

Factors Correlated with Digital Competency Among Youth in the 21st Century: A Meta-Analysis

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(Received: September 29, 2025; Revised: January 3, 2026; Accepted: January 6, 2026)

Abstract

Digital competency (DC) is widely recognized as a foundational skill for 21st-century citizens, encompassing technical proficiency, critical thinking, and responsible use of digital tools. This study conducted a meta-analysis to quantitatively synthesize the relationship between various factors and youth DC, following the PRISMA guidelines. The meta-analysis included 42 eligible studies comprising 49 effect sizes focusing on youth (ages 12–24). A random-effects model revealed a large, significant positive correlation between the examined factors and youth digital competency ($r=.525$, $Fisher's\ z = 0.583$, $p<.001$). However, extremely high heterogeneity was detected ($I^2=99.49\%$). Key subgroup analysis was performed comparing factor types: Internal/Individual Variables (e.g., self-efficacy, cognitive skills) showed an estimated average correlation of $z=0.475$, which was comparable in magnitude to environmental, social norms, and other variables (e.g., parental mediation, SES), which showed $z=0.481$. The findings confirm the overall importance of both intrinsic and extrinsic factors in shaping DC, while the high variance suggests a strong need to identify contextual and methodological moderators.

Keywords: digital competency, digital literacy, youth, meta-analysis, correlates

Introduction

Digital Competency has become one of the most important foundational skills for citizens in the twenty-first century, as digital technology permeates every aspect of life. Beyond merely being technically proficient with digital tools, digital competency includes using digital tools for learning, work, and social interaction in a confident, critical, and responsible manner (Vuorikari et al., 2022). This competency is a combination of knowledge, abilities, and attitudes, per the Digital Competence Framework for Citizens (Dig Comp) developed by the European Commission (Vuorikari et al., 2022). Information and data literacy,

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communication and teamwork, digital content creation, safety, and problem solving are its five main categories (Vuorikari et al., 2022). A knowledge-based society is built on people's ability to access, assess, manage, and produce information (Rizza, 2014).

Digital competency is essential to the development of youth, a group that has grown up with digital technology, in a variety of areas, such as the intellectual, emotional, and social domains (Gutiérrez Ángel et al., 2022). Strong digital competency is essential for fostering online safety, advancing education (Learning.com Team, 2023), and preparing students for the workforce of the future. However, it has been widely refuted that teenagers are "Digital Natives" and should naturally be proficient in digital technology. According to a number of studies, many teenagers lack the profound comprehension and critical thinking abilities required to successfully negotiate the dangers and complexities of the digital world, including cyberbullying, addiction, and data security (Rizza, 2014). Therefore, a crucial educational and societal agenda is to comprehend the elements that either support or impede youth digital competency.

A significant amount of research has been conducted in the last ten years in an effort to determine the variables associated with teenage digital competency. These elements fall into three general categories: environmental, demographic/contextual, and individual. Cognitive (like critical thinking), affective (like attitudes and self-efficacy), and behavioral (like the frequency and kind of online activities) are examples of individual factors. Interestingly, one important predictor has been found to be internet self-efficacy (Lu & Gu, 2024).

Concurrently, opportunities for access, support, and use of digital technologies are still influenced by demographic and contextual factors like age, gender, and socioeconomic status (SES) (Shi et al., 2024). The "Digital Divide" of today encompasses differences in skills and the advantages of usage, not just access to devices or the internet (Fang & Nie, 2025). Additionally, the educational system, curriculum design, and the role of parental mediation are all important environmental factors that shape youth digital competency (Erstad et al., 2021). But even with the increasing amount of research on this subject, the results are still varied, disjointed, and occasionally incongruous (Kreuder et al., 2024). It is challenging to create a clear and complete picture because of differences in how digital competency is defined and measured, as well as the variety of samples and research settings. Thus, this research was conducted to perform a meta-analysis of correlation coefficients to determine the summary effect size of the relationship between various factors and the digital competency of youth and analyze and present the characteristics of the primary research studies in this field to map the current research landscape.

