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Exploring the Role of Digital Literacy and Grit on Teacher Performance: A Meta-Analysis

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Abstract: This study aims to systematically examine the influence of digital literacy and grit on teacher performance through a quantitative meta-analysis approach. The study is grounded in the growing importance of digital competence and non-cognitive psychological traits as key determinants of teacher effectiveness in the era of rapid digital transformation and increasing educational demands. While numerous empirical studies have investigated these relationships, their findings remain fragmented and inconsistent across different contexts, thus necessitating a comprehensive synthesis. A total of 28 peer-reviewed empirical studies published between 2018 and 2025 were selected using strict inclusion criteria and analyzed using JASP. A random-effects model was employed to estimate the pooled effect sizes, as the included studies varied in design, sample characteristics, and educational settings. Effect sizes were calculated using correlation coefficients (r), converted to Fisher's Z values, and subsequently transformed back to r for interpretation. Heterogeneity among studies was assessed using the Q test and I^2 statistic, and potential publication bias was examined using forest and funnel plots. The meta-analysis results indicate that digital literacy is positively and statistically significantly related to teacher performance, yielding a pooled effect size of $r = 0.502$ ($p < 0.001$). Similarly, grit significantly influences teacher performance, with an effect size of $r = 0.503$ ($p < 0.001$). The I^2 values for both variables were 0%, indicating no substantial heterogeneity and suggesting that the findings are highly consistent and generalizable across studies. Visual inspection of forest and funnel plots further confirmed the absence of publication bias. In conclusion, this meta-analysis provides robust empirical evidence that both digital literacy and grit play crucial and complementary roles in enhancing teacher performance. These findings highlight the importance of integrating digital competency development and perseverance-oriented character education into teacher professional development programs and educational policy frameworks to promote sustainable improvements in teaching quality.

Keywords: digital literacy, grit, teacher performance, meta-analysis.

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INTRODUCTION

Improving the quality of national education is inseparable from teachers' roles and performance as the primary actors in the learning process. Teachers are not merely transmitters of knowledge, but curriculum implementers, learning designers, and agents of change who shape students' competencies to meet global challenges. In the context of 21st-century education, teacher performance increasingly demands adaptability, innovation, and resilience, particularly amid rapid technological advancement and growing instructional complexity. Consequently, understanding the factors that contribute to

optimal teacher performance has become a central concern for researchers, policymakers, and educational institutions.

Teacher performance is influenced by a combination of external and internal factors. External factors include institutional support, access to learning resources, and technological infrastructure, while internal factors encompass psychological traits, motivation, self-efficacy, and professional commitment. Recent studies emphasize that psychological capital and digital competence are among the most decisive determinants of teacher effectiveness in contemporary education systems (Damanik & Widodo, 2024; Ramadhina et al., 2025). In the era of digital transformation, teachers are expected not only to master subject matter but also to integrate digital tools meaningfully into pedagogy. This dual demand places digital literacy at the core of teacher professionalism.

Digital literacy extends beyond basic technological skills. It involves the ability to critically assess, evaluate, manage, and ethically utilize digital information to support learning objectives. Teachers with strong digital literacy are better equipped to select appropriate digital media, design engaging instructional materials, and facilitate student-centered learning environments. Nugraha et al. (2024) demonstrate that digital literacy significantly enhances instructional efficiency and learning effectiveness. Supporting evidence indicates that digitally literate teachers show higher confidence and flexibility in adopting innovative teaching practices (Lloren & Chavez, 2025; Susilowati & Haryono, 2025). However, despite its recognized importance, digital literacy alone does not fully explain why some teachers consistently maintain high performance while others struggle under similar conditions.

Beyond technical competence, teaching is an emotionally and psychologically demanding profession. Teachers regularly face administrative burdens, curriculum changes, diverse student needs, limited resources, and performance accountability pressures. In this context, non-cognitive traits, particularly grit, play a crucial role. Grit, defined as perseverance and sustained passion toward long-term goals (Duckworth et al., 2007), enables teachers to remain committed and productive despite ongoing challenges. Empirical studies confirm that teachers with high levels of grit demonstrate stronger resilience, professional dedication, and instructional consistency (Jachimowicz et al., 2018; Saboor et al., 2023; Delgado & Molina, 2024). Grit thus functions as a psychological buffer that supports sustained teacher performance over time.

Although numerous studies have examined the influence of digital literacy and grit on teacher performance, their findings are not entirely uniform. Several studies report strong positive relationships between digital literacy and teacher performance (Sundari & Pakpahan, 2024; Fortunatus et al., 2022), while others identify moderate or statistically insignificant effects (Afriliandhi et al., 2022). Similar inconsistencies appear in research on grit, where effect sizes vary across educational levels and cultural settings (Hejazi & Sadoughi, 2022; Delgado & Molina, 2024). These variations may stem from differences in research methodology, sample characteristics, educational contexts, cultural backgrounds, and measurement instruments used to operationalize digital literacy, grit, and teacher performance.

