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The Impact of Digital and Manual- Based Learning Approaches on Student Learning Outcomes in High School Level

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Abstract

This study aims to compare the effectiveness of digital and manual-based learning approaches on student academic outcomes at SMA Negeri 6 Bandar Lampung. The background of this research is based on the need to understand the contribution of each approach in the context of secondary education, in line with the rapid development of educational technology. This research employs a mixed methods approach with a sequential explanatory design. A total of 160 students were selected using stratified random sampling to represent the diversity of class levels and majors. Quantitative data were collected through learning outcome tests, student engagement questionnaires, and classroom activity observations, while qualitative data were obtained through in-depth interviews with selected teachers and students. The analysis results show that digital-based learning significantly enhances student engagement and allows the use of interactive multimedia content. Meanwhile, the manual approach tends to be more effective in supporting deep cognitive processing and conceptual understanding. These findings suggest that the integration of both approaches, proportionally adjusted to the characteristics of the subject matter and learning objectives, has the potential to optimize student learning outcomes. The implications of this study include the need for curriculum development and learning strategies that are adaptive to technological dynamics while still maintaining the effective traditional pedagogical elements.

Keywords: Digital Learning, Manual-Based Learning, Student Engagement, Academic Outcomes, Secondary Education

Introduction

The proliferation of information and communication technologies has engendered profound and systemic transformations across numerous sectors, with education being one of the most dynamically impacted domains. The increasing integration of digital technologies into pedagogical practice has not only redefined the architecture of learning environments but also catalyzed a paradigmatic shift from traditional, instructor-led modalities to more student- centered, interactive, and flexible educational ecosystems (Means et al., 2010; Voogt et al., 2015). The digitalization of education manifested through tools such as virtual

learning environments, adaptive platforms, and multimedia content delivery systems has ostensibly democratized access to knowledge while simultaneously enhancing the potential for differentiated and autonomous learning trajectories.

Despite these optimistic prospects, the implementation of digital pedagogies invites critical scrutiny, particularly regarding their comparative efficacy vis-à-vis conventional manual-based instructional models. While digital learning frameworks afford expansive access to information repositories, support real-time formative assessment, and facilitate multisensory engagement (Kay et al., 2017), they are also implicated in a host of pedagogical challenges. These include attenuated cognitive depth due to superficial engagement, heightened susceptibility to extraneous digital distractions, and uneven distribution of digital fluency among both learners and instructors (Selwyn, 2016; Warschauer & Matuchniak, 2010). Such issues underscore the need for a more nuanced appraisal of the educational affordances and limitations of digital learning infrastructures.

Conversely, manual learning modalities entrenched in the history of formal education continue to be lauded for their pedagogical robustness. Grounded in structured, face-to-face instructional interactions, these approaches prioritize dialogic engagement, critical reflection, and the cultivation of disciplinary habits through practices such as note-taking, discourse, and tactile learning activities (Biggs & Tang, 2011; Lammers & Murphy, 2002). In contexts where digital infrastructures are underdeveloped or where learners benefit from scaffolded guidance, traditional methods remain instrumental in fostering epistemic fluency and deep cognitive processing.

This dichotomy assumes particular relevance within senior secondary education, where learners occupy a transitional cognitive stage characterized by the maturation of abstract reasoning and metacognitive capacities (Piaget, 1972). High school students, especially those situated within diverse socio-educational environments such as SMA Negeri 6 Bandar Lampung, navigate complex developmental demands that necessitate pedagogical interventions responsive to both technological affordances and conceptual rigor. Bransford et al. (2000) emphasize the imperative for learning environments to extend beyond content transmission, advocating instead for instructional designs that facilitate knowledge construction, contextual application, and reflective synthesis.

The extant literature offers a wealth of insights into the discrete advantages and drawbacks of both digital and manual learning strategies. However, there is a conspicuous paucity of empirical research that juxtaposes these modalities within an integrative analytical framework, particularly in the context of secondary education in developing educational systems. Existing meta-analyses and empirical inquiries (Zheng et al., 2016; Bernard et al., 2004) have seldom addressed the synergistic or comparative dynamics of these pedagogical approaches with sufficient granularity. This lacuna substantiates the rationale for the present investigation, which seeks to delineate the relative efficacy of digital and manual instruction with respect to academic achievement, student engagement, and the cultivation of autonomous learning competencies.