Rationale for the Present Study

Given this fragmentation of knowledge, this study identifies a significant gap: the lack of a comprehensive quantitative synthesis to evaluate the overall magnitude of the relationship between various factors and youth digital competency. A meta-analysis, a statistical tool for combining and analyzing results from multiple studies, allows for the estimation of a reliable average effect size and a systematic examination of the variance across study findings. Therefore, this research has two primary objectives:

1. To conduct a meta-analysis of correlation coefficients to determine the summary effect size of the relationship between various factors and the digital competency of youth.
2. To analyze and present the characteristics of the primary research studies in this field to map the current research landscape.

Methods

This study adheres to established guidelines for systematic reviews and meta-analyses, such as PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and the Cochrane Handbook, to ensure transparency and replicability (Shaw, 2018).

1. Search Strategy and Study Selection

A systematic literature search was conducted across Scopus, Web of Science, PsycINFO, and ERIC, covering publications up to December 2023. The search combined terms related to digital competency ("digital competence," "digital literacy," "ICT skills"), the target population ("youth," "youth," "student"), and research type ("correlation," "factors," "predictors"). The selection process involved two independent stages: an initial screening of titles and abstracts, followed by a full-text review of potentially relevant articles. Disagreements were resolved via discussion between the two researchers. Inclusion criteria required studies to: 1) use an youth sample (ages 12-24); 2) include a measure of digital competency or a related construct; 3) report the Pearson correlation coefficient (r) or provide sufficient data for its calculation; and 4) be published in a peer-reviewed journal. Exclusion criteria targeted qualitative, experimental (without baseline correlations), non-youth samples, and review/meta-analysis articles.

The initial search yielded 59 studies, of which 52 passed the initial title/abstract screening. Seven studies were excluded at this stage due to: irrelevant common themes ($n=2$), using a working-age sample ($n=3$), being abstract-only ($n=1$), and utilizing inappropriate

statistics ($n=1$). The remaining 52 studies proceeded to full-text review, which led to the exclusion of 10 more articles for the following reasons: the dependent variable's operational definition did not match the scope ($n=3$), insufficient statistical data to calculate the correlation coefficient ($n=4$), and using a non-target sample population ($n=3$). Consequently, a final total of 42 studies were included in the meta-analysis, comprising 38 studies that directly reported the correlation coefficient and 4 studies where the correlation coefficient was calculated from other reported statistics.

2. Statistical Analysis

2.1 Data extraction and effect size calculation

A standardized coding form was developed to extract key information from each eligible study, including bibliographic details, sample characteristics (sample size (N), mean age, educational level), research context (country), instruments used, and the necessary statistical data (correlation coefficient: r). For descriptive purposes, additional characteristics such as research field, sampling method, and data collection method were also coded (Shaw, 2018). The Pearson correlation coefficient (r) served as the primary effect size metric. Prior to the meta-analysis, each (r) value was transformed into Fisher's (z) using the standard Fisher's r -to- z transformation. This process normalizes the sampling distribution and stabilizes the variance, making the data suitable for pooling. The final pooled results were back-transformed to r for interpretation using the formula $r = \tanh(z)$ (Revelle, & Revelle, 2015).

2.2 Meta-analytic model and heterogeneity assessment

Given the observed diversity in study designs, samples, and measurement tools, a **Random-Effects Model** was employed, assuming that the true effect sizes vary across the included studies (Hedges & Olkin, 1985). The model estimates the mean of the distribution of these true effects. The between-studies variance (τ^2) was estimated using the Restricted Maximum-Likelihood (REML) method.

