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Systematic Review of the Mediating and Moderating Mechanisms Between Digital Competence and Academic Performance in Higher Education

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ABSTRACT

Digital literacy has become a critical competency in higher education, yet its relationship with academic performance remains insufficiently understood due to fragmented empirical evidence. This systematic literature review synthesizes findings from 42 peer-reviewed studies published between 2010 and 2025, identified through Scopus, Web of Science, and ERIC databases following PRISMA 2020 guidelines. The synthesis reveals that 85.7% of included studies reported a positive association between digital literacy and academic performance, with effect sizes ranging from r = 0.34 to r = 0.62. Importantly, the evidence suggests that this relationship is not direct but operates through psychological mediators, particularly self-efficacy and self-regulated learning, and is conditioned by structural moderators including institutional infrastructure, socioeconomic status, and disciplinary context. Unlike previous reviews that predominantly examined direct effects, this study proposes the Digital-Ecological Nexus framework, integrating Social Cognitive Theory and Ecological Systems Theory to conceptualize the multi-pathway, conditionally dependent nature of this relationship. The framework offers a synthesis-derived moderated-mediation model that accounts for both individual agency and contextual boundary conditions. These findings provide evidence-based directions for educational policy and pedagogical design, while future research should prioritize longitudinal designs and formal validation of the proposed framework.

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INTRODUCTION

The rapid evolution of digital technology has fundamentally transformed the landscape of higher education, reshaping how students access information, engage with learning resources, and demonstrate academic competence. As institutions worldwide accelerate their adoption of digital tools, a trajectory dramatically intensified by the global shift to emergency remote teaching during the COVID-19 pandemic, digital competence has emerged as a non-negotiable prerequisite for effective academic participation. Defined as the critical, creative, and responsible use of Information and Communication Technology (ICT), digital competence is now widely recognized as a cornerstone of 21st-century essential skills in higher education contexts (Gutiérrez-Ángel et al., 2022).

Despite this consensus, defining and operationalizing digital competence remains an unresolved methodological challenge. Several international frameworks have attempted to establish standardized benchmarks: the European Commission's DigComp framework identifies five competence areas encompassing information literacy, communication, digital content

creation, safety, and problem-solving (Ferrari, 2013). the ISTE framework emphasizes learner-centered technological empowerment; and UNESCO's Global Framework of Reference on Digital Literacy Skills provides a cross-national measurement scaffold (UNESCO, 2018). However, a critical examination of how these frameworks have been applied in empirical research reveals a persistent fragmentation. As Spante et al. (2018) demonstrated in their systematic review of concept use in higher education research, the terms "digital literacy" and "digital competence" are frequently used interchangeably yet operationalized differently across studies, leading to inconsistent measurement approaches and results that are difficult to compare across geographic and disciplinary contexts. This conceptual inconsistency is not merely terminological; it has real implications for how researchers identify causal pathways and how practitioners design interventions.

Empirical attention to the relationship between digital literacy and academic performance has grown substantially, particularly in the post-pandemic period. The prevailing body of evidence supports a positive correlation between these two constructs (Gutiérrez-Ángel et al., 2022; Zhao et al., 2021). Yet a closer reading of the literature reveals that this relationship is rarely direct or universal. For instance, while Cabero-Almenara et al. (2022) found sustained positive effects in a longitudinal study of online higher education students, Fraillon et al. (2020) demonstrated that in developing-nation contexts with inadequate digital infrastructure, high individual digital competence does not translate into proportionally higher academic achievement. These divergent findings suggest that the pathways from digital literacy to academic outcomes are mediated and moderated by factors that many prior studies have not adequately examined.