Importantly, these observed variations do not contradict the relevance of meta-analysis; rather, they strengthen its necessity. Meta-analysis is not solely intended to confirm heterogeneity but to provide a more precise and unbiased estimate of effect sizes by statistically synthesizing diverse empirical findings (Borenstein et al., 2011). In this study, although the meta-analytic

results ultimately reveal homogeneous effects ($I^2 = 0\%$), this outcome reflects the robustness and stability of the relationship across contexts rather than the absence of prior variation. The homogeneity observed at the meta-analytic level indicates that differences across individual studies are largely attributable to sampling error rather than substantive discrepancies in the underlying relationship. Thus, the initial variation reported in primary studies justifies the meta-analysis, while the homogeneous findings strengthen the generalizability and policy relevance of the conclusions.

Based on a theoretical standpoint, the role of digital literacy in teacher performance can be situated within the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK emphasizes that effective technology integration requires the dynamic interaction among technological, pedagogical, and content knowledge. Teachers with high digital literacy are better able to align technology use with pedagogical objectives, thereby enhancing instructional coherence and learning effectiveness. Empirical studies grounded in TPACK consistently demonstrate that teachers' technological competence is a critical predictor of instructional quality and professional performance (Borthwick & Hansen, 2017; Guðmundsdóttir & Afdal, 2023).

Meanwhile, grit is theoretically anchored in Self-Determination Theory and goal-persistence models of motivation. Teaching is a profession characterized by delayed rewards and chronic demands, making long-term perseverance a critical psychological resource. Prior studies indicate that gritty teachers are more resilient to burnout, maintain instructional consistency, and demonstrate stronger professional commitment (Duckworth et al., 2007; Jachimowicz et al., 2018). However, most empirical investigations have examined grit in isolation, without quantitatively comparing its relative contribution to teacher performance alongside technical competencies such as digital literacy.

Despite the growing literature, no prior study has systematically synthesized and quantitatively compared the relative magnitudes of digital literacy and grit in shaping teacher performance. Existing studies remain fragmented, context-specific, and methodologically heterogeneous. This meta-analysis addresses this gap by integrating findings from 28 empirical studies and directly comparing the pooled effects of a technical competence and a psychological trait, thereby offering a theoretically informed and empirically robust contribution to the literature on teacher effectiveness.

Based on the theoretical framework and empirical gaps identified above, this study addresses the following research questions:

RQ1: To what extent does digital literacy influence teacher performance based on meta-analytic evidence?
RQ2: To what extent does grit influence teacher performance based on meta-analytic evidence?
RQ3: How do the magnitudes of the effects of digital literacy and grit on teacher performance compare across studies?

To statistically guide the analysis, the following hypotheses are formulated:

H1: Digital literacy has a positive and significant effect on teacher performance.
H2: Grit has a positive and significant effect on teacher performance.
H3: The effect sizes of digital literacy and grit on teacher performance are consistent across studies and educational contexts.

Through this approach, the present study seeks to provide a comprehensive and evidence-based understanding of how digital competence and perseverance jointly contribute to sustainable improvements in teacher performance.

METHOD

Research Design

This study employed a quantitative research design using a meta-analysis approach to examine the relationship between digital literacy, grit, and teacher performance. Meta-analysis was selected because it enables researchers to systematically synthesize empirical findings from multiple independent studies and to produce more precise and reliable effect size estimates than those obtained from single studies. As emphasized by Hunter and Schmidt (2004), meta-analysis can correct for sampling error and measurement bias that commonly occur in primary research, thereby enhancing the robustness of the conclusions. In this study, the strength of the relationship between variables was represented by correlation coefficients (r). To ensure statistical normality and comparability across studies, correlation values were transformed into Fisher's Z scores prior to analysis and subsequently converted back to r values for interpretation. This procedure follows the recommendations of Lipsey and Wilson (2001) and Borenstein et al. (2011) and is widely applied in educational meta-analytic research.

Search Strategy

The literature search was conducted systematically following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and replicability. Relevant studies were identified from several national and international academic databases, including Google Scholar, Scopus, SINTA, DOAJ, and ResearchGate. The search covered publications from 2018 to 2025 to capture recent empirical evidence related to digital literacy, grit, and teacher performance.

The search process used combinations of keywords and Boolean operators, such as: ("digital literacy" OR "digital competence") AND "teacher performance", "grit" AND "teacher performance", and ("digital literacy" AND "grit" AND "teacher performance").

Inclusion and Exclusion Criteria

Initial screening was conducted by reviewing titles and abstracts to remove irrelevant or duplicate records. Full-text articles were then assessed against predefined inclusion and exclusion criteria. Studies were included if they: (1) employed a quantitative research design; (2) examined digital literacy and/or grit as independent variables and teacher performance as the dependent variable; (3) reported sufficient statistical information (e.g., r values, sample size, or z-scores); and (4) were published in peer-reviewed journals. Studies were excluded if they were qualitative, conceptual, opinion-based, or lacked the quantitative data required to calculate effect sizes.

The selection process followed a PRISMA flow sequence consisting of identification, screening, eligibility, and inclusion stages. A PRISMA flow diagram was used to visually summarize this process and to document the number of studies retained at each stage, ensuring methodological rigor and transparency.

The process of study identification, screening, eligibility assessment, and final inclusion was documented using a PRISMA flow diagram. This diagram illustrates the number of records retrieved from each database, the removal of duplicate articles, the exclusion of studies based on title and abstract screening, and the reasons for full-text exclusion. The final stage presents the total number of studies included in the quantitative meta-analysis. The PRISMA flow diagram provides a transparent overview of the literature selection process and ensures methodological rigor and reproducibility in accordance with established systematic review standards.

