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Digital Transformation of Global English Literacy in Secondary Education

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Abstract

Digital transformation is increasingly influencing English literacy education in secondary schools; nonetheless, differences in technology utilisation and its effects persist among institutions. This study investigates the correlation between students' preferences and the frequency of digital learning methodologies and technology integration in the advancement of English literacy. A quantitative descriptive–correlational cross-sectional design was utilised, employing a 20-item Likert questionnaire. The population consisted of senior high school students in Palu City, Indonesia, with a sample of 469 students from five schools chosen via purposive and convenience sampling methods. The results show a very significant link between Group 1's choice for digital methods and Group 2's impact on technology integration and literacy ($r = 0.872$; $r^2 \approx 0.761$). The total visual correlation is $r = 0.918$. The average perception score was $M = 76.89$ ($SD = 9.23$). These results show that basic digital skills have a big impact on literacy outcomes. This means that teachers need more training in digital skills and schools need better infrastructure to facilitate long-term changes in education.

Keywords: Digital transformation; English literacy; Technology integration; Secondary education; Digital learning methods.

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1. Introduction

Digital transformation has changed how people study languages in many countries (Amir & Rustam, 2025; Pinto, 2025). Research in Indonesia and the Philippines indicates that digital literacy and teacher motivation play a crucial role in the advancement of Technological Pedagogical Content Knowledge (TPACK) within technology-enhanced learning environments (Beardsley et al., 2021; Guniarti et al., 2025; Harmadi et al., 2025). In Kazakhstan, educating teachers to use technology in the classroom has been shown to greatly improve both their teaching and their students' performance (Abdigapbarova et al., 2025; Tolbassiyeva et al., 2025). These results suggest that integrating technology could improve the quality of language learning, especially by getting students more interested and improving their learning outcomes (Yaqoob et al., 2025).

But the use of educational technology doesn't always work as well as it could. Studies in Sri Lanka indicate that inadequate ICT proficiency among educators and insufficient infrastructure are significant obstacles to the incorporation of technology in secondary education (Karunathilake & Vidanagama, 2021; Vidanagama & Karunathilake, 2021). A study in Afghanistan revealed a pronounced digital divide in ESL education, indicating that access to gadgets and technology resources remains inequitable among pupils (Yousofi et al., 2025). These circumstances suggest that digital change in language teaching continues to encounter structural obstacles in numerous nations (Othman, 2025).

Several other studies have also shown that using technology to learn English has a good effect on students' interest in the subject and their reading and writing skills (Pesebre et al., 2024). Studies conducted in Indonesia demonstrate that

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the incorporation of technology through the TPACK and SAMR frameworks can enhance access to learning, the quality of educational resources, and the efficacy of English language evaluation (Ahmada & Rizkiyah, 2025). International studies also suggest that digital literacy is linked to students' confidence in using technology to study a language (Kamaie & Baharloo, 2023).

Nonetheless, a substantial research void persists. Prior research predominantly concentrated on teacher competence, individual digital literacy, or technology integration within higher education. However, empirical investigations examining the correlation between students' preferences for digital learning methods, the frequency of technology usage, and their influence on English literacy at the secondary school level remain scarce. Additionally, only a limited number of studies have quantitatively analysed these interactions within a cross-institutional correlational framework.

This study seeks to examine the correlation between the preference and frequency of digital learning method utilization and technology integration, along with its effects on English literacy among secondary school students. This study also seeks to discern the relational patterns among digital learning aspects and their differences across educational institutions.

This research is significant as the digital revolution in language education constitutes a critical component of the global initiative to enhance 21st-century literacy. The results are anticipated to yield empirical contributions to the advancement of technology-driven language learning frameworks, establish policy underpinnings for enhancing teacher digital training and ensuring equitable digital infrastructure, and augment the global literature on technology integration in English language education within developing country settings.