Heterogeneity was formally assessed using Cochran's Q -test and the I^2 statistic (Higgins et al., 2003). I^2 values of approximately 25%, 50%, and 75% were interpreted as low, moderate, and high levels of heterogeneity, respectively. A 95% prediction interval (PI) was also calculated to estimate the plausible range of true effect sizes in future studies.

2.3 Sensitivity and subgroup analyses

To investigate the potential for publication bias, funnel plot asymmetry was assessed visually, complemented by formal statistical tests: Begg and Mazumdar's rank correlation test and Egger's regression test (Shaw, 2018). To explore potential sources of

heterogeneity, a subgroup analysis was conducted to compare effect sizes across samples from internal/individual variables (e.g., self-efficacy, cognitive skills) and environmental, social Norms, and other Variables (e.g., parental mediation, SES), based on consistently extracted moderator data. All statistical analyses were performed using Jamovi Version 2.6, which utilizes the metafor package in R.

Results

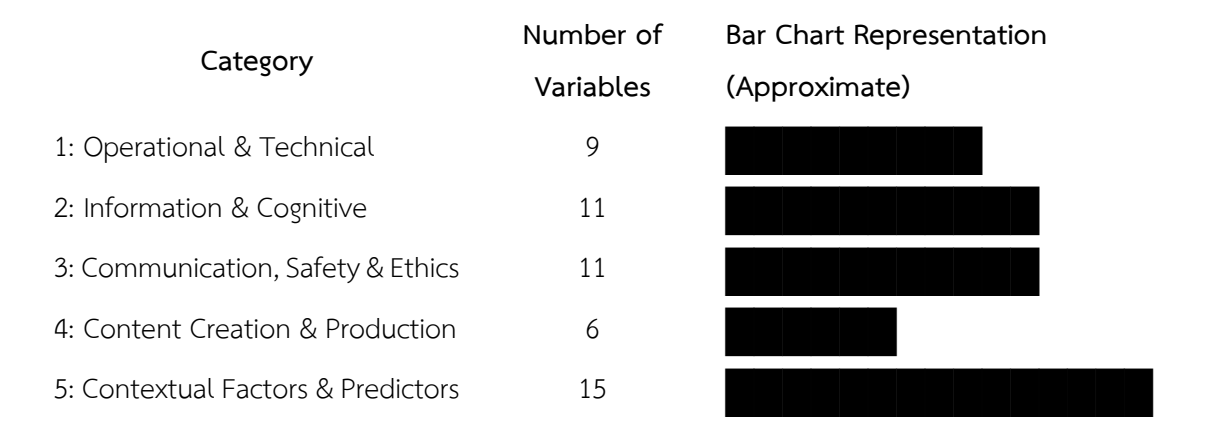
This section presents the findings according to the two research objectives, beginning with a descriptive overview of the selected studies, followed by the results of the meta-analysis.

1. Characteristics of Included Studies

Following the systematic review, 42 studies met the criteria for descriptive analysis (Objective 2), and 49 effect sizes (which could originate from the same article reporting multiple correlations) provided sufficient data for the meta-analysis. Summarizing the key characteristics of the 42 studies reveals several prominent features of the current research landscape. First, research is predominantly concentrated in Asia (54.8%) and Europe (35.7%), with very few studies from other continents. Second, the primary population studied is university students (57.1%), significantly outnumbering secondary school students (31.0%). Third, the majority of studies are situated within the behavioral and social sciences (71.4%) and favor online data collection methods (59.5%).