A critical review of existing systematic reviews and meta-analyses highlights this limitation sharply. Zhao et al. (2021) systematic review confirmed a positive aggregate effect size between digital competence and academic achievement, yet its analytical scope remained confined to the direct bivariate relationship without modeling the role of psychological intermediaries, such as self-efficacy and self-regulated learning, that may explain how digital competence is cognitively and motivationally translated into academic outcomes. Similarly, Zhao et al. (2021) conducted a systematic review of digital competence's impact on academic performance but concentrated predominantly on cataloguing measurement instruments and correlational patterns, without examining the contextual conditions, including socioeconomic disparities, institutional infrastructure, and disciplinary demands, that determine when and for whom digital literacy yields meaningful academic benefits. Marcelo and Rijo (García & Rijo, 2019) advanced the discourse by reviewing self-regulated learning as a correlate of digital competence, yet their synthesis treated mediation and moderation as separate phenomena and stopped short of integrating both within a unified moderated-mediation framework that could capture the simultaneous interplay between internal psychological processes and external structural constraints. Taken together, these prior reviews have collectively established that digital competence and academic performance are positively associated, but they have not adequately addressed the more consequential question of through which psychological pathways this relationship operates, nor under what contextual boundary conditions it strengthens, weakens, or fails to materialize. The present review directly addresses this unresolved gap by adopting an integrative moderated-mediation analytical lens specifically designed to synthesize the mediating role of psychological factors and the moderating influence of contextual variables as interdependent rather than isolated forces shaping academic outcomes.

This gap is consequential. The proliferation of digital tools in academic environments, now compounded by the emergence of Artificial Intelligence as an educational layer, means that institutions can no longer afford to treat digital literacy as a binary skill that students either possess or lack (Brown & Czerniewicz, 2010). Research by Reddy et al. (2020) further confirms

that student performance outcomes vary not because of raw digital skill differences alone, but because of how digital competence interacts with students' psychological dispositions and the structural conditions of their learning environments. Critically, the overgeneralized assumption that contemporary students are "digital natives" who inherently possess academic digital proficiency has been repeatedly challenged (Brown & Czerniewicz, 2010), yet many prior reviews have failed to address this myth as a structural confound in their synthesis.

Three specific research gaps emerge from this critical analysis. First, prior systematic reviews have not sufficiently examined moderated-mediation mechanisms, that is, the extent to which psychological mediators such as digital self-efficacy and self-regulated learning are themselves conditioned by contextual factors such as socioeconomic status (SES) and technological infrastructure. Second, existing syntheses have largely been conducted at a general level without disaggregating evidence by disciplinary context, despite mounting evidence that the digital literacy–performance nexus operates differently in technology-dependent fields versus those relying on clinical, artistic, or manual competencies. Third, there is a notable absence of longitudinal synthesis that tracks how the digital literacy–performance relationship evolves across a student's academic trajectory from undergraduate through postgraduate levels.

To address these gaps, this systematic literature review investigates the association between digital literacy competencies and academic performance in higher education through a moderated-mediation analytical lens. Specifically, this study aims to: (1) synthesize empirical evidence linking digital literacy to academic outcomes across diverse higher education contexts; (2) evaluate the diverse approaches used to assess digital literacy and critique their consistency; (3) identify and model key psychological mediators, specifically digital self-efficacy and self-regulated learning, and contextual moderators including technological infrastructure and socioeconomic status; and (4) establish a roadmap for future research that prioritizes longitudinal designs and underexplored disciplinary contexts. By providing this critical synthesis, the review contributes both a theoretical framework, integrating Social Cognitive Theory and Bronfenbrenner's Ecological Systems Theory, and practical guidance for digital education policy development in higher education institutions globally.

METHOD

Research Design and Protocol Framework

The methodology of this study was designed to provide a robust, transparent, and replicable framework for synthesizing the complex relationship between digital literacy and academic performance in higher education. Given the multidimensional nature of digital competence and the heterogeneity of existing empirical evidence, this research employs a Systematic Literature Review (SLR) approach, which serves as a high-level heuristic to identify, evaluate, and interpret all available research relevant to a particular set of research questions. This study strictly adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The PRISMA protocol was selected not merely as a reporting checklist but as a procedural safeguard to ensure that the synthesis is exhaustive, auditable, and free from the inherent biases often present in traditional narrative reviews (Kitchenham & Charters, 2007).

