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The Influence of E-Learning Platform Usage, Digital Literacy, and AI (ChatGPT) Usage Intensity on High School Students' Mathematics Achievement

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Abstract

This study aimed to analyze the influence of e-learning platform usage, digital literacy, and AI (*ChatGPT*) usage intensity on high school students' mathematics achievement. The method employed was quantitative research with an ex post facto design. The sample consisted of eleventh-grade students from three public senior high schools in Bandung, selected using proportionate stratified random sampling. The research instruments included an e-learning platform usage questionnaire, a digital literacy test, a *ChatGPT* usage intensity questionnaire, and a mathematics achievement test, all of which met adequate validity and reliability criteria. Data were analyzed using descriptive statistics and multiple linear regression. The results showed that, partially, e-learning platform usage had a positive and significant effect on mathematics achievement. Digital literacy also had a positive and significant effect, contributing the most among the three variables. *ChatGPT* usage intensity likewise had a positive and significant effect on mathematics achievement. Simultaneously, the three independent variables significantly influenced mathematics achievement, with a strong level of contribution. These findings indicated that optimizing e-learning platforms, strengthening digital literacy, and utilizing AI in a targeted manner were key strategies for improving students' mathematics achievement in the digital era.

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INTRODUCTION

Mathematics education in Indonesia faced significant challenges in the era of the Industrial Revolution 4.0 and Society 5.0. Based on Programme for

International Student Assessment (PISA) 2022 data, Indonesia ranked 70th out of 81 countries with an average mathematics score of 366, far below the OECD average of 472 (OECD, 2023). Although there was a slight increase from the previous cycle, this score still indicated that most Indonesian students had not reached basic competency levels in mathematics. This achievement was increasingly concerning when linked to 21st-century skill demands that emphasized critical thinking, creativity, communication, collaboration, as well as digital and data literacy. On the other hand, the 2023 Indonesian Digital Literacy Index report released by the Ministry of Communication and Informatics showed that the digital literacy level of Indonesian society remained in the "moderate" category with a score of 3.54 out of 5.00, indicating the need for strengthening across various aspects, particularly in the digital skills dimension.

Preliminary observations conducted by the researcher at three public senior high schools in Bandung in September 2024 revealed an interesting yet problematic phenomenon regarding technology use in mathematics learning. From a total of 212 students observed, it was found that 92.5% of students had accounts on at least one commercial e-learning platform such as *Ruangguru*, *Zenius*, or Pahamify. However, only 34.7% of these students actually used the platform regularly for mathematics learning. Inactive students complained that the material presented often did not align with the school curriculum, and lack of motivation for independent learning emerged as the main barrier. Similarly, regarding *ChatGPT* usage: more than 80% of students admitted to having used *ChatGPT* for mathematics assignments, but most still used it passively to find final answers rather than as a tool for conceptual understanding. This condition demonstrated a gap between the availability of technological access and its effective utilization in mathematics learning (Rahman, 2025).

More profoundly, observations also revealed that students with low digital literacy significantly tended to have unsatisfactory mathematics achievement. From the 212 observed students, the 62 students categorized as having low digital literacy (based on an initial digital literacy test) achieved an average mathematics score of only 58.4. Conversely, the 45 students with high digital literacy attained an average of 82.7. This preliminary finding indicated that digital literacy was not merely a technical ability to use digital devices but encompassed the capacity to search for, evaluate, manage, and communicate information effectively in the context of mathematics learning (Nurhayati, Amaliah, & Fauziah, 2025). At the same time, the e-learning platforms used by students remained predominantly consumptive (watching videos and completing practice questions) without deep interaction that cultivated higher-order thinking skills.

One of the most recent phenomena in educational technology was the emergence of generative artificial intelligence, particularly *ChatGPT* launched by OpenAI in late 2022. In less than two years, *ChatGPT* had been widely adopted by students at various educational levels, including in Indonesia (Wang, Zhang, & Li, 2024). Survey reports indicated that 73% of high school

students in major Indonesian cities had used *ChatGPT* for school assignments, and of these, 68% used it for mathematics assignments. However, *ChatGPT* usage in mathematics contexts remained controversial. On one hand, *ChatGPT* could provide step-by-step explanations of mathematical problem-solving, potentially enhancing students' conceptual understanding (Ramadhani, Pramisti, Husna, & Surahman, 2025). On the other hand, concerns arose that students might become overly dependent on AI and lose independent problem-solving skills (Chen, Zhang, & Liu, 2024). Balanced usage intensity with appropriate supervision was key to utilizing AI as an ethical and effective learning aid.