The summary consolidates and categorizes the variables related to Digital Literacy, Digital Competence, ICT Skills, and ICT Competency identified across the reviewed literature, organizing them into thematic dimensions commonly utilized in research frameworks. The variables are broadly classified into Digital Competence Dimensions and Associated Predictors and Outcomes (contextual factors, psychological states, and learning results). Categorization of digital and ICT-related variables based on the sources, variables can be systematically grouped into five major categories: category1 operational and technical skills (Instrumental Dimension) that encompasses fundamental knowledge and practical ability required to handle digital devices and tools, category2 information and cognitive literacy (Content and Evaluation) that focuses on the higher-order mental processes required to navigate, evaluate, and extract meaning from digital information, category3 communication, safety, and ethical/social dimension that includes interaction, collaboration, security awareness, and adherence to social/legal norms in digital environments, category4 digital

content creation and production that involves generating, adapting, and distributing new digital content, category 5 associated contextual factors, attitudes, and outcomes (Predictors) that variables influence, moderate, or are consequences of Digital/ICT Competence. The following bar chart illustrates the count of unique variables within each major research category, providing a clear overview of the conceptual emphasis in the literature provided.



2. Meta-Analytic Results of Correlation Coefficients for Overall Group

The primary meta-analysis included 49 effect sizes from the eligible studies. The results are summarized in table 1 and discussed in detail below.

Table 1 Random-effects meta-analysis of factors correlated with youth digital competency

Group	k	Fisher's z (95% CI)	r	τ^2	I ² (%)	Q (df)
Overall	49	0.583 [0.492, 0.675]	.525	0.098	99.49	7000.80 (48)***
Subgroups						
Secondary Education	25	0.534 [0.403, 0.666]	.488	0.099	99.56	5471.53 (24)***
Higher Education	24	0.635 [0.502, 0.769]	.562	0.096	98.62	1189.80 (23)***

*Note: k = number of effect sizes, CI = confidence interval, r = back-transformed correlation coefficient, τ^2 = between-studies variance, I² = heterogeneity index, Q = Cochran's Q statistic, df = degrees of freedom. **p<.001.

2.1 Overall Summary Effect Size

The random-effects model analysis of all 49 effect sizes yielded a mean Fisher-transformed correlation of z=0.583 (95% CI [0.492, 0.675], *p*<.001). When back-transformed to a Pearson correlation coefficient, this corresponds to r=.525. According to Cohen's (1988) criteria, this represents a large positive correlation. This result indicates that, on average, the factors examined in these studies have a significant and strong positive relationship with youth digital competency.

2.2 Heterogeneity

The analysis of heterogeneity is one of the most critical findings of this study. Cochran's Q statistic was large and statistically significant ($Q(48) = 7000.800$, $p < .001$), and the I^2 index was extremely high at 99.49%. This indicates that nearly all of the observed variance in effect sizes is due to true differences between studies, rather than sampling error alone. This finding is further corroborated by the 95% prediction interval, which ranged from -0.052 to 1.218. The wide span of this interval, which includes zero and slightly negative values, suggests that although the overall average effect is positive and large, the results of future studies could be highly variable, ranging from no correlation to a very strong positive correlation. (Table1 and Figure 2)

2.3 Risk of Bias

The methodological quality and risk of bias (RoB) for the included cross-sectional studies were assessed using the adapted Newcastle-Ottawa Scale for Cross-Sectional Studies (NOS-CS), with a maximum total score of 10 points. The overall RoB assessment revealed that the majority of studies (66.67%) were classified as having a low risk of bias (scoring 7–10 points), while the remaining third (33.33%) were categorized as having an unclear risk of bias (scoring 4–6 points), and importantly, no studies were rated as high risk (0.00%). Domain-level analysis indicated the highest methodological quality in the Outcome domain, with 71.43% of studies achieving a low risk score (3 points), whereas the Selection and Comparability domains showed low risk in 54.76% of the studies each. Furthermore, only a negligible number of studies demonstrated a high risk of bias across all domains: Selection (4.76%), Comparability (2.38%), and Outcome (2.38%), suggesting a generally robust and acceptable quality among the studies included in this meta-analysis (Table2 and Figure1).