Anchored in a sequential explanatory mixed methods paradigm, this study synthesizes quantitative and qualitative data to yield a multidimensional evaluation of instructional

impact. By incorporating perspectives from students across various grade levels and disciplinary streams, the research captures a heterogeneous array of educational experiences. Methodological triangulation drawing from standardized assessments, attitudinal surveys, ethnographic observations, and semi-structured interviews serves to bolster the validity and interpretive depth of the findings. The ultimate objective is to inform the development of pedagogical frameworks that are not only empirically grounded and contextually relevant but also sufficiently agile to reconcile the innovations of digital education with the enduring strengths of manual pedagogy (UNESCO, 2022).

Literature Review

Digital Learning in Secondary Education

Digital learning refers to the strategic integration of information and communication technologies (ICT) to support, enrich, and transform the teaching and learning process (Ally, 2009). In secondary education, digital learning encompasses the use of hardware such as laptops, tablets, and smartphones, along with a wide array of educational software, including Learning Management Systems (LMS), educational applications, and virtual learning environments (Kay et al., 2017). These tools have evolved from mere delivery mechanisms into integral components of the modern educational landscape, influencing not only how content is delivered but also how learning is conceptualized, facilitated, and assessed.

Global research underscores the significant potential of digital learning to enhance student motivation, broaden access to diverse learning materials, and enable differentiated instruction that caters to the varied needs of learners (Means et al., 2010; Zheng et al., 2016). The incorporation of multimedia elements—visual, auditory, and interactive—has been found to support multimodal learning and foster deeper cognitive engagement, particularly in alignment with constructivist pedagogies that prioritize student autonomy and critical thinking. However, while the promise of digital learning is profound, its actualization depends heavily on context, infrastructure, and pedagogical intent. As Selwyn (2016) cautions, the mere presence of technology in the classroom does not guarantee positive educational outcomes. Rather, its impact is contingent upon its thoughtful integration and the pedagogical strategies employed to maximize its potential.

The challenges facing the implementation of digital learning are particularly pronounced in the context of secondary education. These challenges include the risk of cognitive overload due to an overwhelming array of online resources, the presence of digital distractions stemming from non-academic content, and the notable disparities in digital literacy among students and educators (Warschauer & Matuchniak, 2010). These barriers are especially evident in schools with varying levels of digital infrastructure, which is often the case in many developing regions, including parts of Indonesia.

This issue is keenly relevant in the case of SMA Negeri 6 Bandar Lampung, which represents a microcosm of the broader challenges faced by schools in developing regions striving to integrate digital tools into their pedagogical practices. While this institution has made strides in adopting digital learning environments, the local context highlights both the potential benefits and limitations of digital pedagogies. For example, students may benefit from enhanced engagement through interactive learning tools, but the disparities in access to devices and digital literacy remain significant barriers to equitable learning outcomes. These

dynamics reflect a global concern: as educational institutions worldwide seek to integrate technology, there remains a critical need for robust teacher training, curriculum alignment, and infrastructural support to ensure that the digital divide does not exacerbate existing inequalities (Selwyn, 2016).

Thus, this study, while situated within the local context of SMA Negeri 6 Bandar Lampung, has broader implications for secondary education globally. It provides valuable insights into how schools in similar socio-economic and infrastructural contexts can navigate the complexities of digital integration. It also underscores the importance of a holistic approach to educational technology adoption—one that not only considers technological access but also the pedagogical strategies that ensure meaningful learning outcomes. As the global educational landscape continues to evolve, the findings of this study can inform educational policy and practice, contributing to more equitable, adaptive, and impactful digital learning experiences worldwide.

Manual (Traditional) Learning and Its Relevance

Manual learning, which focuses on direct interaction between teachers and students, as well as the use of print media such as textbooks and worksheets, remains a foundational element in educational systems worldwide (Biggs & Tang, 2011). Despite the growing trend of educational digitalization, this traditional approach continues to maintain its relevance, particularly in contexts of learning that prioritize deep conceptual understanding and the development of higher-order cognitive skills. Activities such as reading, note-taking, engaging in direct discussions, and completing written assignments are integral components of the learning process that not only reinforce content comprehension but also enhance students' analytical and critical thinking abilities.