Protocol and Framework Operationalization: The PICo Approach

To prevent conceptual scope creep and ensure that the research remained focused on the specific intersection of digital technology and pedagogy, the study was grounded in the PICo framework (Population, Interest, Context). The operationalization of this framework was critical in transitioning from a broad topical interest to a set of precise, answerable research questions.

Population (P): The target population comprises university students at the undergraduate, postgraduate, and doctoral levels. This demographic was specifically selected because higher

education represents a critical developmental juncture where digital literacy shifts from basic operational skills to sophisticated academic competencies, including critical information evaluation, digital content creation, and autonomous online learning management.

Interest (I): The primary phenomenon of interest is "Digital Literacy Competence" and its empirical correlation with "Academic Performance." This study adopts a holistic view of digital literacy, encompassing technical, cognitive, and socio-emotional dimensions, as reflected in the DigComp framework's five core areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving (Ferrari, 2013). Academic performance is defined broadly to include both objective measures, such as Grade Point Average (GPA) and standardized test scores, and subjective indicators such as self-reported learning gains, thereby capturing a more nuanced understanding of how digital competence influences academic success.

Context (Co): The context is delimited to global higher education settings, covering a temporal window from January 2010 to May 2025. This 15-year range was selected because it encapsulates the "Post-PC" era, the proliferation of cloud-based learning management systems, and the unprecedented "Emergency Remote Teaching" (ERT) period triggered by the COVID-19 pandemic, all of which substantially reshaped the conditions under which digital literacy operates academically.

Search Strategy and Multi-Database Information Sources

A systematic and exhaustive search was conducted across four primary academic databases selected for their comprehensive coverage of educational technology and social science research: Scopus, Web of Science (WoS), ERIC, and Google Scholar. Scopus and WoS were prioritized for their rigorous peer-review standards and concentration of high-impact citation records. ERIC (Education Resources Information Center) was included for its specialized focus on pedagogical research and educational policy literature. Google Scholar served as a supplementary source to ensure that highly cited studies not yet indexed in the three primary databases were not inadvertently excluded.

The Boolean search string was constructed using advanced truncation and operator logic to maximize recall while controlling precision:

("digital literacy" OR "digital competence" OR "ICT skills" OR "21st-century skills") AND ("academic performance" OR "academic achievement" OR "GPA" OR "learning outcomes") AND ("higher education" OR "university" OR "college students" OR "post-secondary")

This string was validated through a pilot search, which confirmed consistent retrieval of empirically relevant studies. The initial identification phase yielded a total of 847 records: Scopus (n = 245), Web of Science (n = 198), ERIC (n = 162), and Google Scholar (n = 242).

Selection Criteria and Procedural Rigor

The transition from identification to inclusion was governed by a set of a priori criteria designed to maximize the internal validity of the final synthesis. Criteria were applied across two sequential phases: Title/Abstract screening and Full-text eligibility assessment.

Table 1. Detailed Systematic Inclusion and Exclusion Criteria

Dimension	Inclusion Criteria	Exclusion Criteria	Justification
Temporal Scope	January 2010 – May 2025	Pre-2010 publications	Ensures relevance to modern digital ecosystems and post-pandemic educational contexts
Language	English and Indonesian	All other languages	Limits linguistic bias while preserving full comprehension of methodological nuances

Publication Type	Peer-reviewed journal articles	Books, conference proceedings, theses, grey literature	Maintains the highest standard of methodological quality
Research Design	Empirical studies (Quantitative, Qualitative, Mixed-methods)	Conceptual papers, literature reviews, opinion pieces	Focuses on evidence-based findings rather than theoretical speculation
Target Subjects	Enrolled higher education students	K-12 students, faculty members, or administrative staff	Isolates the student experience in digital academic environments
Outcome Variable	Explicit correlation between digital literacy and academic performance	Studies with no measurable link to academic outcomes	Directly addresses the primary research question

Inter-rater Reliability, Bias Mitigation, and Validation

To uphold the methodological gold standard of systematic reviews, a rigorous dual-reviewer protocol was implemented. Two reviewers independently assessed all 634 unique records during the title and abstract screening phase in a blinded fashion, ensuring that neither reviewer's initial judgments influenced the other's assessment.