Table 2 Risk of Bias (RoB) Assessment

RoB list	RoB level (points)	Percentage (%)
Selection	low risk (4-5)	54.76
	unclear risk (3)	40.48
	high risk (0-2)	4.76
comparability	low risk (2)	54.76
	unclear risk (1)	42.86
	high risk (0)	2.38
Outcome	low risk (3)	71.43
	unclear risk (2)	26.19
	high risk (0-1)	2.38
Overall RoB	low risk of bias (7-10)	66.67
	unclear risk of bias (4-6)	33.33
	high risk of bias (0-3)	0.00

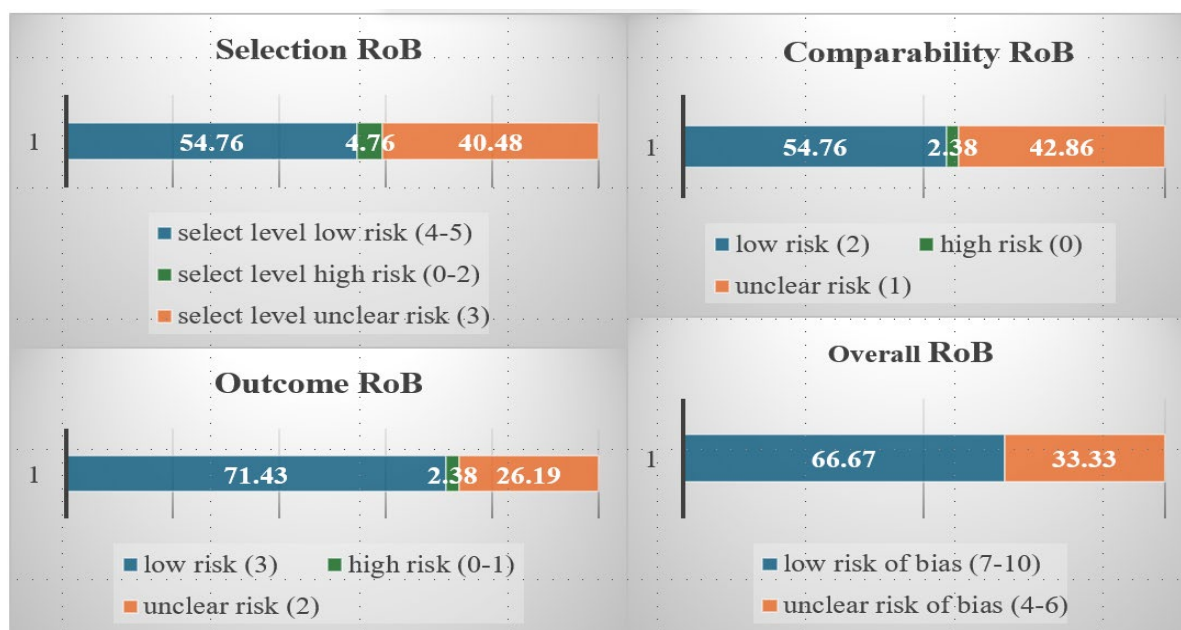


Figure 1 Risk of Bias (RoB) Assessment

2.4 Publication Bias

Publication bias was assessed via visual inspection of a funnel plot, which plots effect sizes against their standard errors. Visually, the funnel plot appeared reasonably symmetric. This observation was supported by statistical tests: both Begg's rank correlation test ($p=.856$) and Egger's regression test ($p=.431$) found no evidence of significant asymmetry. Therefore, it is unlikely that publication bias has substantially affected the validity of the summary effect size in this study and shown in table 3. Summary, the funnel plot indicates that while the results of this meta-analysis are likely not distorted by publication bias, they are characterized by a very high degree of heterogeneity, meaning the relationship between the factors and digital competency varies significantly from one study to another (Figure 2)

Table 3 Publication Bias Assessment

Test Name	value	p
Fail-Safe N	284113.000	<.001
Begg and Mazumdar Rank Correlation	-0.018	0.856
Egger's Regression	0.794	0.431
Trim and Fill Number of Studies	0.000	.