From the perspective of social constructivism theory, particularly Vygotsky's (1978) ideas, face-to-face interaction in manual learning plays a crucial role in the internalization of new concepts. This process enables students to connect new knowledge with their prior experiences through more direct and personal dialogue with the teacher. Thus, this interaction not only strengthens academic understanding but also helps students develop social and communication skills that are essential in real-life contexts. Vygotsky emphasized the importance of the zone of proximal development (ZPD), where the most effective learning occurs through active support from the teacher, who helps guide students toward higher levels of independence.

Furthermore, manual learning fosters the development of important skills such as long-term concentration, academic perseverance, and effective time management (Bransford et al., 2000). These skills are essential in preparing students for the challenges they will face in their professional and academic lives. In traditional learning environments, students are encouraged to engage with tasks that require sustained focus and the management of time and learning resources.

Globally, although many schools around the world are increasingly focusing on the integration of technology into the learning process, manual learning remains highly relevant, particularly in concept-based learning and subjects that demand deep cognitive thinking. This approach not only provides students with a solid foundation in understanding material but also

encourages them to develop academic discipline and independence in learning. For instance, in many developing countries where access to technology may be limited, manual learning continues to be the primary strategy for delivering quality education by maximizing the use of available resources (Warschauer & Matuchniak, 2010).

Therefore, while digital learning offers flexibility and the potential for innovation, manual learning still plays an irreplaceable role, especially in contexts requiring the development of deep conceptual understanding and complex critical thinking skills. As technology continues to evolve, it is important to continuously reassess the relevance and sustainability of traditional approaches, both locally and globally, to ensure that students receive a comprehensive and balanced learning experience.

Comparison of the Effectiveness of Digital and Manual Learning

Various studies have sought to compare the effectiveness of digital and manual learning approaches. A meta-analysis conducted by Bernard et al. (2004) found that online learning (which utilizes digital technologies) is at least as effective, if not more effective, than face-to-face learning in certain contexts. The success of digital learning, however, was shown to be highly contingent on the design of the learning experience, rather than solely on the medium used. This finding underscores the importance of pedagogical strategies in determining the success of digital education, highlighting that the mere presence of technology does not guarantee improved outcomes.

In contrast, a study by Zheng et al. (2016) on one-to-one laptop initiatives revealed that the use of digital devices can lead to improvements in academic performance, digital literacy, and student engagement. Digital learning environments allow for individualized learning pathways, greater access to resources, and the integration of interactive and multimedia content that may enhance student motivation and participation. However, the study also found that in areas such as critical thinking and the resolution of complex problems, traditional manual approaches continued to show superior results. This suggests that while digital tools can enhance certain aspects of learning, they may not yet replace the value of deep, conceptual thinking developed through traditional, manual learning processes (Kay et al., 2017).

Further reinforcing this view, Means et al. (2014) emphasize that blended learning—an approach that combines both digital and traditional learning methods—tends to yield better academic outcomes than either method when used in isolation. This finding suggests that the integration of digital technologies with conventional face-to-face teaching approaches is an effective strategy for improving student learning outcomes. The success of blended learning is contingent upon thoughtful consideration of course content, teaching objectives, and the profile of the learners, as well as the optimal integration of both digital and manual components. This hybrid model has the potential to cater to diverse learning preferences, fostering a more holistic and inclusive educational environment.

Therefore, it can be argued that a well-balanced combination of both digital and manual learning approaches, tailored to the subject matter and the individual needs of students, represents an optimal strategy for secondary education. By leveraging the strengths of both

methods, educators can create a more dynamic and engaging learning experience that supports
the development of a wide range of academic and cognitive skills.

Factors Affecting Effectiveness

Several key factors influence the effectiveness of both digital and manual learning, including:

1. Student and Teacher Readiness: Students with high digital literacy are better positioned to succeed in digital learning environments, while teachers who can pedagogically integrate technology into their instruction enhance the effectiveness of its use (Voogt et al., 2015). This readiness requires not only access to digital tools but also a familiarity with how to use them meaningfully within a learning context. The ability to seamlessly integrate digital technologies into teaching practices is crucial in ensuring that digital learning environments foster academic engagement rather than becoming sources of distraction.
2. Learning Design: The effectiveness of learning, whether digital or manual, is significantly influenced by how the content is structured, how interactions are facilitated, and how feedback is provided (Laurillard, 2012). A well-designed learning experience is one that considers the needs of the learners, the subject matter, and the pedagogical objectives. Effective learning design in both digital and manual settings encourages active student participation, fosters meaningful interactions, and provides timely feedback that supports learning improvement.
3. Motivation and Engagement: Digital learning has the potential to significantly enhance student engagement through interactive media, personalized learning pathways, and multimedia content. However, if not managed effectively, digital learning can lead to distractions, reduced focus on academic content, and disengagement from the learning process (Kay et al., 2017; Selwyn, 2016). It is critical to balance the benefits of technological tools with strategies that maintain academic rigor and ensure that students remain focused on their learning objectives.