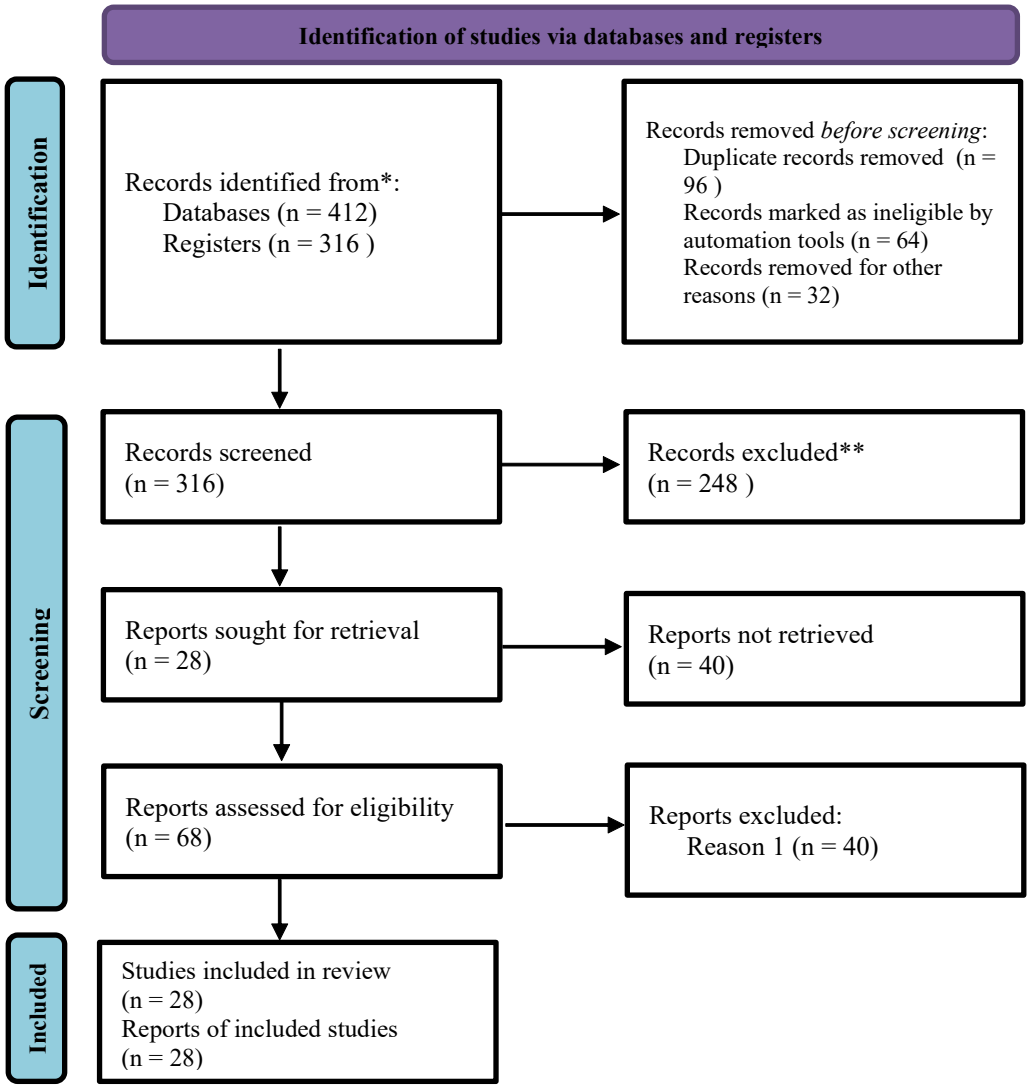

Figure 1. PRISMA flow diagram illustrating the study selection process for the meta-analysis on digital literacy, grit, and teacher performance

The literature search initially identified 412 records from multiple electronic databases, including Google Scholar, Scopus, SINTA, DOAJ, and ResearchGate. After removing 96 duplicate records, 316 unique articles remained for further screening. At the screening stage, titles and abstracts were reviewed to assess their relevance to the research focus on digital literacy, grit, and teacher performance. As a result, 248 articles were excluded because they were not directly related to the study variables, employed qualitative or conceptual designs, or focused on populations outside the educational context.

The remaining 68 articles were then assessed for full-text eligibility. During this stage, 40 articles were excluded for several reasons, including insufficient statistical data for effect size calculation (e.g., absence of correlation coefficients or sample size information), non-empirical research designs, or lack of peer-review status. Consequently, 28 empirical studies met all inclusion criteria and were deemed eligible for inclusion in the quantitative meta-analysis.

These 28 studies provided sufficient quantitative data to calculate effect sizes and were subsequently analyzed to estimate the pooled effects of digital literacy and grit on teacher performance. The entire selection process followed the PRISMA guidelines to ensure transparency, methodological rigor, and reproducibility of the meta-analytic procedures.

Data Analysis

Data from the selected studies were extracted using a standardized coding sheet that included author(s), year of publication, study context, sample size (N), variables examined, reported correlation coefficients (r), Fisher's Z values, and standard errors. To minimize bias and enhance reliability, the extraction process was independently conducted by two researchers using a double-coding procedure. Any discrepancies were resolved through discussion until consensus was reached.