Note. Fail-safe N Calculation Using the Rosenthal Approach

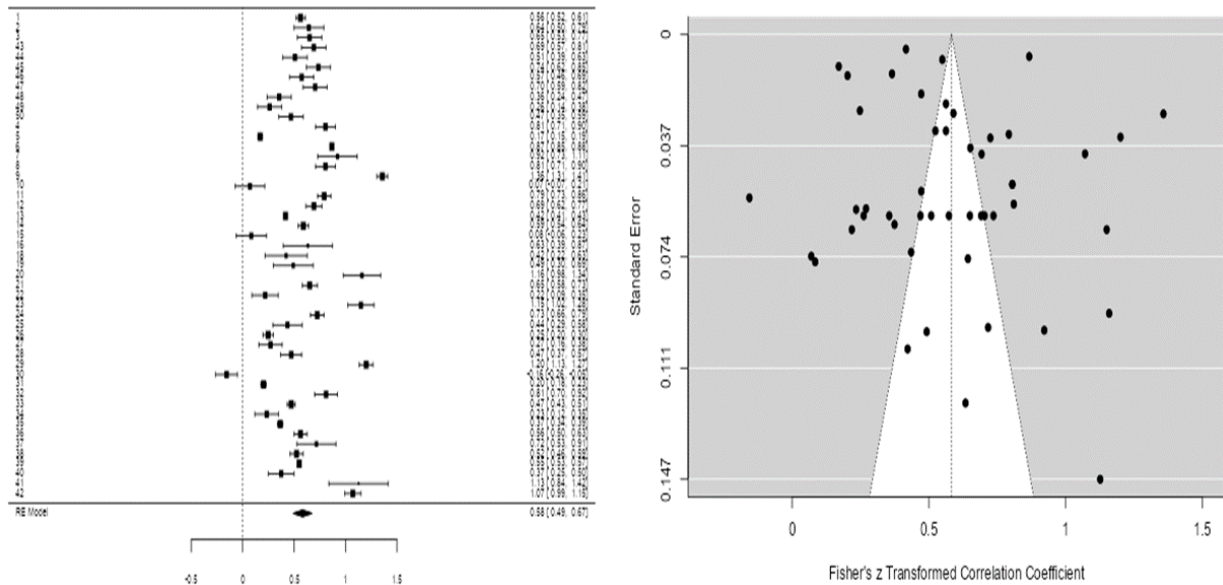


Figure 2 Funnel plot and Forest plot for Overall Group

3. Meta-Analytic Results of Correlation Coefficients for Subgroup

3.1 Subgroup Analysis 1: Internal/Individual Variables

Meta-Analytic Effect Size. This subgroup, representing internal variables (cognitive, affective, and skill domains) included $k_1 = 20$ effect sizes. The estimated average Fisher's r -to- z transformed correlation coefficient was 0.475 (95% CI: 0.436 to 0.514). The average outcome was highly significant ($z = 24.023$, $p < 0.000$).

Heterogeneity. Significant heterogeneity was again detected ($Q(19) = 7284.713$, $p < 0.000$), with a high I^2 of 98.19% and τ^2 of 0.041. The 95% prediction interval for the true outcomes was 0.078 to 0.872. Since the entire interval is positive, the true outcomes of the studies in this subgroup are generally in the same positive direction as the estimated average outcome.

Outliers and Publication Bias. No outliers ($+/-3.506$) or overly influential studies were identified. However, the analysis for publication bias yielded mixed results. The Begg and Mazumdar Rank Correlation Test indicated significant funnel plot asymmetry ($p = 0.046$), while the Egger's Regression Test did not ($p = 0.458$). The Fail-Safe N was very large at 838,818. The visual inspection of the funnel plot below suggests a potential for bias.