Theoretical Framework

This study is grounded in several key educational theories:

1. Constructivist Theory (Vygotsky, 1978; Piaget, 1972): This theory emphasizes the role of social interaction and active experience in knowledge construction. According to Vygotsky, learning is a social process where students co-construct understanding through dialogue and collaboration. Piaget's stages of cognitive development further suggest that students at different developmental stages benefit from different types of learning experiences. Constructivism highlights the importance of a learner-centered approach, whether in digital or manual settings, where students actively engage with content and develop a deeper understanding of the material.
2. Cognitive Load Theory (Sweller, 1988): This theory underscores the importance of considering the cognitive load of learners when designing learning experiences. According to Sweller, excessive cognitive load can hinder learning, especially when information is presented in ways that overwhelm the learner's working memory. In the context of digital learning, where multimedia and interactive elements may enhance engagement, careful design is necessary to ensure that cognitive load remains manageable. This theory provides insight into how both digital and manual learning environments must be tailored to minimize unnecessary cognitive strain and optimize learning.
3. Blended Learning Framework (Garrison & Vaughan, 2008): This framework integrates the

best elements of both online and face-to-face learning environments. Blended learning leverages the flexibility and accessibility of digital tools while retaining the personal, interactive nature of traditional learning methods. The integration of digital and manual approaches enables educators to provide a more comprehensive learning experience that caters to diverse student needs, encourages engagement, and fosters deeper learning outcomes.

By combining these theories, this research investigates how digital and manual learning approaches influence academic outcomes, student engagement, and the development of academic skills at the secondary education level. Theoretical frameworks such as constructivism and cognitive load theory provide essential insights into how learners interact with and process information, while the blended learning framework offers practical guidance for integrating both digital and traditional pedagogies effectively.

Methods

This study adopts a quantitative comparative approach with a mixed-methods sequential explanatory design to assess the effectiveness of digital and manual learning on students' academic achievement, engagement, and development of academic skills at SMA Negeri 6 Bandar Lampung. The quasi-experimental design utilizes a non-equivalent control group model, with two groups: one receiving digital learning and the other receiving manual learning. The research will take place during the odd semester of the 2025/2026 academic year, with a sample of 160 grade XI students selected through purposive sampling, ensuring eligibility criteria such as no barriers to digital access and a minimum attendance rate of 90%. Data will be collected through academic tests (pre-test and post-test), an engagement questionnaire adapted from the Student Engagement Instrument, and semi-structured interviews with 10 students from each group and 5 teachers. Quantitative data will be analyzed using statistical tests including the Kolmogorov-Smirnov Test for normality, Levene's Test for homogeneity of variances, Independent Samples T-Test, and Paired Samples T-Test for hypothesis testing, with a significance level of $p < 0.05$. Qualitative data from interviews will be analyzed using thematic analysis. Validity will be ensured through control of external factors and selection of a representative research setting, while reliability will be assessed via Cronbach's Alpha for the questionnaire and KR-20 for academic tests. Ethical considerations, including informed consent, confidentiality, and the right to withdraw from the study, will be strictly followed.

Data Analysis

Quantitative data will be analyzed through a series of statistical procedures. The normality of the data will be tested using the Kolmogorov-Smirnov Test, and the homogeneity of variances will be assessed using Levene's Test. To test the hypotheses, an Independent Samples T-Test will be used to compare the post-test results between groups, while a Paired Samples T-Test will be applied to compare pre-test and post-test results within the same group, with a significance level set at $p < 0.05$. Qualitative data from interviews will be analyzed using thematic analysis, as developed by Braun and Clarke (2006), involving stages such as transcription, coding, theme identification, and the construction of narrative interpretations. The internal validity of the study will be maintained by controlling for external factors such as students' technological backgrounds, while external validity will be enhanced by selecting a research setting that is representative of the secondary education context in Indonesia. The reliability of the instruments will be tested by calculating the reliability coefficients

(Cronbach's Alpha for the questionnaires and KR-20 for the academic tests). All research procedures will be conducted with ethical considerations, including obtaining written consent from the school and parents, ensuring participant anonymity and confidentiality, and granting participants the right to withdraw from the study at any time without consequence.