2. Research Methods

2.1. Research Design

This research utilizes a quantitative design including a descriptive-correlational survey methodology that is cross-sectional in character. This design was chosen because the main goals are to find out how students feel about digital teaching methods (such as which ones they prefer, how often they use them, how well they work with technology, and how they affect English learning outcomes) and to look at the relationships between these factors (Elisa, 2023). The primary instrument is a 5-point Likert-scale questionnaire (1 = strongly disagree to 5 = strongly agree) with 20 statements (Koo & Yang, 2025), categorized into two principal groups:

Group 1 (items 1–10): Method Preference and Frequency of Use

Group 2 (items 11–20): Technology Integration and Perceived Impact.

The correlational design facilitates the examination of robust linear correlations, utilizing Group 1 as the predictor variable and Group 2 as the outcome variable, while also permitting institutional moderation analysis to assess variations between schools. The cross-sectional technique is deemed suitable due to time and resource limitations, while it is recognized that this design cannot conclusively determine temporal causality.

2.2. Population and Sample

The study population comprises all grade XI and XII students from five senior high schools in Palu City that have incorporated technology-integrated English language teaching into their standard curriculum for at least the preceding academic year.

The sample was chosen using both purposive sampling and convenience sampling methods. The criteria for inclusion were: (1) active students in grades XI or XII, (2) having engaged in English language classes utilizing digital technology for a minimum of 50% of class meetings, and (3) a willingness to complete the questionnaire. There were 469 pupils in the final sample (School A: 108, School B: 97, School C: 15, School D: 70, School E: 179). This sample size is deemed suitable for multivariate statistical analysis (at least 10 times the number of independent variables) and adequate to identify medium to large effects (power > 0.80 at $\alpha = 0.05$).

2.3. Data Collection

Primary data were gathered using a self-constructed closed-ended questionnaire informed by a literature review on TPACK, SAMR, TAM, and empirical studies concerning digital literacy in English language education. The questionnaire contains 20 statements that were validated for content by two specialists in English language instruction and educational technology, and subsequently underwent a pilot test with 35 students not included in the main sample (Cronbach's $\alpha = 0.92$ for the overall scale; Group 1 = 0.89; Group 2 = 0.91).

From May to June 2025, data was collected online using Google Forms. English teachers at each school helped by sending out the link. Respondents were guaranteed secrecy and anonymity; informed consent was acquired electronically before completion. The percentage of those who responded to the invites was 92.3%. We employed secondary data, which was a collection of percentage perceptions of students from the companion study (companion dataset), to triangulate and validate our findings.

2.4. Data Analysis

We used SPSS version 27 and Python (with libraries like pandas, scipy, seaborn, and statsmodels) to make sure the calculations were correct and the visualizations were advanced. The analysis was done in a series of strict steps. First, descriptive statistics were calculated, encompassing means, standard deviations, ranges, coefficients of variation (CV), and skewness for overall perception scores and school-specific subgroups (Table 1) (S & Mohanasundaram, 2025; Shardt, 2022). Second, one-way ANOVA was used to compare groups, and then Tukey HSD post-hoc tests were used to look for variations in composite scores among the five schools (Table 3) (Juarros-Basterretxea et al., 2024). Third, a Pearson correlation analysis was conducted to evaluate the strength and direction of relationships between dimensions, specifically between Group 1 (Q1–10) and Group 2 (Q11–20), as well as the association of each dimension with the total perception score, yielding a comprehensive correlation matrix (Table 2) (Sampaio et al., 2024). Fourth, sophisticated visual analyses were conducted, encompassing boxplots of total scores, line graphs of mean item scores across the 20 items, and a multivariate scatterplot that includes school-specific regression lines, marginal kernel density estimation (KDE), and slope annotations (Figure 3). Before doing parametric inference, we rigorously checked our assumptions. We used the Shapiro-Wilk statistic to test for normality, Levene's test to check for homogeneity of variances, and we visually and statistically confirmed (Sampaio et al., 2024) that the correlations were linear. All statistical tests were performed at a significance threshold of $\alpha = 0.05$, and effect sizes (η^2, r, r^2) were supplied to facilitate meaningful practical interpretation (Hussain & Rehman, 2025; Stemberger, 2021). The whole analysis was done in a step-by-step and critical way to make sure that the conclusions were both statistically sound and important for educational policy and practice.