3.2 Subgroup Analysis 2: Environmental, Social Norms, and Other Variables

Meta-Analytic Effect Size. This subgroup included $k_2 = 29$ effect sizes focused on environmental variables, social norms, and other external factors. The estimated average

Fisher's r-to-z transformed correlation coefficient was 0.481 (95% CI: 0.411 to 0.550). This effect size is significant ($z=13.576$, $p<0.001$) and comparable in magnitude to subgroup 1.

Heterogeneity. Similar to the other analyses, there was a high degree of heterogeneity detected ($Q(28) = 5109.390$, $p < 0.001$), with an I^2 of 99.20% and τ^2 of 0.047. The 95% prediction interval was entirely positive, ranging from 0.052 to 0.909. This confirms that the true outcomes for studies in this subgroup are generally in the same positive direction as the estimated average outcome.

Outliers and Publication Bias. No outliers (± 3.2200) or influential studies were identified in this subgroup. For publication bias, neither the Begg and Mazumdar Rank Correlation Test ($p=0.827$) nor the Egger's Regression Test ($p=0.972$) indicated any statistically significant funnel plot asymmetry. The Fail-Safe N was 212,890.

Discussion

This study aimed to synthesize a quantitative overview of the factors correlated with youth digital competency. The findings reveal a complex and compelling picture, which will be discussed in the following sections.

1. Synthesizing the Findings: A Strong but Inconsistent Relationship

The primary finding of this meta-analysis is twofold and must be considered in tandem. On one hand, the summary effect size ($r = .525$) indicates a strong positive correlation on average. This provides quantitative confirmation that the factors researchers have focused on—be they individual, social, or environmental—have a significant connection to the development of youth digital competency. This result aligns with a substantial body of recent research that consistently links higher digital competency to factors such as internet self-efficacy, active parental mediation, and engagement in informal digital learning. On the other hand, an equally important finding is the extremely high level of heterogeneity ($I^2 = 99.5\%$), which serves as a crucial caveat that this average value masks immense variability among individual studies. The practical implication of this high heterogeneity is reflected in the wide 95% prediction interval that includes zero. This means we cannot confidently apply the average $r = .525$ to predict the relationship in any specific context, as the true effect in a particular situation could differ dramatically from this mean. Therefore, the main conclusion is not simply that "there is a positive relationship," but rather that "this positive relationship is highly variable and context-dependent."

2. Analyzing Heterogeneity: A Symptom of a Developing Field

This extreme heterogeneity is not merely a statistical limitation but a significant finding in itself, reflecting the current state of knowledge in this field. The sources of this heterogeneity can be attributed to several interconnected causes:

2.1 Conceptual Ambiguity. A primary cause is the lack of a standardized conceptual framework and operational definition for "digital competency." While frameworks like Dig Comp are widely acknowledged, their practical application varies. For instance, whereas one study might define competence through the lens of digital content creation, another might prioritize critical information evaluation and spotting **misinformation**, inevitably leading to different correlational patterns.

2.2 Methodological Diversity. The analysis revealed a wide variety of measurement instruments, often with inadequate reporting of their psychometric properties. This is a critical issue, as the choice of instrument—whether self-report questionnaires versus performance-based tasks—can significantly alter outcomes. Recent research by Hatlevik (2022) demonstrates that self-perceived competence often does not align with actual demonstrated skills, contributing significantly to measurement variance.

2.3 Diversity of Factors Studied. One of the key findings of this meta-analysis is the diversity of factors associated with youth digital competency. Internal factors (e.g., cognitive abilities, self-efficacy, and digital skills) and external factors (e.g., socioeconomic status, family support, educational environment, social norms, and technology access) produced comparable effect sizes ($z = 0.475$ and $z = 0.481$, respectively). This suggests that digital competency is a multidimensional construct shaped by the combined influence of personal and contextual factors rather than by a single dominant predictor. This finding is consistent with Scheerder et al. (2017), who concluded that digital skills are influenced by multiple interacting determinants, including demographic characteristics, educational opportunities, socioeconomic resources, and technology access. Likewise, Livingstone et al. (2023) emphasized that the benefits of digital skills depend on both learners' capabilities and the contexts in which those skills are developed and applied. Together, these studies support the view that the diversity of predictors identified in this meta-analysis reflects the multifaceted nature of digital competency. The high heterogeneity observed in both subgroups ($I^2 = 98.19\%$ and 99.20%) further suggests that the effects of these predictors vary across populations, educational settings, and research contexts. Future studies should

therefore adopt integrative models that consider both individual and contextual factors to better explain variations in youth digital competency.