Descriptive Quantitative Data

This study involved 160 students, divided into two groups: the digital learning group (80 students) and the manual learning group (80 students). Quantitative data were collected from pre-test and post-test results, as well as a student engagement questionnaire.

Pre-Test and Post-Test Results

Prior to the intervention, a pre-test was administered to assess students' initial abilities. The average pre-test score for the digital learning group was 68.4 (SD = 8.3), while the manual learning group had an average pre-test score of 67.9 (SD = 7.8). Independent samples t-test results indicated no significant difference between the two groups at the pre-test stage ($p = 0.627$), suggesting that both groups were equivalent in their baseline performance.

After the intervention, a post-test was conducted. The average post-test score for the digital learning group was 82.7 (SD = 6.5), while the manual learning group scored an average of 78.1 (SD = 7.2). The independent samples t-test revealed a significant difference between the two groups at the post-test stage ($t(158) = 4.215$, $p < 0.001$), indicating that digital learning was significantly more effective in improving academic outcomes compared to manual learning.

Student Engagement Questionnaire Results

The results from the engagement questionnaire indicated that the average engagement score for the digital learning group was 4.21 (on a 5-point scale), while the manual learning group scored 3.89. An independent samples t-test revealed a significant difference between the two groups ($p = 0.003$), with the digital learning group demonstrating higher cognitive and emotional engagement. However, there was no significant difference in the behavioral engagement dimension between the two groups ($p = 0.074$). These findings suggest that digital learning not only significantly enhanced academic outcomes but also positively influenced student engagement in the learning process. Additionally, qualitative data were collected through semi-structured interviews with 10 students from each group and 5 teachers to further enrich the understanding of the findings.

The thematic analysis of student interviews revealed several key themes:

1. Accessibility and Learning Motivation

Most students in the digital learning group reported that the use of technology-based learning tools (such as videos, online quizzes, and interactive platforms) enhanced their motivation to study. One student shared, "Learning through digital media makes me more excited because the material feels more alive and not boring."

2. Conceptual Understanding

On the other hand, some students in the manual learning group expressed that, although traditional methods felt more boring, they felt better able to grasp concepts deeply due to direct interaction with teachers and more intensive class discussions.

3. Technical Difficulties

A few students in the digital learning group faced technical challenges, such as unstable internet connections and limited skills in using certain devices. However, overall, these issues did not significantly hinder the learning process.

The Teachers Interviewed

The teachers interviewed in this study noted that digital learning is highly effective for enhancing student engagement and for facilitating the delivery of complex content with the help of multimedia tools. However, they also pointed out that manual learning is more effective in developing critical thinking skills, face-to-face discussions, and fostering study discipline. One teacher remarked, "Technology is very helpful for capturing students' attention, but to develop reasoning, direct classroom discussions are still necessary." Overall, the findings of this research indicate that the digital learning approach offers significant advantages in increasing student engagement and academic outcomes. However, manual learning still has strengths in fostering deeper conceptual understanding. The integration of both methods in teaching practice is regarded as the most optimal approach..

Discussions

The results of this study indicate that digital learning is significantly more effective in improving students' academic performance compared to manual learning. Quantitative data from the pre-test and post-test revealed a greater improvement in the digital learning group, with an average post-test score of 82.7 compared to 78.1 for the manual learning group. Furthermore, the student engagement questionnaire showed that students in the digital group had higher engagement scores, particularly in cognitive and emotional dimensions. These results underscore the potential of digital learning to enhance academic outcomes, a finding that resonates with global trends in educational technology integration.

These findings align with Hattie's (2009) research, which highlights that the use of technology in learning can enhance student motivation and engagement. Hattie notes that technology-enabled learning provides quicker, interactive feedback, contributing to improved learning outcomes. This is consistent with international studies, such as those by Lai and Hwang (2016), which found that technology-based learning increases student engagement and academic performance, particularly in interactive learning environments. The rise of digital tools in classrooms worldwide—especially in response to the COVID-19 pandemic—has accelerated the need to explore their effects on learning, making this study a valuable contribution to the ongoing global conversation on educational technology.