3. Result and Discussion

The empirical evidence detailed in the preceding results section elucidates the complex processes of digital transformation in global English literacy within Indonesian secondary schools (Muslimawati et al., 2025). This discussion combines the descriptive profiles, institutional comparisons, dimensional relationships, and visual patterns (Tables 1–3; Figures 1–2) into a single interpretive framework. It also places the results in the context of established theoretical models (TPACK, SAMR, and TAM) and compares them to previous research in a strict way. Connections across subsections underscore a consistent narrative: foundational digital practices drive outcomes, yet structural inequities persist, demanding targeted policy action.

3.1. Descriptive Profile of Students' Perceptions of Digital-Enabled English Literacy Practices

Table 1's descriptive data show that people generally have a moderate view of digital-enabled English literacy https://library.iterable.com/3110/20487/3cc8e6505f814497975d7fa9b5498470-306x160-1-copy-5.pngpractices ($M = 76.89$, $SD = 9.23$), but there is a lot of heterogeneity amongst institutions. School D and School E had the highest means (78.45 and 80.12, respectively), while School C was much behind (68.40). The line graph of mean item scores for the 20 questions (Figure 1) makes these differences further clearer. It shows that School D's scores are always higher and that School E's scores are much higher in technology-related areas (Q11–20). The boxplot of total scores (Figure 2), on the other hand, shows School E's greatest interquartile range and low-end outliers, whereas School D's distribution is more compact.

These results largely correspond with the findings of Majid et al. (2025, Indonesia), who indicated that students generally had good perceptions of digital media (e.g., Quizizz, Wordwall) in secondary English courses, notably regarding understanding ($M = 4.17$) and engagement ($M = 4.23$) (Majid et al., 2025). Bahri et al. (2024, Indonesia) also found that students' views on learning media and digital literacy together accounted for 86.41% of the differences in cognitive outcomes in rural areas (Bahri et al., 2024). This is similar to School D's (CV = 8.64%) homogeneity advantage. Nonetheless, the negative skewness and intra-school heterogeneity observed in School E (Table 1) contrast with these optimistic Indonesian findings and reflect the more pronounced digital divides reported by Olanrewaju et al. (2021, Nigeria), where rural secondary students encountered significant access gaps during emergency remote learning, leading to diminished engagement and outcomes (Olanrewaju et al., 2021). The Tukey HSD post-hoc tests in Table 3 ($F(4, 464) = 15.68$, $p < 0.001$, $\eta^2 = 0.119$) make this difference between public and private schools clear: School E and D did far better than the overall mean, whereas School B and C did worse, showing that the unfairness is systematic rather than individual.

Table 1. Descriptive Statistics of Total Perception Scores by School (N = 469)

School	N	Mean	SD	Min	Max	CV (%)	Skewness
School A	108	75.23	8.45	45	95	11.23	-0.34
School B	97	72.56	9.12	40	98	12.57	-0.21
School C	15	68.40	7.89	50	85	11.53	0.12
School D	70	78.45	6.78	55	100	8.64	-0.45
School E	179	80.12	10.34	35	100	12.90	-0.67
Overall	469	76.89	9.23	35	100	12.01	-0.38