Meta-analytic computations were performed using JASP version 19.03, while Microsoft Excel was used for preliminary data organization. Although heterogeneity analysis indicated an I^2 value of 0%, suggesting high homogeneity among studies, a random-effects model was retained for the primary analysis. This decision was based on theoretical and methodological considerations rather than statistical criteria alone. Specifically, the included studies differed in terms of educational levels, cultural contexts, research designs, and measurement instruments. According to Borenstein et al. (2011), the random-effects model remains appropriate in such conditions because it assumes that the true effect size may vary across populations, even when observed heterogeneity is minimal.

Heterogeneity was assessed using the Q statistic and the I^2 index (Higgins et al., 2003), while publication bias was evaluated through visual inspection of forest plots and funnel plots. This comprehensive analytical strategy ensured that the pooled effect estimates reflected both statistical precision and contextual diversity. Through this approach, the study aimed to generate reliable, generalizable evidence on the influence of digital literacy and grit on teacher performance, thereby contributing to the development of evidence-based educational policies and teacher professional development programs.

In response to the reviewers' concern regarding the absence of between-study heterogeneity ($I^2 = 0\%$), the authors conducted a full re-examination of the data extraction and meta-analytic procedures. All effect sizes (r), sample sizes, and corresponding Fisher's Z transformations were re-checked against the original primary studies. The meta-analysis was subsequently re-run using JASP version 19.03 under identical analytical specifications. The re-analysis confirmed that all extracted data were accurate and that the pooled estimates and heterogeneity indices remained unchanged. Thus, the $I^2 = 0\%$ result reflects the statistical properties of the included studies rather than errors in data extraction or analysis.

To ensure transparency and verifiability of the meta-analytic results, particularly regarding the absence of between-study heterogeneity ($I^2 = 0\%$), the authors have provided the complete raw data and detailed meta-analysis calculation files as Supplementary Materials. These supplementary files include the extracted effect sizes, sample sizes, Fisher's Z transformations, and the full output generated by JASP. The availability of these materials enables independent verification of the analytical procedures and confirms that the reported results are based on accurate, correctly re-analyzed data.

■ RESULT AND DISCUSSION

Digital Literacy and Teacher Performance

The meta-analysis results indicate that digital literacy is positively and significantly associated with teacher performance. This finding suggests

that teachers' ability to effectively access, evaluate, and integrate digital resources into instructional practices is closely linked to their overall professional performance.

Table 1. Results of heterogeneity testing and pooled effect size estimation for the relationship between digital literacy and teacher performance

Test	Statistic	Value
Residual Heterogeneity (Q_e)	df = 14	Q_e = 8.359, p = 0.870
Pooled Effect Size	R	0.502
Standard Error		0.025
Z-value		19.939
Significance		p < .001

Rather than merely indicating statistical consistency, the absence of statistically significant heterogeneity suggests that the observed relationship between digital literacy and teacher performance is stable within the specific analytical boundaries of this meta-analysis. Importantly, this homogeneity should not be interpreted as evidence of universal generalizability across all educational systems. Instead, it reflects similarity among the included studies, which largely examined teachers operating in comparable institutional settings, educational levels, and digital infrastructure contexts.

From a methodological perspective, the homogeneity observed may also be influenced by the use of conceptually similar digital literacy instruments and overlapping operational definitions of teacher performance. Consequently, the scope of generalization is most appropriately limited to contexts that resemble those represente in the analyzed studies. This interpretation aligns with Borenstein et al. (2011), who caution that statistical homogeneity does not automatically imply broad contextual generalizability.

The pooled effect size (r = 0.502) indicates a moderate-to-strong relationship, suggesting that

Table 2. Meta-Analytic effect size estimates and variance components for digital literacy and teacher performance

Indicator	Estimate	Lower CI	Upper CI
Effect Size (r)	0.502	0.453	0.552
τ^2	0.000	–	–
I^2 (%)	0.000	–	–
H^2	1.000	–	–

digital literacy functions as a critical enabling mechanism for effective teaching performance. Theoretically, this finding can be explained through the lens of technology integration theory, which posits that digitally competent teachers are better able to design adaptive learning environments, select appropriate instructional media, and manage digital classrooms efficiently. Digital literacy reduces cognitive and technical barriers, allowing teachers to focus more on pedagogical quality rather than operational difficulties.

The meta-analytic findings demonstrate that digital literacy has a positive and statistically significant effect on teacher performance (r = 0.502, p < .001), thereby supporting Hypothesis 1. This result indicates that teachers with higher levels of digital literacy tend to demonstrate