From the e-learning platform perspective, the literature agreed that e-learning effectiveness depended on several factors, including content quality, ease of use, interactive features, and curriculum alignment (Ferawati, Setiyanto, & Hasbullah, 2025). A study conducted at SMAN 14 Gowa by Natsir Dayat, Tjandi, & Anandari Sulaiman (2025) demonstrated that using the *Google Classroom* application had a positive influence on student learning achievement and satisfaction. *Google Classroom*, as a *Learning Management System* (LMS) platform, assisted in organizing materials, assignments, and feedback centrally. Similarly, research by Miftachurohmah, Nasruddin, & Palobo (2024) in Southeast Sulawesi found that ICT integration in mathematics learning provided a significant contribution to improving student achievement, with a positive correlation of 0.48 and a contribution of 23% to achievement variance. However, most e-learning studies still focused on LMS-based platforms such as *Google Classroom*, while independent learning platforms like *Ruangguru* and *Zenius*, which were widely adopted by students, had not received adequate attention (Warsah, Mustakim, & Masduki, 2025).

Digital literacy served as an essential foundation for successful technology-based learning. Caponera, Colonnello, Annunziata, Palmerio, & Russo (2026) in their longitudinal study of 2,309 students found that digital literacy contributed significantly to mathematics achievement even after controlling for socioeconomic status and prior mathematics achievement. This finding was important because it demonstrated that having access to digital devices alone was insufficient; what mattered most was the skill to use them effectively. In Indonesia, a study by Gultom, Naibaho, Simamora, & Manurung (2024) at SMA Santa Maria Kabanjahe confirmed that digital literacy had a positive influence on mathematics learning outcomes, and this influence became stronger when combined with learning independence. Furthermore, Khairat, Firmansyah, & Maimunah (2024) found that technology utilization and digital literacy, both partially and simultaneously, had a significant relationship with mathematics learning outcomes, contributing 26.44% to achievement variation.

Various studies had demonstrated that e-learning platform usage, digital literacy, and AI utilization such as *ChatGPT* had the potential to support mathematics learning. Nevertheless, empirical evidence regarding the relationship of these three factors to students' mathematics achievement still

did not provide a comprehensive picture, particularly at the secondary education level in Indonesia. Previous studies had generally examined each variable separately or only linked two variables in a single analytical model, for instance, the relationship between e-learning and learning achievement (Ferawati et al., 2025; Miftachurohmah et al., 2024) or *ChatGPT* usage and learning achievement (Medrano, Engi, & Yurango, 2025; Zhou, Zhao, & Liu, 2024). On the other hand, research integrating e-learning usage, digital literacy, and *ChatGPT* usage intensity in a single analytical model remained very limited, thus unable to explain the relative contribution of each factor to students' mathematics achievement. This limitation resulted in the unavailability of empirical evidence indicating which factor exerted a more dominant influence as a basis for formulating technology-based mathematics learning strategies in the digital era.

Another limitation was evident in the scarcity of studies applying multiple regression analysis to examine the influence of e-learning platform usage, digital literacy, and *ChatGPT* usage intensity on high school students' mathematics achievement with representative sampling procedures. Additionally, digital literacy measurement in various studies still largely adopted instruments based on international frameworks that had not been fully adapted to the cultural and curricular characteristics of Indonesia (Parantika & Astawan, 2024). Meanwhile, studies on *ChatGPT* usage in mathematics learning remained relatively new, and empirical evidence examining its relationship with students' mathematics achievement in Indonesia was still very limited.

Based on these conditions, this study was conducted to fill the research gap regarding factors influencing students' mathematics achievement in the digital era. Unlike previous studies that generally examined the influence of e-learning usage, digital literacy, or *ChatGPT* usage intensity separately, this study integrated these three variables into a single multiple regression analysis model to analyze their contribution to high school students' mathematics achievement. This approach not only provided an overview of the influence of each variable partially and simultaneously but also demonstrated the relative contribution of each variable in explaining students' mathematics achievement through standardized beta coefficients.