2.4 Contextual Differences. Another important finding of this meta-analysis is the substantial variation in effect sizes across different educational, cultural, and socioeconomic contexts. Although both internal and external factors showed significant positive relationships with youth digital competency, the exceptionally high heterogeneity ($I^2 = 98.19\%$ and 99.20%) suggests that contextual conditions moderate these relationships. This finding is consistent with Helsper (2012), who argued that digital inclusion and exclusion are embedded within broader social and educational structures rather than determined solely by individual characteristics. Similarly, Scheerder et al. (2017) concluded that digital skills are influenced by multiple interacting determinants, including socioeconomic resources, educational opportunities, demographic characteristics, and technology access, with their effects varying across contexts. In addition, Gottschalk and Weise (2023) emphasized that digital competency develops within an educational ecosystem that includes infrastructure, teacher support, curriculum implementation, and equitable access to technology. Together, these findings suggest that contextual diversity is a plausible explanation for the substantial between-study heterogeneity observed in this meta-analysis. Therefore, interventions to enhance youth digital competency should be adapted to local educational and social conditions. Future research should further examine contextual moderators, such as educational systems, socioeconomic environments, and cultural characteristics, to better explain variations in digital competency across diverse settings.

Recommendation

1. Theoretical Implications

The findings highlight the need for greater theoretical and methodological consistency in the field. A clearer conceptual framework for digital competency is required, together with measurement instruments whose psychometric properties have been rigorously validated. Such instruments should reflect the multidimensional nature of digital competency, including cognitive, skill-based, and attitudinal components.

2. Practical and Policy Implications

For policymakers and educators, the findings highlight the need for caution when generalizing results from a single study to develop one-size-fits-all policies. The substantial heterogeneity indicates that educational interventions should be tailored to specific contexts

and informed by needs assessments before large-scale digital literacy programs are implemented. The findings also point to the need for further research among understudied groups, particularly rural and out-of-school youth, to promote greater equity.

Limitations and Future Research Directions

This study has several limitations that should be considered. The most significant limitation is the inability to conduct a meta-regression to statistically investigate the sources of heterogeneity, due to the diversity and inconsistent reporting of independent variables in the primary studies. Other limitations include restricting the analysis to English-language publications, which may introduce a language bias, and the aggregation of diverse factors, which necessitates careful interpretation of the mean effect size. Based on these limitations, several directions for future research can be proposed: 1) Primary studies must adhere to higher standards for reporting methodology and the psychometric properties of their instruments. 2) Future meta-analyses should be more narrowly focused on specific groups of predictors to draw clearer conclusions. 3) There is a critical need for more research in underrepresented regions and populations to achieve a more complete and global understanding.

Conclusion

This meta-analysis has synthesized the quantitative evidence on the relationship between various factors and the digital competency of youth. The results show that, on average, this relationship is positive and relatively large in magnitude. However, the most significant contribution of this study may not be the presentation of this average, but the revelation of extremely high heterogeneity, which reflects the diversity and complexity of the current research landscape. This finding indicates that the strength of the correlation is highly dependent on the factors studied, the population, and the surrounding context. Therefore, future research must be directed toward establishing clearer conceptual and methodological standards, which will serve as a foundation for developing policies and practices that can genuinely foster the digital competency essential for all youth to thrive in the 21st century.

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