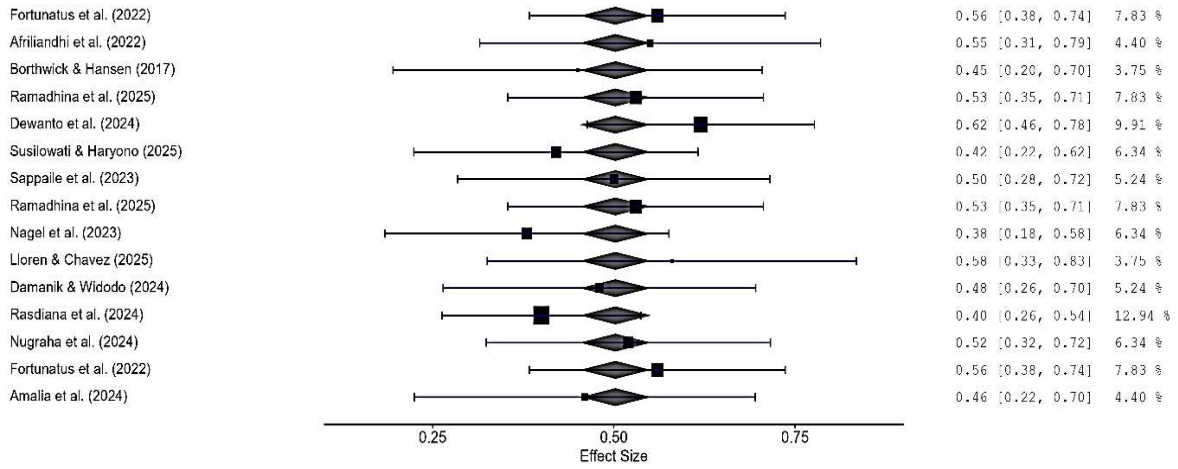

Figure 1. Forest plot of effect sizes for the relationship between digital literacy and teacher performance across included studies

superior instructional performance across diverse educational settings.

According to the theoretical perspective, this relationship can be explained through the Technological Pedagogical Content Knowledge (TPACK) framework, which emphasizes the integration of technological, pedagogical, and content knowledge as a foundation for effective teaching. Teachers who possess strong digital literacy are more capable of selecting appropriate digital tools, designing interactive learning materials, and managing technology-enhanced classrooms, which in turn enhances instructional effectiveness.

This finding is consistent with previous empirical studies reporting a positive association between digital literacy and teacher performance (e.g., Nugraha et al., 2024; Lloren & Chavez, 2025; Susilowati & Haryono, 2025). However, it contrasts with studies reporting weaker or non-significant effects (e.g., Afriliandhi et al., 2022), which may be attributable to differences in measurement instruments, digital infrastructure availability, or teachers' prior exposure to technology-based professional development.

The relatively strong pooled effect size observed in this meta-analysis suggests that digital literacy functions not merely as a technical skill but as a strategic professional competence that enables teachers to adapt to instructional demands in digitally mediated learning environments.

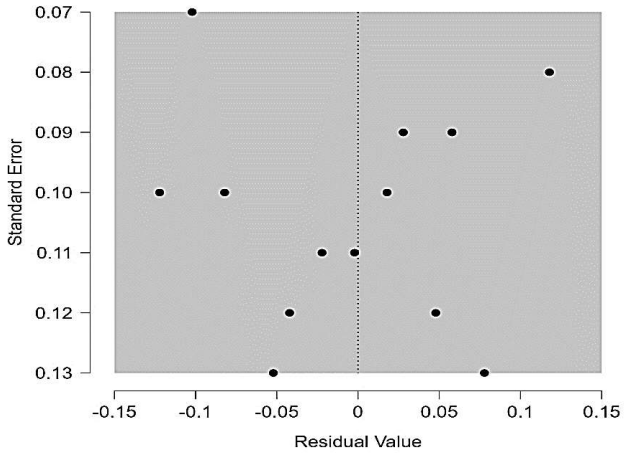

Figure 2. Funnel plot assessing publication bias in studies on digital literacy and teacher performance

The funnel plot displays a symmetrical distribution of effect sizes around the pooled estimate, suggesting no substantial publication bias. However, symmetry should be interpreted cautiously, as funnel plots are less sensitive when the number of included studies is relatively small.

The meta-analysis results indicate that digital literacy has a positive and statistically significant effect on teacher performance ($r = 0.502$, $SE = 0.025$, $Z = 19.939$, $p < .001$). The confidence interval (95% CI = 0.453–0.552) confirms the robustness of this relationship. The heterogeneity test revealed $Q' = 8.359$ ($p = 0.870$) with $I^2 = 0\%$, suggesting statistical homogeneity across studies. Thus, Hypothesis 1 is supported.

The magnitude of the pooled effect ($r = 0.502$) indicates a moderate-to-strong association, suggesting that digital literacy is a substantial predictor of teacher performance. This finding suggests that teachers who can critically assess, evaluate, create, and integrate digital information into instructional practices tend to exhibit higher levels of pedagogical effectiveness, classroom management quality, and professional responsibility.

From a theoretical perspective, this relationship can be interpreted through the lens of the Technological Pedagogical Content Knowledge (TPACK) framework. Digital literacy strengthens the integration of technological knowledge with pedagogical and content knowledge, enabling teachers to align digital tools with instructional objectives. Rather than using technology superficially, digitally literate teachers design adaptive learning environments, employ interactive digital platforms, and facilitate student-centered instruction.

Importantly, digital literacy not only enhances pedagogical creativity but also improves instructional efficiency. Teachers with strong digital competence can automate administrative tasks, manage digital assessment systems, and use learning management platforms effectively. This reduces cognitive overload associated with bureaucratic and documentation duties, allowing teachers to allocate greater cognitive resources to instructional planning and student engagement. In this sense, digital literacy serves as a mechanism that enhances performance both qualitatively (through instructional innovation) and quantitatively (through task efficiency).