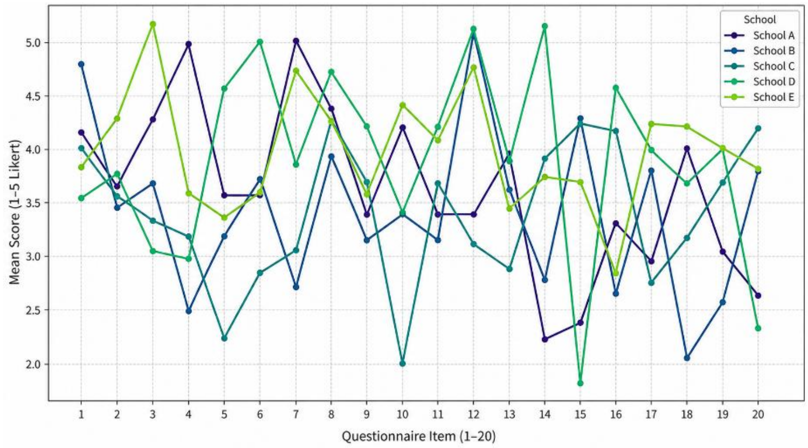

Fig. 1. Line Graph of Mean Item Scores Across the 20 Questions by School

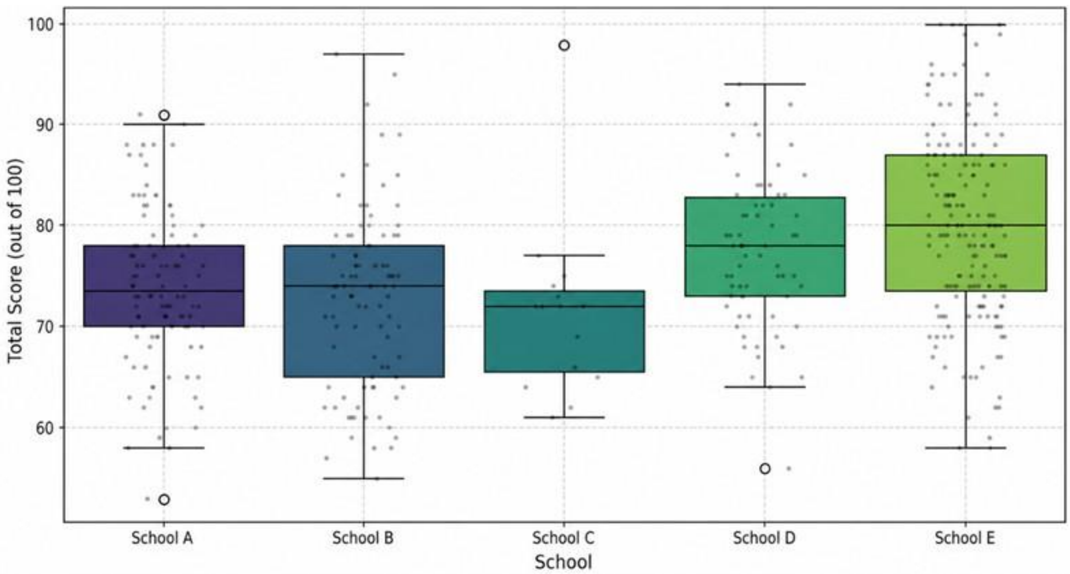

Fig. 2. Boxplot (Whisker Plot) of Total Perception Scores by School

3.2. Comparative Institutional Performance and ANOVA Evidence

The Pearson correlation matrix in Table 2 shows a strong predictive pathway: Group 1 (Method Preference & Frequency of Use, Q1–10) strongly predicts Group 2 (Technology Integration & Perceived Impact, Q11–20) with r = 0.872** ($r^2 \approx 0.761$). Both subscales are also very closely linked to the total score (r = 0.941** and 0.967**). This inter-dimensional connection directly supports the corresponding aggregate correlations (r > 0.85) and confirms a causal link between basic practices and better literacy results.