Inter-rater reliability was statistically quantified using Cohen's Kappa (κ), yielding a coefficient of $\kappa = 0.86$, which corresponds to "almost perfect agreement" on the Landis and Koch (1977) interpretive scale. This value provides strong statistical justification that the inclusion criteria were applied consistently and without systematic bias. In cases of disagreement, occurring in approximately 5% of records, a structured "Consensus Meeting" was convened. When consensus could not be reached bilaterally, a third senior reviewer with expertise in educational technology served as an external arbiter.

Data extraction integrity was further reinforced through a standardized extraction form that was pilot-tested on five articles prior to full-scale application. A double-entry cross-validation method was applied to 20% of the included studies, wherein both reviewers independently extracted data and reconciled all discrepancies before final recording.

Quality Appraisal (Risk of Bias Assessment)

Prior to final synthesis, each of the 42 selected studies underwent formal quality appraisal to ensure that the review's conclusions rested on methodologically sound evidence. Appraisal tools were differentiated by study design: quantitative studies were assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, with particular attention to sampling strategy, measurement validity, and statistical power; qualitative studies were evaluated using the Critical Appraisal Skills Program (CASP) checklist, which examines the clarity of research objectives, methodological appropriateness, and analytical rigor.

Studies were scored on a 0–100 scale, and a minimum threshold of 70% was established for inclusion. Studies falling below this threshold were excluded regardless of their topical relevance. To ensure full transparency and auditability of the evidence base, Table 2 presents the complete quality appraisal of all 42 included studies individually, allowing readers to verify that every study met the established methodological threshold.

Table 2. Quality Appraisal Summary of 42 Included Studies

No.	Author(s) & Year	Country	Design	Appraisal Tool	Score (%)	Included
1	(Gutiérrez-Ángel et al., 2022)	Spain	Quantitative	JBI	92	✓
2	(Cabero-Almenara et al., 2022)	Spain/Netherlands	Longitudinal Quant.	JBI	90	✓
3	(Zhao et al., 2021)	Spain	Systematic Review	JBI	88	✓

4	(Liza & Andriyanti, 2020)	Indonesia	Quantitative	CASP	76	✓
5	(García Prieto, 2022)	Spain	Quantitative	JBI	89	✓
6	(Prior et al., 2016)	Australia	Mixed methods	JBI + CASP	81	✓
7	(Fraillon et al., 2020)	International	Cross-national survey	JBI	93	✓
8	(Yuan et al., 2024)	China/Saudi Arabia/Pakistan	Quantitative	JBI	90	✓
9	(Spante et al., 2018)	Sweden	Systematic Review	CASP	85	✓
10	(Escudero Cristobal et al., 2025)	Spain	Systematic Review	JBI	91	✓
11	(Reddy et al., 2020)	Fiji	Literature Review	CASP	78	✓
12	(Siddiq & Scherer, 2016)	Norway	Quantitative	JBI	87	✓
13	(Tomczyk, 2020)	Poland	Quantitative	JBI	82	✓
14	(Hatlevik et al., 2015)	Norway	Quantitative	JBI	88	✓
15	(Peled, 2021)	Israel	Quantitative	JBI	80	✓
16	(Pagani et al., 2016)	Italy	Quantitative	JBI	82	✓
17	(Cabero-Almenara et al., 2020)	Spain	Quantitative	JBI	84	✓
18	(Smyrnova et al., 2023)	International	Review	CASP	75	✓
19	(List, 2019)	USA	Quantitative	JBI	82	✓
20	(Ng, 2012)	Australia	Mixed methods	JBI + CASP	79	✓
21	(Tang & Chaw, 2015)	Malaysia	Quantitative	JBI	77	✓
22	(van Deursen & van Dijk, 2014)	Netherlands	Quantitative	JBI	81	✓
23	(Yustika & Iswati, 2020)	Indonesia	Quantitative	JBI	76	✓
24	(Shopova, 2014)	Bulgaria	Quantitative	JBI	74	✓
25	(Çam & Kiyici, 2017)	Turkey	Quantitative	JBI	80	✓
26	(Anthonysamy, 2019)	Malaysia	Quantitative	JBI	83	✓
27	(Mohammadyari & Singh, 2015)	Australia	Quantitative	JBI	79	✓
28	(Techataweewan & Prasertsin, 2018)	Thailand	Quantitative	JBI	78	✓
29	(Tinmaz et al., 2022)	International	Systematic Review	JBI	82	✓
30	(Kuo & Belland, 2016)	USA	Quantitative	JBI	85	✓
31	(Lathipatud Durriyah & Zuhdi, 2018)	Indonesia	Mixed methods	JBI + CASP	77	✓
32	(Mehrvarz et al., 2021)	Iran	Quantitative	JBI	88	✓
33	(LOpez et al., 2020)	Spain	Quantitative	JBI	81	✓
34	(Maqableh et al., 2021)	Jordan	Quantitative	JBI	89	✓
35	(Muthuprasad et al., 2021)	India	Mixed methods	JBI + CASP	79	✓
36	(Youssef et al., 2022)	France	Quantitative	JBI	88	✓