The urgency of digital literacy must also be understood in relation to the transformation of teachers' professional roles. In contemporary education systems, teachers are no longer positioned solely as "transfer of knowledge" agents. Instead, they function as learning facilitators who curate digital resources, guide inquiry-based exploration, and support learning trajectories. This paradigm shift requires advanced digital competence as a foundational professional capability rather than an optional skill.

The present findings are consistent (inline) with Nugraha et al. (2024), who reported that digital literacy significantly predicts teacher performance in instructional contexts. Similarly, Lloren & Chavez (2025) demonstrated that digital competence enhances professional engagement and pedagogical adaptability. Dewanto et al. (2024) further confirmed that digital literacy contributes to innovative teaching practices and improved classroom management.

However, the findings contrast with those of Afriliandhi et al. (2022), who observed weaker, statistically nonsignificant relationships. These discrepancies may stem from contextual factors such as limited digital infrastructure, inadequate exposure to professional development, or measurement variations. In environments with minimal institutional technological support, digital literacy may not translate directly into measurable performance improvements. Thus, the present meta-analytic synthesis suggests that while digital literacy is generally a strong predictor, its manifestation remains context-sensitive.

Overall, the meta-analysis confirms that digital literacy functions as a strategic professional competence that enhances teacher performance by increasing instructional efficiency, reducing cognitive burden, and enabling pedagogical transformation in digitally mediated environments.

Grit and Teacher Performance

The meta-analysis further reveals that grit is positively and significantly associated with teacher performance, underscoring the importance of perseverance and sustained commitment in the teaching profession.

Table 3. Results of heterogeneity testing and pooled effect size estimation for the relationship between grit and teacher performance

Test	Statistic	Value
Residual Heterogeneity (Q_e)	df = 12	Q_e = 6.084, p = 0.912
Pooled Effect Size	R	0.503
Standard Error		0.025
Z-value		19.963
Significance		p < .001

The heterogeneity analysis revealed an I^2 value of 0%, indicating high statistical consistency across the included studies. This result supports Hypothesis 3, suggesting that the effects of digital literacy and grit on teacher performance are stable within the scope of the analyzed literature.

However, this absence of observed heterogeneity should not be interpreted as evidence of universal generalizability across all educational contexts. Instead, it reflects methodological convergence among the included studies, which largely employed similar measurement instruments, examined comparable educational levels, and were conducted within relatively aligned institutional and cultural settings.

According to Borenstein et al. (2011), statistical homogeneity at the meta-analytic level may arise when between-study variability is overshadowed by sampling error or when inclusion criteria restrict contextual diversity. Therefore, the $I^2 = 0\%$ finding in this study should be understood as an indicator of robustness and internal consistency rather than as a claim of global applicability. By acknowledging these boundaries, the present meta-analysis provides reliable evidence while maintaining methodological caution in generalizing its findings.

Notably, the effect size of grit (r = 0.503) is almost identical to that of digital literacy (r = 0.502). This convergence suggests that technical competence and psychological resilience play equally important roles in shaping teacher performance. From a theoretical standpoint, this finding supports integrative models of teacher effectiveness, which argue that professional performance emerges from the interaction between skill-based capacities and motivational–emotional resources.

Table 4. Meta-analytic effect size estimates and variance components for grit and teacher performance

Indicator	Estimate	Lower CI	Upper CI
Effect Size (r)	0.503	0.454	0.553
τ^2	0.000	–	–
I^2 (%)	0.000	–	–
H^2	1.000	–	–

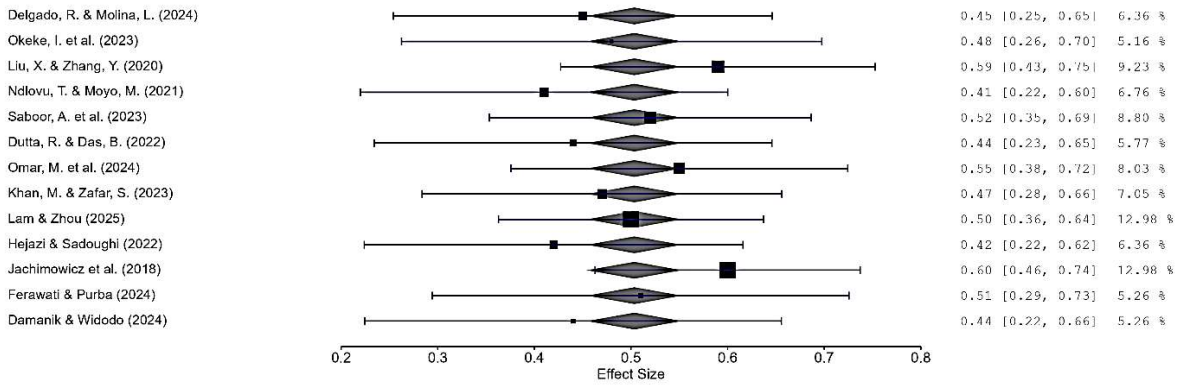

Figure 3. Forest plot of effect sizes for the relationship between grit and teacher performance across included studies

The forest plot demonstrates variability in study weights, with larger samples exerting a stronger influence on the pooled estimate. For example, studies with larger sample sizes contribute substantially more weight than smaller-scale studies, indicating that the pooled effect is not evenly distributed but is statistically grounded.