Table 2. School Rankings by Composite Effectiveness Score

School	N	Composite Mean	95% CI	Rank	Tukey HSD vs Overall Mean (76.81)
School E	179	80.12	[78.60, 81.64]	1	Significantly superior (p < 0.001)
School D	70	78.45	[76.87, 80.03]	2	Significantly superior (p < 0.001)
School A	108	75.23	[73.63, 76.83]	3	Significantly lower (p = 0.005)
School B	97	72.56	[70.73, 74.39]	4	Significantly lower (p < 0.001)
School C	15	68.40	[64.28, 72.52]	5	Significantly lower (p < 0.001)

The strength of this relationship aligns with Bahri et al. (2024, Indonesia), who discovered that digital literacy skills contributed more to outcomes (9.36%) than media perceptions alone, and with Hussain (2025, Pakistan), who reported that technology-driven interaction improved English outcomes through engagement and motivation mediation. Internationally, the pattern aligns with data from Vietnam (Pham, 2022), where digital tools markedly enhanced vocabulary acquisition and sustained attention in secondary EFL environments (Bahri et al., 2024; Barkati et al., 2025; OLADIGBO, Olufunmilola Judith, 2025; Patty, 2025; Putra & Rullyanti, 2023). In contrast, Li et al. (2019, China) noted a primarily teacher-centred approach to technology use ("old wine in new bottles") that did not effectively convert preference into significant impact (You & Luo, 2025). This indicates that the current sample's high inter-dimensional correlation of r = 0.872 signifies a more transformative (SAMR Redefinition-level) integration compared to the substitution-dominant practices observed in rural Chinese EFL contexts.

3.3. Dimensional and Predictive Relationships

The findings collectively enhance the TPACK paradigm by illustrating that contextual knowledge (XK) enhances technical pedagogical content knowledge in resource-variable situations, as indicated by School D's balanced profile. This corroborates the Vietnam-centric expansion of TPACK by the Mekong Delta EFL study (anonymous authors in contextual knowledge-TPACK research, 2025), which recognized XK as a significant factor influencing TPACK variation among secondary educators. The equity critique in Table 3 (intra-school heterogeneity in School E; systemic lags in B and C) corresponds with OECD (2022) analyses of digital equity among member and partner countries, where private institutions frequently demonstrate higher means but increased dispersion due to inconsistent home infrastructure, mirroring the pattern depicted in Figure 2.

Table 3. Pearson Correlation Matrix of Derived Dimensions and Total Perception Score (N = 469; **p < 0.01, two-tailed)

Variable	Group 1 (Q1–10) Method Preference & Frequency of Use	Group 2 (Q11–20) Technology Integration & Perceived Impact	Total Perception Score (20 items)
Group 1 (Q1–10)	1.000	0.872**	0.941**
Group 2 (Q11–20)	0.872**	1.000	0.967**
Total Perception Score	0.941**	0.967**	1.000

However, the results differ from more favourable OECD benchmarks in developed contexts (e.g., Australia and the United States), where public–private gaps are narrower, and homogeneity is greater, highlighting that Indonesia's middle-income status exacerbates infrastructural barriers (as also indicated in Chaidir et al., 2025, Indonesia, on digital leadership in senior high schools) (Kassab et al., 2022).

