gaps on e-learning in rural secondary schools and remote communities across Nigeria during the COVID19 pandemic. *International Journal of Educational Research Open*, 2, 100092. <https://doi.org/10.1016/j.ijedro.2021.100092>

- Purnadewi, G. A. A., Arnawa, N., & Tatminingsih, S. (2023). The influence of school culture, learning interest, and learning motivation on science learning outcomes. *Indonesian Journal of Educational Development (IJED)*, 4(2), 126-138. <https://doi.org/10.59672/ijed.v4i2.3040>
- Putra, A. K., Sumarmi, S., Handoyo, B., Purwanto, P., & Islam, M. N. (2021). Pengembangan virtual field trips berbasis geospasial technology: Peningkatan kompetensi TPACK guru melalui geoeu workshop (Development of virtual field trips based on geospasial technology: Improving teachers' TPACK competencies through geoeu workshop). *Jurnal Integrasi Dan Harmoni Inovatif Ilmu-Ilmu Sosial*, 1(12), 1354-1363. <https://doi.org/10.17977/um063v1i12p1354-1363>
- Schmid, M., Brianza, E., Mok, S. Y., & Petko, D. (2024). Running in circles: A systematic review of reviews on technological pedagogical content knowledge (TPACK). *Computers & Education*, 214, 105024. <https://doi.org/10.1016/j.compedu.2024.105024>
- Sriadhi, S., Hamid, A., & Restu, R. (2022). Web-based virtual laboratory development for basic practicums in science and technology. *TEM Journal*, 11(1), 396-402. <https://doi.org/10.18421/tem111-50>
- Sudirtha, I. G., Widiana, I. W., Setemen, K., Sukerti, N. W., Widiartini, N. K., & Santiyadnya, N. (2022). The impact of blended learning assisted with self-assessment toward learner autonomy and creative thinking skills. *International Journal of Emerging Technologies in Learning (IJET)*, 17(06), 163-180. <https://doi.org/10.3991/ijet.v17i06.29799>
- Sugiyono. (2020). *Metode penelitian kuantitatif, kualitatif dan R&D* (Vol. 1). Alfabeta.
- Susilawati, E., Taufiq, A. U., & Hasanah, U. (2023). Development of liveworksheet-based interactive LKPD on the biodiversity material of class x. *Bio-inoved: Jurnal Biologi-Inovasi Pendidikan*, 5(1), 17-27. <https://doi.org/10.20527/bino.v5i1.14719>
- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257-285. [https://doi.org/10.1016/0364-0213\(88\)90023-7](https://doi.org/10.1016/0364-0213(88)90023-7)
- Taylor, A. D., & Hung, W. (2022). The Effects of Microlearning: A Scoping Review. *Educational Technology Research and Development*, 70(2), 363-395. <https://doi.org/10.1007/S11423-022-10084-1>
- Utaminingsih, S., Amalia, I., & Sumaji, S. (2024). Management of Mathematics Learning Based on Interactive Digital Worksheets to Improve Students' Critical Thinking Ability. *Journal of Curriculum and Teaching*, 13(1), 159. <https://doi.org/10.5430/jct.v13n1p159>
- Widana, I. W., Sumandya, I. W., Citrawan, I. W., Widana, I. N. S., Ibarra, F. P., Quicho, R. F., Delos Santos, M. R. H. M., Velasquez-Fajanela, J. V., & Mukminin, A. (2023). The effect of teachers' responsibility and understanding of the local wisdom concept on teachers' autonomy in developing evaluation of learning based on local wisdom in a special needs school. *Journal of Higher Education Theory and Practice*, 23(10), 152-167. <https://doi.org/10.33423/jhetp.v23i10.6189>
- Widana, I. W., & Laksitasari, B. D. (2023). Improving students' learning outcomes on circle equation material using GeoGebra software. *Indonesian Journal of Educational Development (IJED)*, 4(1), 32-39. <https://doi.org/10.59672/ijed.v4i1.2792>
- Wijaya, N. M., Kastolani, W., & Yani, A. (2024). A literature review: Geography learning based on microlearning to increase student's ecoliteracy. *E3S Web of Conferences*, 600, 02017. <https://doi.org/10.1051/e3sconf/202460002017>
- Zeitlhofer, I., Zumbach, J., & Schweppe, J. (2024). Complexity affects performance, cognitive load, and awareness. *Learning and Instruction*, 94, 102001. <https://doi.org/10.1016/j.learninstruc.2024.102001>