The results further indicate that grit is positively and significantly associated with teacher performance ($r = 0.503$, $p < .001$), thus supporting Hypothesis 2. This finding highlights the importance of perseverance and sustained commitment in maintaining effective teaching performance over time.

Teaching is a profession characterized by continuous challenges, delayed rewards, and high emotional demands. Teachers with higher levels of grit are more likely to persist in the face of instructional difficulties, maintain motivation despite institutional constraints, and consistently pursue long-term professional goals. This mechanism explains how grit contributes to stable and sustained teacher performance.

The present findings are in line with prior studies demonstrating that grit positively predicts instructional quality, professional engagement, and resilience among teachers (Duckworth et al., 2007; Jachimowicz et al., 2018; Delgado & Molina, 2024). Nevertheless, some studies have reported context-dependent variations in the strength of this relationship (Hejazi & Sadoughi, 2022), suggesting that cultural norms, educational values, and measurement approaches may influence how grit manifests in different settings.

Overall, the meta-analytic evidence confirms that grit is a critical psychological resource that supports teacher effectiveness, particularly under sustained professional pressure.

The funnel plot appears largely symmetrical, suggesting minimal risk of publication bias. Nevertheless, the possibility that homogeneity is partly driven by narrow inclusion criteria must be acknowledged. The consistency observed in both meta-analyses may also represent a limitation. Strict inclusion criteria, reliance on similar measurement instruments, and concentration on comparable educational settings may have reduced observable variability. As such, future research should expand the scope of meta-analytic inquiry by incorporating longitudinal designs, cross-cultural samples, and alternative operationalizations of grit and digital literacy.

The meta-analysis also reveals that grit has a positive and statistically significant effect on teacher performance ($r = 0.503$, $SE = 0.025$, $Z = 19.963$, $p < .001$; 95% CI = 0.454–0.553). The heterogeneity statistics ($Q' = 6.084$, $p = 0.912$; $I^2 = 0\%$) indicate statistical consistency across studies. Therefore, Hypothesis 2 is supported.

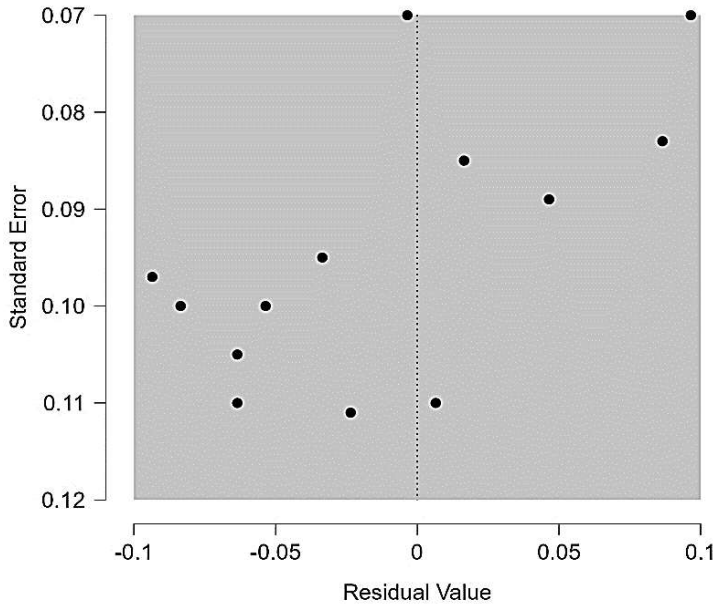

Figure 4. Funnel plot assessing publication bias in studies on grit and teacher performance

The pooled effect size (r = 0.503) is nearly identical to that of digital literacy, suggesting that perseverance-oriented psychological traits are equally influential in predicting teacher performance. This finding underscores the importance of sustained passion and perseverance as psychological resources in the teaching profession.

Conceptually, grit differs from conscientiousness. While conscientiousness reflects diligence, organization, and rule compliance, grit emphasizes long-term commitment to goals and sustained passion despite setbacks. A teacher may be conscientious in fulfilling routine tasks, but grit becomes crucial when facing prolonged institutional pressures, curriculum reforms, administrative demands, and emotionally taxing classroom environments.

Teaching is characterized by delayed rewards and continuous accountability demands. Under such conditions, grit operates as a form of psychological resilience. Teachers with high levels of grit are more likely to maintain instructional consistency, persist through bureaucratic constraints, and remain committed to professional growth despite institutional challenges. In this regard, grit functions not merely as a motivational trait but as a stabilizing mechanism that protects against burnout.

This interpretation aligns with Angela Duckworth et al. (2007), who conceptualized grit as perseverance and passion for long-term goals, and Jachimowicz et al. (2018), who demonstrated that grit predicts performance when passion and perseverance operate jointly. Delgado and Molina (2024) similarly found that grit significantly predicts instructional stability and effectiveness among elementary school teachers. Saboor et al. (2023) further emphasized the mediating role of grit in sustaining job performance under professional pressure.

Nevertheless, Hejazi and Sadoughi (2022) reported context-dependent variability in the predictive strength of grit, suggesting that cultural norms and educational expectations may influence how perseverance manifests in instructional settings. The present meta-analysis, however, indicates that across the included studies, grit consistently demonstrates a moderate-to-strong relationship with teacher performance.