Qualitative data from student interviews revealed that digital media enhances motivation to learn, although some students encountered technical difficulties. This finding is consistent with Chen et al. (2020), who identified that technical barriers, such as unstable internet access, can hinder the effectiveness of digital learning. This challenge is not unique to Indonesia, as many countries, particularly in rural or underserved regions, continue to face similar issues with infrastructure and access to digital tools (UNESCO, 2020). The results here reflect the broader global need to address such disparities to maximize the benefits of digital learning.

On the other hand, teachers emphasized that while digital learning is effective in capturing students' attention, manual learning remains crucial for developing critical thinking skills and fostering direct interaction. This observation supports Garrison and Anderson’s (2003) findings on the importance of social interaction in learning, which is often more effectively achieved

through traditional methods. As the global education community continues to advocate for blended learning models, integrating both digital and manual approaches seems essential to creating a more balanced, holistic educational experience.

Ultimately, this study suggests that the combination of digital and manual learning provides a more comprehensive strategy to improve students' understanding and critical thinking. Zhao et al. (2005) also support this notion, indicating that the integration of both approaches offers greater benefits in enhancing conceptual understanding and cognitive skills. As countries worldwide look to refine their educational systems, the findings from this study contribute to the growing body of research advocating for blended learning models, demonstrating their potential to bridge the gap between traditional teaching methods and modern digital tools.

Conclusions

This study demonstrates that digital learning is significantly more effective in enhancing students' academic outcomes compared to traditional manual learning. The pre-test and post- test results show a greater improvement in the digital learning group, as well as higher engagement scores in cognitive and emotional dimensions. Although digital learning offers advantages in terms of motivation and engagement, some students faced technical difficulties that could impact the learning process.

On the other hand, traditional learning remains superior in fostering deeper conceptual understanding and critical thinking skills through direct interaction. Therefore, integrating both digital and traditional learning methods is considered the most optimal approach to enhancing student learning outcomes and engagement.

This study provides valuable insights for educators and policymakers in designing effective and adaptive teaching strategies in the digital age. By acknowledging the advantages and challenges of both approaches, educators can create a balanced learning environment that maximizes academic achievement and student involvement. Additionally, the findings contribute to global discussions on the integration of technology in education, offering practical implications for addressing the digital divide and improving educational equity worldwide.

Furthermore, this study contributes theoretically by reinforcing the relevance of constructivist learning theories, cognitive load theory, and the blended learning framework in the context of secondary education. It provides empirical support for the proposition that integrating digital and manual approaches fosters both engagement and deep learning, validating assumptions within the blended learning paradigm. By examining how students cognitively and emotionally respond to both modalities, the study extends the application of cognitive load theory to mixed instructional environments in developing countries. Contextually, this research addresses a critical gap in the literature by providing insights from an Indonesian high school setting, where disparities in digital infrastructure and student readiness remain prevalent. The findings highlight the importance of adaptable pedagogical strategies that balance innovation with inclusivity, especially in socio-educational systems navigating digital transformation. As such, this study not only enriches global discourse on effective learning design but also serves as a reference for policymakers and educators striving to build equitable, context-responsive learning ecosystems in similar educational landscapes.

Limitations and Future Studies

This study has several limitations that should be considered. First, the sample size used was limited to 160 students, which may restrict the generalizability of the findings to a broader population. Therefore, further research with a larger and more diverse sample is recommended to provide more representative results. Additionally, the short duration of the study may not be sufficient to observe the long-term impact of digital and manual learning, suggesting the need for longitudinal research to assess the effectiveness of both methods over a longer period. This study also did not control for other variables that could influence learning outcomes, such as students' educational background, intrinsic motivation, and technological skills. These factors should be considered in future studies to obtain a more comprehensive understanding. Furthermore, the specific learning context of this study may not reflect all educational situations, and results could vary if applied in different environments.

For future research, it is recommended to increase the sample size by involving more students from diverse backgrounds and educational levels to enhance the validity and generalizability of the findings. Longitudinal studies are also highly encouraged to evaluate the long-term effects of digital and manual learning on students' academic performance and engagement. Additionally, it is important to control for other variables that may influence learning outcomes, such as student motivation and parental support, in order to better understand the factors contributing to the success of learning. Future research could also explore hybrid learning models that combine elements from both methods and conduct more in-depth qualitative analysis of students' and teachers' experiences in daily learning practices. By considering these limitations and recommendations, future studies could make a more significant contribution to understanding the effectiveness of digital and manual learning in educational contexts.

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