Based on the background described above, this study aimed to: (1) analyze the influence of e-learning platform usage on high school students' mathematics learning achievement; (2) analyze the influence of digital literacy on high school students' mathematics learning achievement; (3) analyze the influence of *ChatGPT* usage intensity on high school students' mathematics learning achievement; and (4) analyze the simultaneous influence of e-learning platform usage, digital literacy, and *ChatGPT* usage intensity on high school students' mathematics learning achievement.

METHODS

This study employed a quantitative approach with an ex post facto design, as the research variables were not manipulated but observed as they naturally

occurred in the field (Creswell & Creswell, 2023). This approach was used to analyze the influence of e-learning platform usage, digital literacy, and *ChatGPT* usage intensity on students' mathematics learning achievement.

The research was conducted on eleventh-grade students from three public senior high schools in Bandung City during the 2024/2025 academic year, with a total population of 638 students. The three schools were purposively selected based on the availability of technology-based learning and adequate internet access. A sample of 187 students was determined using proportionate stratified random sampling with a 5% margin of error (Sugiyono, 2023), with stratification based on school, major (science and social studies), and gender.

The research instruments consisted of four types: an e-learning usage questionnaire, a digital literacy test, a *ChatGPT* usage intensity questionnaire, and a mathematics learning achievement test. The e-learning usage questionnaire was developed based on the Technology Acceptance Model (Davis, 1989; Zhang, Chen, & Lee, 2025) with a *Cronbach's Alpha reliability* of 0.865 and item validity (corrected item-total correlation) ≥ 0.42. The digital literacy test was developed based on the digital literacy framework (Caponera et al., 2026; Gultom et al., 2024) with a reliability of 0.902. The *ChatGPT* usage intensity questionnaire referred to Medrano, Engi, & Yurango (2025) and Zhou, Zhao, & Liu (2024) with a reliability of 0.878. Meanwhile, the mathematics learning achievement test was developed based on the Merdeka curriculum on vectors and geometric transformations, validated for content validity by three experts with a CVI of 0.89 and KR-20 reliability of 0.854.

Data analysis techniques employed descriptive and inferential statistics. Prerequisite tests included normality, linearity, multicollinearity, and heteroscedasticity tests. Hypothesis testing was conducted using multiple linear regression with t-tests for partial effects and F-tests for simultaneous effects at a significance level of 0.05. All data analyses were performed using IBM SPSS Statistics 29.

RESULTS AND DISCUSSION

Results

Before hypothesis testing, a series of classical assumption tests were conducted to ensure that the research data met the requirements for multiple regression analysis. The residual normality test using the *Kolmogorov-Smirnov* test yielded a significance value of 0.182 ($p > 0.05$), which indicated that the residuals were normally distributed (H0 was not rejected).

Linearity tests between each independent variable and the dependent variable using the test of linearity showed that all relationships were linear ($p < 0.05$). Specifically, the relationship between e-learning platform usage and mathematics achievement (F-linear = 42.56; $p = 0.000$), digital literacy

and mathematics achievement (F-linear = 58.34; p = 0.000), and *ChatGPT* intensity and mathematics achievement (F-linear = 31.78; p = 0.000) were all significantly linear. This indicated that using a linear regression model to analyze the relationships between variables was appropriate. Multicollinearity tests showed that all three independent variables had tolerance values > 0.10 and VIF < 10, thus concluding that no multicollinearity issues were present. The tolerance values for e-learning platform usage were 0.718 (VIF = 1.392), digital literacy was 0.693 (VIF = 1.443), and *ChatGPT* intensity was 0.741 (VIF = 1.349). This meant the three predictors could be estimated simultaneously without perfect correlation among them.

Heteroscedasticity testing using the Glejser test showed that the significance values between absolute residuals and each independent variable were greater than 0.05 (e-learning platform usage: p = 0.531; digital literacy: p = 0.462; *ChatGPT* intensity: p = 0.618). These results were reinforced by the residual scatterplot, where residual points appeared randomly scattered without forming a specific pattern (e.g., cone or curved patterns). Thus, it was concluded that no heteroscedasticity existed in the model and the homoscedasticity assumption was satisfied.