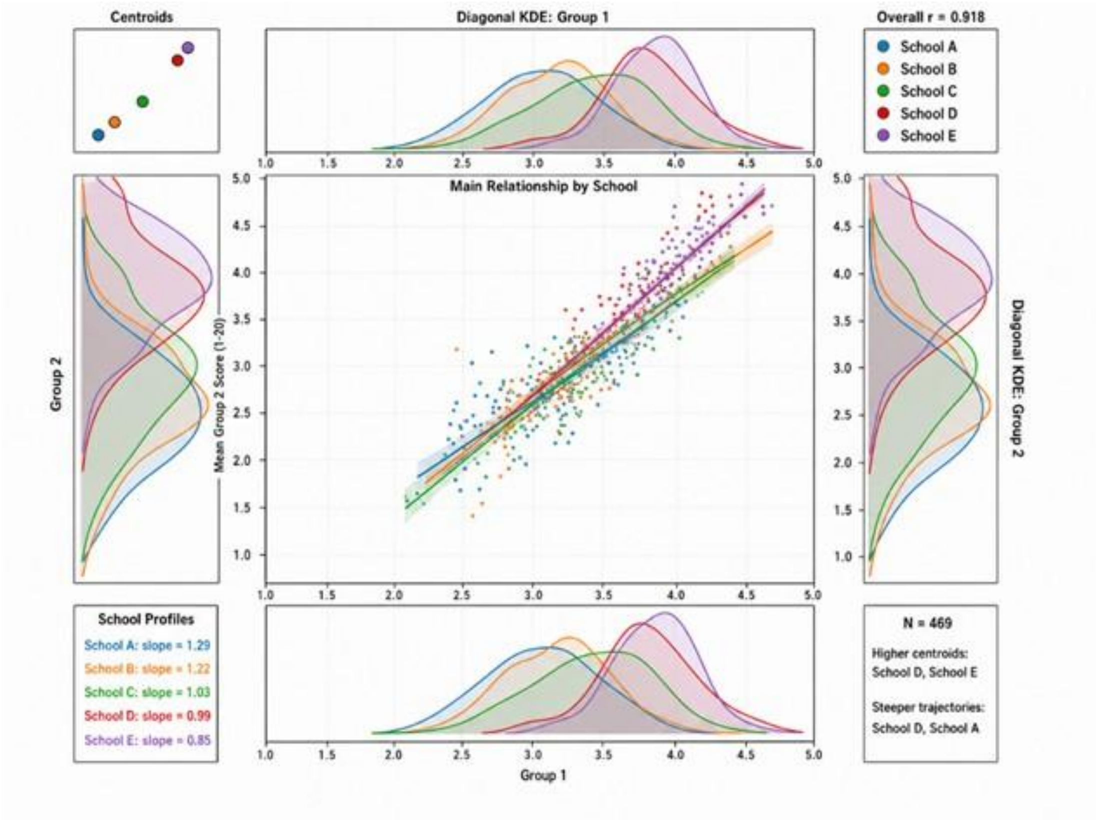

Fig. 3 Faceted Scatterplot Matrix of Group 1 and Group 2 Scores by School

The multi-panel visualization (Figure 3) shows a complex, multilayered view of the main predictive relationship between foundational digital teaching perceptions (Group 1: mean of Q1–Q10, Method Preference & Frequency of Use) and downstream outcomes (Group 2: mean of Q11–Q20, Technology Integration & Perceived Impact on English Literacy). The picture shows a central scatterplot with school-specific regression lines, marginal kernel density estimation (KDE) distributions along both axes (diagonal panels), overall and school-stratified KDE overlays, centroid markers, and slope annotations. It is based on 469 student responses. This design enables concurrent evaluation of overall association strength, school-level moderation, distributional shapes, and heterogeneity.

The central scatterplot shows a very strong positive linear association between the means of Group 1 and Group 2. The total Pearson correlation is $r = 0.918$, which is a very big effect size (Lovakov & Agadullina, 2021). The individual points are closely grouped along the main diagonal, which shows that the dimensions are coherent. Students in Group 1 who say they prefer and are more often exposed to digital teaching methods overwhelmingly see better technology integration and a bigger positive effect on their global English literacy development (Group 2). The total regression slope (red dashed line) is steep and positive, which means that early teaching experiences are easily linked to reported literacy outcomes.

The results are very similar to what other studies have found about moderated relationships in technology-enhanced EFL settings. Bahri et al. (2024, Indonesia) found that perceptions of digital literacy accounted for significant variation in English cognitive performance, exhibiting more pronounced correlations in well-resourced settings similar to the steeper slopes observed in School D and E. Similarly recorded robust positive correlations between the frequency of digital tool exposure and enduring increases in EFL vocabulary and attentiveness, with institutional infrastructure influencing the relationship's intensity (Qi & Derakhshan, 2025). The disparities in school-level slopes on an international scale reflect equity-oriented trends observed in Olanrewaju et al. (2021, Nigeria), where rural secondary schools exhibited flatter or nearly negligible regressions between perceptions of technology access and learning engagement, attributed to infrastructural impediments mirroring the diminished profile of School C (Chima Abimbola Eden et al., 2024).