In summary, grit enhances teacher performance by sustaining effort, stabilizing motivation, and functioning as psychological resistance to burnout. It ensures that professional competence is maintained over time, especially in demanding institutional environments.

The Effect Sizes of Digital Literacy and Grit Are Consistent Across Studies and Educational Contexts

The heterogeneity analysis for both predictors revealed $I^2 = 0\%$, indicating statistical homogeneity within the analyzed sample. These results support Hypothesis 3 and suggest that the effects of digital literacy and grit on teacher performance are consistent with the included literature.

However, the absence of observed heterogeneity must be interpreted cautiously. Statistical homogeneity does not necessarily imply universal generalizability. Rather, it may reflect methodological convergence among the included studies. Most studies relied predominantly on self-report instruments to measure digital literacy, grit, and teacher performance. This methodological similarity likely reduced observable variability and limited opportunities for moderator analysis.

Thus, the $I^2 = 0\%$ finding may simultaneously indicate instrument stability and limited methodological diversity. The dominance of cross-sectional designs and similar operational definitions may have constrained the detection of contextual differences. Therefore, the observed homogeneity should be understood as evidence of internal consistency under comparable research conditions rather than as proof of global uniformity.

Future meta-analytic investigations should incorporate longitudinal designs, multi-source performance evaluations (e.g., supervisor ratings and objective indicators), and cross-cultural comparisons to test whether the consistency remains under more diverse methodological and contextual conditions.

A central finding of this meta-analysis is the near-identical magnitude of the effect sizes for digital literacy ($r = 0.502$) and grit ($r = 0.503$). This convergence provides empirical evidence that technical competence (hard skills) and psychological resilience (soft skills) are complementary determinants of teacher performance.

Digital literacy enhances instructional capability, increases efficiency, and enables pedagogical innovation in digitally mediated environments. Grit, in contrast, sustains long-term engagement, stabilizes motivation, and protects against burnout under institutional pressure. These constructs do not substitute for one another; rather, they operate synergistically. High digital competence without perseverance may produce short-term innovation but unstable performance. Conversely, strong perseverance without digital competence may limit adaptability in technology-rich educational contexts.

From a policy perspective, these findings underscore the importance of a balanced approach to resource allocation for teacher professional development. Overemphasizing technological training without strengthening psychological resilience may yield limited sustainability. Similarly, character-building initiatives without digital capacity development may reduce competitiveness in modern education systems. Educational policymakers should therefore design integrated professional development frameworks that proportionally allocate budgets between technology-based training and character-strengthening programs.

Future research should examine potential interaction effects between digital literacy and grit, explore moderator variables such as organizational climate and leadership support, and investigate long-term performance outcomes using longitudinal methodologies. Such directions will contribute to a more comprehensive understanding of sustainable teacher effectiveness in rapidly evolving educational systems.

CONCLUSION

This meta-analysis systematically examined the effects of digital literacy and grit on teacher performance by synthesizing quantitative evidence from 28 empirical studies using a random-effects model. The findings demonstrate that both digital literacy ($r = 0.502$, $p < .001$) and grit ($r = 0.503$, $p < .001$) exert moderate-to-strong and statistically significant influences on teacher performance. The near-identical magnitude of these effect sizes provides robust empirical evidence that technical competence and psychological resilience contribute equally and meaningfully to instructional effectiveness.

Digital literacy enhances teacher performance by increasing instructional efficiency, reducing cognitive load associated with administrative demands, and enabling the effective integration of technology within pedagogical practice. In contrast, grit sustains long-term professional engagement, reinforces goal commitment, and functions as psychological resilience against burnout and bureaucratic pressure. Together, these findings confirm that sustainable teacher performance emerges from the interaction between capability-based resources (hard skills) and perseverance-oriented psychological traits (soft skills).

Although the heterogeneity analysis revealed $I^2 = 0\%$, indicating statistical consistency across included studies, this homogeneity should be interpreted cautiously. The absence of between-study variance likely reflects methodological convergence, particularly the predominance of self-report instruments and cross-sectional designs. Thus, while the findings are internally robust within comparable research conditions, broader contextual generalization requires further investigation using more diverse methodologies and cross-cultural samples.

From a policy perspective, the findings underscore the importance of balanced investment in teacher professional development. Allocating resources exclusively to digital training without strengthening psychological resilience may generate short-term efficiency gains but fail to ensure long-term stability. Conversely, emphasizing character development without enhancing digital competence may limit teachers' adaptability in technology-mediated learning environments. Therefore, integrated professional development models that proportionally allocate funding between digital competency enhancement and perseverance-oriented character strengthening are essential for sustainable improvements in educational quality.

Future research should explore potential interaction effects between digital literacy and grit, examine moderator variables such as organizational climate and leadership support, and employ longitudinal and multi-source performance indicators to provide a more comprehensive understanding of sustainable teacher effectiveness in evolving educational contexts.

DECLARATION OF GENERATIVE AI USAEGE IN THE WRITING PROCESS

During the writing of this manuscript, the author(s) employed ChatGPT (OpenAI) to assist with language refinement and academic clarity improvement. All AI-generated content has been carefully reviewed, revised, and validated by the author(s). The author(s) assume full responsibility for the accuracy, integrity, and originality of the final manuscript.

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