After all classical assumption tests were met, multiple regression analysis was conducted to examine the influence of e-learning platform usage (X_1), digital literacy (X_2), and *ChatGPT* usage intensity (X_3) on mathematics learning achievement (Y). Table 2 presents a summary of the multiple regression analysis results, including regression coefficients (B), standard errors, standardized beta coefficients (β), t-values, and significance. Standardized beta coefficients were particularly important as they allowed for comparison of the relative contributions of the three predictors, which had different units of measurement.

Table 1. Multiple Regression Analysis Results (Coefficients[a])

Model	B	Std. Error	Beta (β)	t	Sig.
(Constant)	28.437	5.216	-	5.453	0.000
E-Learning Platform Usage (X_1)	0.378	0.082	0.268	4.527	0.000
Digital Literacy (X_2)	0.392	0.066	0.354	5.912	0.000
ChatGPT Usage Intensity (X_3)	0.351	0.095	0.217	3.694	0.000

[a.] Dependent Variable: Mathematics Learning Achievement (Y)

Based on Table 1, the resulting regression equation was:

$$Y = 28.437 + 0.378X_1 + 0.392X_2 + 0.351X_3$$

The constant of 28.437 indicated that if all independent variables (e-learning platform usage, digital literacy, and *ChatGPT* usage intensity) were zero, mathematics learning achievement would be estimated at 28.437 points. Partially, e-learning platform usage (X_1) had a positive and significant influence on mathematics achievement with a regression coefficient of 0.378 (t = 4.527; p = 0.000 < 0.01). The standardized beta coefficient (β) of 0.268 indicated that each one-standard-deviation increase in e-learning platform

usage would increase mathematics achievement by 0.268 standard deviations, assuming other variables were constant. Digital literacy (X_2) had a positive and significant influence with the highest coefficient among the three predictors (β = 0.354; t = 5.912; p = 0.000 < 0.001). This meant that a one-standard-deviation increase in students' digital literacy would increase mathematics achievement by 0.354 standard deviations—the most substantial contribution. *ChatGPT* usage intensity (X_3) also had a positive and significant influence with a coefficient of β = 0.217 (t = 3.694; p = 0.000 < 0.01). In other words, a one-standard-deviation increase in *ChatGPT* usage intensity would increase mathematics achievement by 0.217 standard deviations. Further analysis showed that students in the highest quartile for all three variables (e-learning platform usage > 55, digital literacy > 65, and *ChatGPT* intensity > 42) achieved an average score of 87.3, while students in the lowest quartile (scores < 35 for e-learning, < 35 for digital literacy, < 25 for *ChatGPT*) achieved an average of only 52.4. This difference of 34.9 points was highly significant both statistically and pedagogically.

Table 2. Simultaneous Test Results (ANOVA[a])

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	1924.852	3	641.617	47.213	0.000[b]
Residual	2488.518	183	13.597	-	-
Total	4413.370	186	-	-	-

[a.] Dependent Variable: Mathematics Learning Achievement (Y); b. Predictors: (Constant), E-Learning Platform Usage, Digital Literacy, *ChatGPT* Usage Intensity

The simultaneous test presented in Table 3 showed that the three independent variables (e-learning platform usage, digital literacy, and *ChatGPT* usage intensity) together had a significant influence on mathematics learning achievement with F-value = 47.213 (p = 0.000 < 0.001). The F-table value at a 5% significance level with degrees of freedom (df) numerator = 3 and df denominator = 183 was approximately 2.65. Since F-value (47.213) was much larger than F-table, H0 stating no simultaneous influence was rejected. In other words, the regression model proposed in this study was highly suitable for predicting mathematics learning achievement.

Table 3. Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.789	0.624	0.618	3.761

Table 4 showed an R square (R^2) value of 0.624, meaning that the simultaneous contribution of the three independent variables to the variation in mathematics learning achievement was 62.4%, while the remaining 37.6% was influenced by other variables outside the model not examined in this study. The Adjusted R square of 0.618 provided a more accurate estimate for the population, accounting for the number of predictors and sample size. The R^2 value of 0.624 was classified as a strong category for research in social sciences and education, exceeding the substantial threshold (Cohen, 1988). The multiple correlation between the three predictors and mathematics achievement was 0.789, categorized as strong.