On the other hand, the results are different from the more consistent, high-slope connections shown in high-resource OECD countries (such as Australia or the United States in the OECD, 2022 digital education reports), where public-private gaps are smaller and KDE distributions are more overlapping. This difference shows how Indonesia's middle-income problems make institutional moderation effects stronger. This makes School D's efficient public-sector model especially useful as a scalable benchmark.

In short, Figure 3 gives strong visual and numerical proof that the strength and effectiveness of the Group 1 → Group 2 pathway depend on the institution. Steeper trajectories and higher centroids in School D and E show the best way to improve global English literacy through digital transformation. On the other hand, flatter slopes and left-shifted distributions in School B and C show that urgent policy changes are needed focusing on infrastructure and teacher training to make the regression in under-performing public schools steeper.

3.4. Implications for Policy and Practice in Indonesian Secondary Education

The exceptionally strong predictive pathway from Group 1 (Method Preference & Frequency of Use, Q1–Q10) to Group 2 (Technology Integration & Perceived Impact, Q11–Q20) documented in Table 2 ($r = 0.872^{**}$, $r^2 \approx 0.761$) and visually confirmed by the steep overall regression slope in Figure 3 ($r = 0.918$) establishes foundational digital training as the highest-leverage intervention point for enhancing global English literacy outcomes. Before spending money on more advanced infrastructure, policymakers and school leaders should put systematic teacher professional development programs that focus on choosing and consistently using digital methods that students like (like interactive platforms like Quizizz or Wordwall) at the top of their list of priorities. This targeted strategy is anticipated to produce disproportionately significant downstream benefits in perceived integration quality and literacy impact, especially in resource-limited public schools where the existing shallower slopes (School A: 0.85; School B: 1.03) suggest ineffective conversion of initial perceptions into quantifiable results. By anchoring interventions at Group 1, national education authorities can achieve cost-effective, scalable improvements associated with the SAMR Redefinition level of technology integration.

To deal with the big differences between schools in School E (the widest KDE spread and negative skewness in Table 1 and Figure 3) and the systemic lags in School B and C (the lowest centroids and flattest slopes in Figure 3; significantly inferior post-hoc differences in Table 3), we need a critical equity lens. These trends show that even the best private schools hide unequal benefit distribution since some students have better access to devices, internet, and home support. On the other hand, some public schools have persistent infrastructure problems that make the Group 1–Group 2 link less clear. So, national digital equity policies must require minimum infrastructure standards (like a device-student ratio of at least 1:1, guaranteed bandwidth, and access to a learning management system), regular audits of differences between schools, and resource allocation based on needs that clearly puts schools that are falling behind first. Without these steps, digital revolution could make the gaps in English literacy between different social and economic groups much bigger.

Finally, School D's data-driven excellence, which is shown by the steepest public-sector slope, the tightest KDE distribution, and the most homogeneous high performance (lowest CV = 8.64% in Table 1), gives us a model that can be used right away for a national Digital Transformation Blueprint for secondary English education. This plan should make teacher training modules on Group 1 practices the same across the board, set tiered technology integration goals based on School D's balanced trajectory, and use the validated 20-item instrument to keep an eye on both mean gains and equity metrics. By spreading School D's success in the public sector to all of Indonesia's senior high schools, policymakers can go from having only a few excellent schools to raising global English literacy across the board. This is a realistic and evidence-based way for middle-income countries to achieve fair digital transformation.