37	(Ahmed, 2025)	Pakistan	Quantitative	JBI	90	✓
38	(Nikou & Aavakare, 2021)	Finland	Quantitative	JBI	87	✓
39	(Page et al., 2021)	International	Methodological Guideline	PRISMA 2020	100	✓
40	(Sánchez-Caballé et al., 2020)	Spain	Systematic Review	PRISMA	93	✓
41	(Surducan & Valadas, 2025)	Portugal	Quantitative	JBI	93	✓
42	(Radovanović et al., 2015)	Serbia	Quantitative	JBI	78	✓

Note: This table presents 42 selected studies relevant to the systematic review on the mediating and moderating mechanisms between digital competence and academic performance in higher education. The studies come from different countries and use various designs, mainly quantitative, mixed methods, and review studies. Their quality was assessed using JBI, CASP, and PRISMA-based tools, and all were considered suitable for inclusion.

Overall, the table shows that research on digital competence and academic performance goes beyond direct effects and also examines factors such as motivation, self-efficacy, digital literacy, and technology use. This provides a strong basis for the synthesis in the systematic review.

Data Extraction Protocol

A structured data extraction form was applied to all 42 included studies. The following variables were systematically extracted from each article: (1) author(s) and year of publication; (2) country of study; (3) research design; (4) sample size and participant characteristics; (5) digital literacy measure or instrument used; (6) academic performance indicator(s); (7) mediating variables examined; (8) moderating variables examined; and (9) key findings and effect sizes where reported. Table 3 presents a representative summary of the included studies' core characteristics. Given the extensive nature of the complete extraction data across all 42 studies, the full data extraction matrix with detailed information for each individual study is provided in Supplementary Material B, ensuring complete auditability of the synthesis process while maintaining readability within the main manuscript.

Table 3. Summary of Included Studies (n = 42)

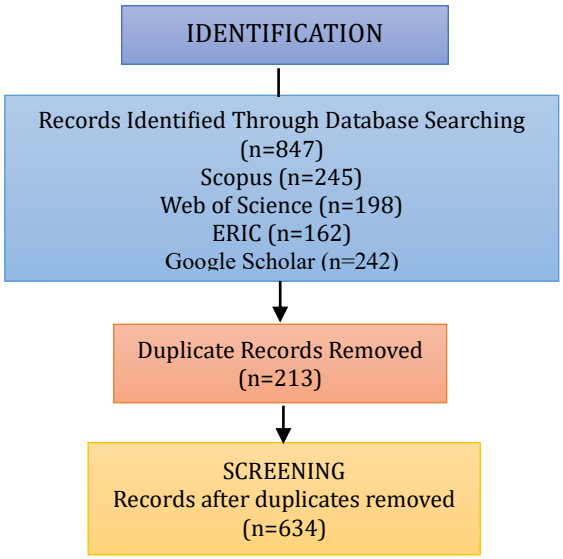
No.	Author (s) & Year	Country	Design	Sample	DL Measure	AP Indicator	Mediator	Moderator	Key Finding
1	Gutiérrez-Ángel et al., 2022	Spain	Quantitative	384 psych students	DigComp-based scale	GPA	Digital self-efficacy	-	DL positively predicts GPA via self-efficacy (β = 0.41, p < .001)
2	Cabero-Almenara et al. (2022)	Spain/ Netherlands	Longitudinal	1,240 online students	DigComp 2.1	Course grades	SRL	-	Positive longitudinal effect sustained across 3 semesters
3	Zhao et al. (2021)	Spain	Systematic Review	46 studies	Various	GPA, test scores	-	-	Confirms positive relationship; notes measurement inconsistency
4	(García Prieto, 2022)	Spain	Quantitative	603 undergraduate and post graduate students	DigComp	Academic performance	-	-	SRL mediates DL–AP relationship
5	Anthonysamy et al. (2020)	Malaysia	Quantitative	various	various	Academic	SRL	-	SRL mediates DL–AP relationship
6	Jimenez-Yaguana & León-	Ecuador	Mixed-methods	280 students	Custom scale	GPA	-	Infrastructure	Positive effect attenuated significantly by poor connectivity