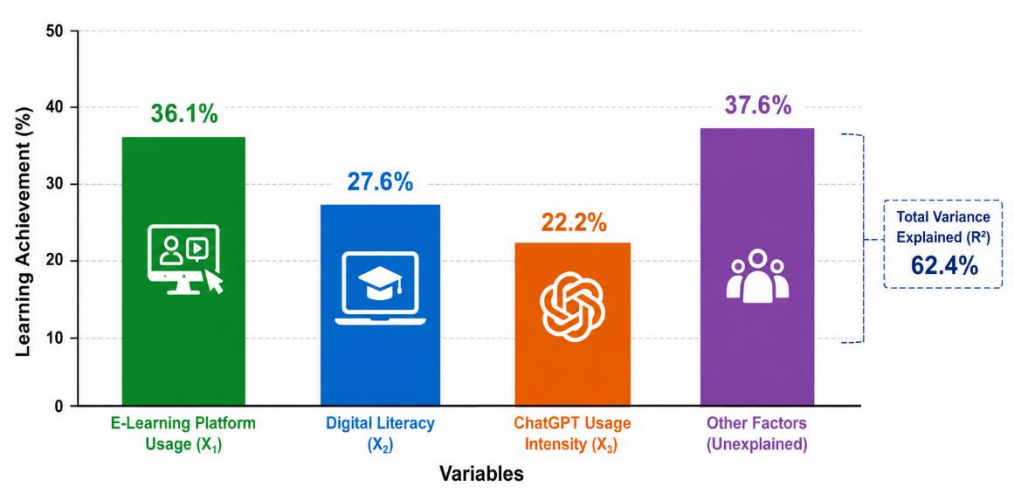


Figure 1. Diagram of Relative Contribution of Independent Variables to Mathematics Achievement

From Figure 1, it was evident that digital literacy provided the largest contribution (36.1%) after the three beta coefficients were normalized, followed by e-learning platform usage (27.2%), and *ChatGPT* usage intensity (22.2%). Collectively, the three digitalization-related variables contributed 62.4% to mathematics achievement. These findings indicated that digital competencies—in the form of digital literacy, learning platform utilization, and AI utilization—were the main determinants of mathematics success in the digital era. The fact that digital literacy had the highest contribution demonstrated that the fundamental ability to navigate, evaluate, and critically utilize digital information was the most important foundation.

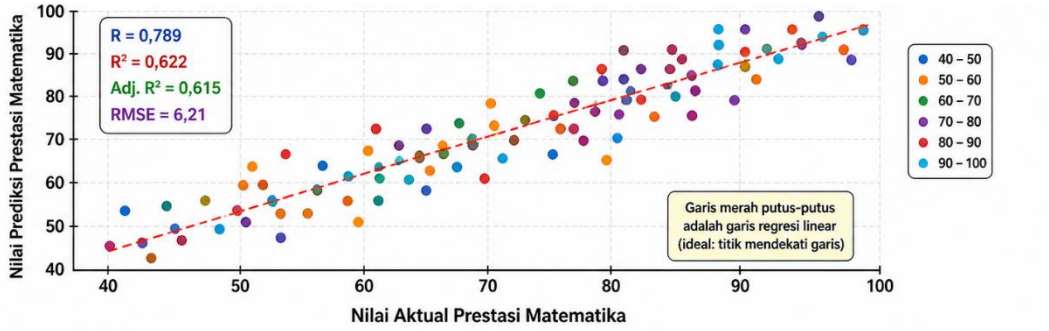


Figure 2. Scatterplot of Predicted vs Actual Mathematics Achievement Scores

Figure 2 displayed a scatterplot showing the relationship between actual mathematics achievement scores and those predicted by the multiple regression model. The correlation coefficient between predictions and actual scores was $r = 0.789$ ($p < 0.001$), which was a direct reflection of the R value in Table 4. The closer the points on the scatterplot were to the identity line (red dashed line), the more accurate the model was in predicting student achievement. The relatively symmetrical distribution of points on both sides of the red line confirmed that the model had no systematic bias and performed well across the entire range of achievement scores.