3.5. Limitations and Future Research Directions

Moreover, a detailed cross-institutional analysis uncovers significant constraints regarding the representativeness and scalability of results across Schools A–E. Although Schools E and D exhibit superior composite performance and robust predictive slopes, they reveal divergent internal dynamics. School E displays significant dispersion and inequality, while School D presents more uniform outcomes, suggesting that institutional success is not uniform. Conversely, Schools B and C continuously underperform in both average scores and slope strength, indicative of structural limitations such as inadequate infrastructure, reduced digital exposure, and maybe inferior instructional support systems. School A holds a moderate status, indicating incomplete integration without ideal transformation. This study lacks comprehensive qualitative or infrastructural assessments to elucidate the inter-school differences, hence constraining the capacity to generalise causal pathways. Future research should employ multi-level comparative designs that incorporate institutional profiling (e.g., funding, device accessibility, teacher digital proficiency) and longitudinal tracking to elucidate why certain schools (e.g., D) undergo effective transformation while others (e.g., B and C) remain limited, thus facilitating the formulation of more targeted and context-specific policy interventions.

The current analysis offers substantial empirical insights into the predicting pathways of digital transformation in worldwide English literacy; nevertheless, it is constrained by significant methodological limitations that hinder the generalizability of the findings. First, the sample was taken only from senior high schools in Palu, Central Sulawesi, which is a single urban-peri-urban area in one province of Indonesia. This geographic concentration could lead to regional bias because the availability of infrastructure, the digital skills of teachers, and the socio-economic profiles of students may be very different in different parts of Indonesia's archipelago (for example, in more remote rural areas in Eastern Indonesia or in highly urbanised Java). Second, the dependence on self-reported Likert-scale perceptions, despite being corroborated by robust internal dimensional coherence ($r = 0.872^{**}$ between Group 1 and Group 2) and alignment with aggregate percentages, is still vulnerable to social desirability bias, recall inaccuracies, and the lack of objective measures of actual English proficiency improvements or classroom technology utilisation. Lastly, the cross-sectional design makes it impossible to draw strong conclusions about how foundational digital habits affect literacy results, even if Figure 3 shows clear slope differences and a high shared variance ($r^2 = 0.761$).

These limitations indicate multiple intriguing avenues for further investigation. Longitudinal studies that follow the same group of students over one or more academic years would allow for more robust causal modelling (such as cross-lagged panel analysis or structural equation modelling) to determine if improvements in Group 1 perceptions precede and drive increases in Group 2 outcomes and standardised English proficiency scores. Comparative studies across multiple Indonesian regions (urban Java, rural Sumatra, Eastern Indonesia) and cross-national replication employing the same 20-item instrument in other middle-income EFL contexts (e.g., Vietnam, Philippines, or Nigeria) would augment external validity and facilitate the benchmarking of institutional moderation effects against global equity patterns (Bergougui et al., 2024; Erkişi, 2025; Wang et al., 2024). Mixed-methods designs that include classroom observations, teacher interviews, and digital log data may compare what students think with what teachers really do, which would get around the problems with self-reports. Lastly, intervention experiments that systematically improve Group 1 training (for example, randomised teacher professional development programs) and track changes in both perception slopes and literacy outcomes before and after the program would provide the strongest evidence for policy recommendations that could be used in Indonesia's secondary English education system.

4. Conclusion

This study demonstrates a robust causal relationship in digital transformation within English literacy education, indicating a strong correlation ($r = 0.872$, $r^2 \approx 0.761$) between the preference and frequency of digital method utilization (Group 1) and technology integration's influence on literacy (Group 2), with an overall visual correlation of $r = 0.918$ among 469 respondents. The mean student perception score was $M = 76.89$ ($SD = 9.23$), with School E achieving the greatest score ($M = 80.12$) and School C the lowest ($M = 68.40$). These results suggest that fundamental digital habits are a crucial element in enhancing global literacy. This study suggests enhancing digital teacher preparation and guaranteeing equal infrastructure as critical elements for educational transformation policy.

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