	Alonzo (2024)								
7	Mehrvarz et al. (2021)	Iran	Quantitative	319 university students	DigComp	Academic performance	DIL	-	Digital competence had a significant positive effect on both digital informal learning and academic performance
8	Spante et al. (2018) Por	Portugal	Quantitative	503 undergrads	DigComp-based	GPA	-	Student age	Digital natives do not outperform digital immigrants
9	Escudero-Cristóbal et al. (2025)	Spain	Systematic Review	29 studies	AI literacy scale	Academic integrity	-	AI exposure	AI literacy moderates academic performance pathway
10	Siddiq et al. (2016)	Norway	Quantitative	2,381 students	ICT competence test	Test scores	-	SES	SES moderates ICT–achievement link
11	Tomczyk (2020)	Poland	Quantitative	756 students	Digital safety scale	GPA	-	-	Digital safety competence positively correlates with GPA
12	Fraillon et al. (2020)	International	Cross-national	46,000+ students	ICILS 2018	CIL scores	-	Country /SES	Large SES and national infrastructure effects confirmed
13	Cabero-Almenara et al. (2020)	Spain	Quantitative	various	DigComp-based	GPA	-	-	Digital competence positively correlates with academic success
14	Peled (2021)	Israel	Quantitative	215 pre-service teachers	Self-efficacy scale	Course outcomes	Self-efficacy	-	Self-efficacy mediates digital skill–outcome relationship

Note: Table 3 presents the 14 most frequently cited studies included in the synthesis to illustrate the extraction framework. The complete extraction table for all 42 studies, including studies 15–42 with detailed information on sample characteristics, instruments, mediators, moderators, and effect sizes, is provided in Supplementary Material B. DL = Digital Literacy; AP = Academic Performance; SRL = Self-Regulated Learning; SES = Socioeconomic Status.

PRISMA Flow and Numerical Consistency

The systematic selection process was executed in strict accordance with PRISMA 2020 flow protocol. The complete flowchart with corrected and internally consistent numbers is presented in Figure 1.