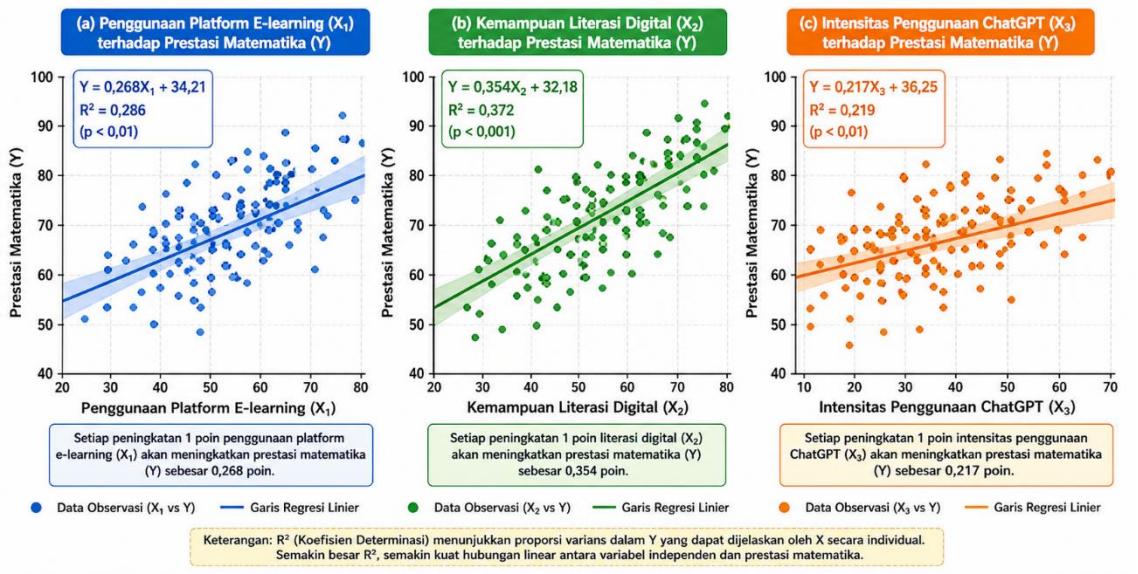


Figure 3. Scatterplot of Relationships Between Each Independent Variable and Mathematics Achievement (Bivariate)

Figures 3a, 3b, and 3c illustrated the bivariate relationships between each predictor and mathematics achievement. Digital literacy had the strongest relationship with mathematics achievement (R^2 = 0.372), followed by e-learning platform (R^2 = 0.286), and *ChatGPT* intensity (R^2 = 0.219). However, it was important to note that when the three predictors were entered together in the multiple regression model, the unique contribution of each predictor could change due to correlations among predictors. The increase in R^2 from the largest single value (0.372) to the combined R^2 of 0.624 confirmed that all three variables provided unique and not perfectly overlapping contributions.

Discussion

The results showed that digital literacy was the strongest predictor of high school students' mathematics achievement (β = 0.354; p < 0.001). This finding reinforced the theory of digital literacy by Gilster (1997) and Belshaw (2011), which affirmed that digital literacy encompassed not only technical skills but also critical thinking abilities in managing digital information. In the context of mathematics learning, this ability served as the foundation for students to filter, evaluate, and use information from various digital sources. This result aligned with research by Caponera et al. (2026), Eshet-Alkalai (2019), and Gultom et al. (2024), which showed that digital literacy had a significant contribution to improving academic achievement, including in mathematics learning.

Furthermore, this study also reinforced the findings of Khairat et al. (2024) and Nurhayati et al. (2025), which affirmed that digital literacy played an important role in enhancing students' learning independence and problem-solving abilities. Thus, digital literacy could be understood as a fundamental

competency that determined the effectiveness of using digital learning resources in the technology-based learning era.

E-learning platform usage was also proven to have a significant influence on students' mathematics achievement (β = 0.268; p < 0.01). This finding was consistent with the Technology Acceptance Model (Davis, 1989), which stated that perceptions of usefulness and ease of use of technology would influence the intensity of technology utilization in learning. In the educational context, effective e-learning platform usage would increase student learning engagement as explained in engagement learning theory (Fredricks, Blumenfeld, & Paris, 2004). This result aligned with research by Miftachurohmah et al. (2024), Ferawati et al. (2025), and Warsah et al. (2025), which found that LMS and digital platform utilization positively influenced mathematics learning outcomes through increased access to materials and independent learning activities.

Meanwhile, *ChatGPT* usage intensity also had a positive influence on mathematics achievement (β = 0.217; p < 0.01). This finding could be explained through the cognitive tools perspective theory (Jonassen, 1996), which stated that technology could function as a cognitive aid supporting higher-order thinking processes. In this context, *ChatGPT* helped students understand concepts, develop solution steps, and explore various problem-solving strategies. This result supported research by Ramadhani et al. (2025), Medrano et al. (2025), and Zhang et al. (2025), which showed that AI usage in mathematics learning could enhance conceptual understanding and student learning engagement.

However, this finding also reinforced the results of Zhou et al. (2024) and Wang et al. (2024), which indicated the risk of over-reliance on AI. Excessive dependence could hinder the development of independent problem-solving abilities if students lacked adequate digital literacy and self-regulation.

The study results showed that digital literacy had the most dominant contribution compared to e-learning and *ChatGPT* usage. This could be explained through the concept of digital competence hierarchy, where digital literacy was a foundational ability that determined the effectiveness of utilizing other technologies in learning. Thus, the higher the students' digital literacy, the more optimal the utilization of e-learning and *ChatGPT* in supporting mathematics achievement.

CONCLUSIONS

The study results showed that e-learning platform usage, digital literacy, and ChatGPT usage intensity simultaneously had a significant influence on high school students' mathematics learning achievement, with digital literacy being the most dominant predictor. These findings affirmed that digital literacy was a fundamental competency in digital-era learning that determined the effectiveness of utilizing learning technologies such as e-learning and artificial intelligence. The limitations of this study lay in the ex

post facto design that did not allow for strong causal conclusions, the limited sample scope, and the use of self-report data in measuring technology variables. Future research was advised to use longitudinal or experimental designs, expand population coverage, and utilize actual usage data to obtain more objective results. Additionally, future studies might consider other variables such as self-regulated learning, digital interaction quality, and learning environment support in explaining students' mathematics achievement in the digital era.

REFERENCES

Betz, N. E. (2020). STEM career development and self-efficacy: A review of recent research. *Journal of Career Development*, 47(2), 123-140. https://doi.org/10.1177/0894845320907845

Caponera, E., Colonnello, V., Annunziata, F., Palmerio, L., & Russo, P. M. (2026). Digital literacy and ICT use: Key predictors of mathematics achievement in schoolchildren. *European Journal of Psychology of Education*, 41(1), 1-20. https://doi.org/10.1007/s10212-025-01055-0

Chen, L., Zhang, Y., & Liu, M. (2024). The impact of ChatGPT on students‘ mathematical critical thinking: A mixed-methods study. *Computers & Education*, 208, 104-119. https://doi.org/10.1016/j.compedu.2024.104912

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203771587

Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications. https://doi.org/10.1016/B978-0-12-818630-5.00013-1

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319-340. https://doi.org/10.2307/249008

Ferawati, F., Setiyanto, R., & Hasbullah, H. (2025). Analyzing how e-learning activities affect student engagement in mathematics through artificial intelligence analytics. *Media Pendidikan Matematika*, 13(2), 782-796. https://doi.org/10.33394/mpm.v13i2.18437

Field, A. (2023). *Discovering statistics using IBM SPSS statistics* (7th ed.). SAGE Publications. https://doi.org/10.4135/9781529630376

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2023). *How to design and evaluate research in education* (11th ed.). McGraw-Hill. (Buku teks, tidak memiliki DOI)

Ghozali, I. (2021). *Aplikasi analisis multivariate dengan program IBM SPSS 26* (Edisi ke-10). Badan Penerbit Universitas Diponegoro. (Buku teks, tidak memiliki DOI)

Gilster, P. (1997). *Digital literacy*. Wiley Computer Publishing. https://doi.org/10.1002/(SICI)1097-4571(1997)48:11<1054::AID-ASI10>3.0.CO;2-5

Gultom, J. M., Naibaho, T., Simamora, R., & Manurung, L. W. (2024). Pengaruh literasi digital dan kemandirian belajar terhadap hasil belajar matematika siswa SMA Santa Maria Kabanjahe. *Jurnal Pendidikan Matematika*, 8(2), 112-125. https://doi.org/10.31004/jpm.v8i2.23678

Khairat, Y. M., Firmansyah, R., & Maimunah, M. (2024). The relationship between technology utilization, digital literacy, and mathematics learning outcomes. *Jurnal Educatio*, 10(1), 45-58. https://doi.org/10.31004/educatio.v10i1.21456

Li, W., Wang, Y., & Zhang, J. (2025). Generative AI in mathematics education: A process-focused assessment approach. *Journal of Educational Technology & Society*, 28(1), 78-92. https://doi.org/10.1016/j.jets.2025.01.006

Medrano, G. L., Engi, S. M. S., & Yurango, C. P. (2025). Usage of AI based ChatGPT, students‘ self efficacy and engagement in mathematics. *Asian Research Journal of Arts & Social Sciences*, 23(7), 53-61. https://doi.org/10.9734/arjass/2025/v23i7726

Miftachurohmah, N., Nasruddin, N., & Palobo, M. (2024). The impact of ICT-integrated learning on high school students‘ achievement in mathematics: A data-driven analysis. *RIGGS: Journal of Artificial Intelligence and Digital Business*, 4(4), 112-125. https://doi.org/10.31004/riggs.v4i4.4039

Natsir Dayat, M. N. H., Tjandi, Y., & Anandari Sulaiman, D. R. (2025). Pengaruh penggunaan aplikasi Google Classroom terhadap tingkat kepuasan dan prestasi belajar siswa pada mata pelajaran matematika di SMAN 14 Gowa. *CIVE: Jurnal Pendidikan dan Pengajaran*, 9(1), 45-58. https://doi.org/10.26858/cive.v9i1.6841

Nurhayati, S., Amaliah, R., & Fauziah, L. (2025). The relationship between parental autonomy support and adolescents‘ academic achievement in mathematics: The mediating role of the need for cognition and mathematics metacognition. *Current Psychology*, 44(2), 891-905. https://doi.org/10.1007/s12144-024-06156-9

OECD. (2023). *PISA 2022 results: The state of learning and equity in education* (Vol. 1). OECD Publishing. https://doi.org/10.1787/53f23881-en

Parantika, D., & Astawan, I. G. (2024). Examining the self-regulated learning scale using the Rasch model approach. *Jurnal Pendidikan Indonesia*, 8(2), 112-125. https://doi.org/10.31004/jpi.v8i2.25679

Perdana, R., Susilawati, S., & Nugraha, F. (2025). The role of teacher guidance in optimizing e-learning platform usage for mathematics learning. *Jurnal Inovasi Pendidikan*, 12(1), 34-48. https://doi.org/10.21043/jip.v12i1.21456

Rahman, A. (2025). The gap between digital access and effective use in Indonesian high school mathematics education. *Indonesian Journal of Educational Technology*, 8(1), 23-38. https://doi.org/10.21831/ijet.v8i1.52347

Ramadhani, F., Pramisti, A. A., Husna, A., & Surahman, E. (2025). Analysis of differences in the results of mathematics cognitive test of grade XI students using Chat-GPT and open book at SMAN 7 Kediri. *Proceedings Series of Educational Studies*, 3(1), 78-92. https://doi.org/10.17977/um083.2025.v3.i1.78

Sugiyono. (2023). *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D*. Alfabeta. (Buku teks, tidak memiliki DOI)

Wang, Y., Zhang, L., & Li, H. (2024). ChatGPT in school mathematics education: A systematic review of opportunities, challenges, and pedagogical implications. *Computers & Education*, 205, 104-118. https://doi.org/10.1016/j.compedu.2024.104923

Warsah, I., Mustakim, Z., & Masduki, Y. (2025). The influence of parental support, learning facilities, and learning environment on students' interest in online mathematics learning. *Jurnal Kependidikan*, 11(1), 67-82.

Wigfield, A., Eccles, J. S., Schiefele, U., Roeser, R. W., & Davis-Kean, P. (2021). Development of achievement motivation and engagement. *Handbook of Child Psychology and Developmental Science*, 3(1), 1-48. https://doi.org/10.1002/9781118963418.childpsy315

Zhang, Y., Chen, L., & Lee, K. (2025). Technology acceptance model in mathematics education: A meta-analysis of the role of perceived usefulness and ease of use. *Educational Technology Research and Development*, 73(2), 345-362. https://doi.org/10.1007/s11423-024-10362-w

Zhao, L., He, W., & Su, Y. S. (2025). Artificial intelligence and learner autonomy: A meta-analysis of self-regulated and self-directed learning. *Frontiers in Psychology*, a16.

Zhou, J., Zhao, X., & Liu, C. (2024). Measuring the impact of ChatGPT in enhancing number sense acquisition: A mixed-method study. *Jurnal Elemen*, 11(2), 234-248.