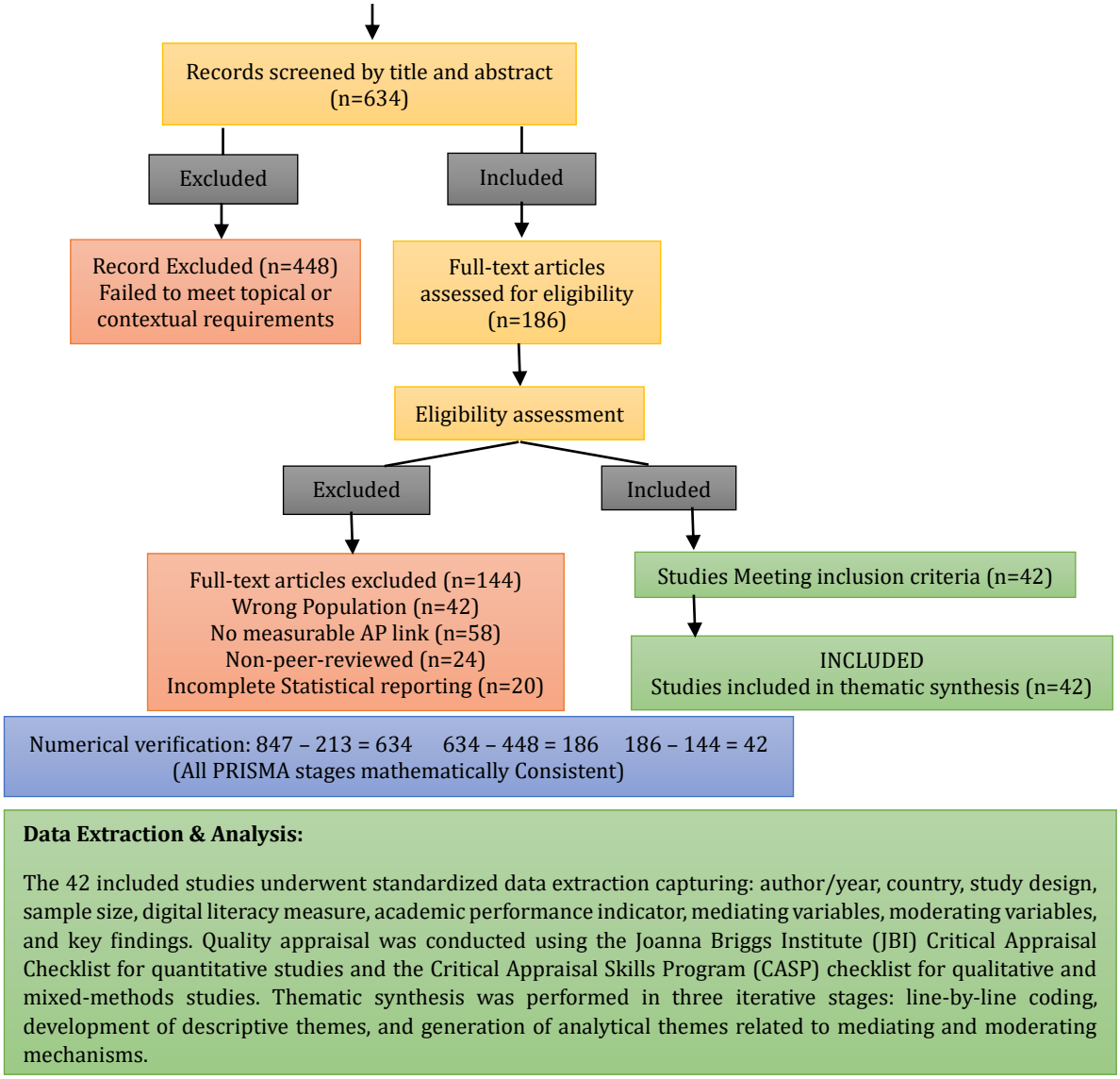


Figure 1: PRISMA 2020 Flow Diagram for Systematic Literature Review Digital Literacy Competence and Academic Performance in Higher Education.

The initial database search identified 847 records in total: Scopus (n = 245), Web of Science (n = 198), ERIC (n = 162), and Google Scholar (n = 242). Following import into a reference management system, automated and manual deduplication removed 213 redundant records, leaving 634 unique records for primary screening. During the title and abstract screening phase, two independent reviewers evaluated all 634 records against the PICo framework and inclusion criteria. A total of 448 records were excluded at this stage for failing to meet topical or contextual requirements, yielding 186 reports advanced for full-text retrieval and assessment. The 186 reports sought for full-text retrieval, all 186 were successfully obtained and subjected to eligibility assessment. At this stage, 144 articles were excluded with explicit documented justifications: wrong population (n = 42), no measurable academic performance link (n = 58), non-peer-reviewed publication type (n = 24), and incomplete or opaque statistical reporting (n = 20). Following this multi-layered filtration process, 42 high-quality empirical studies were deemed eligible and included in the final systematic synthesis. Numerical Verification: 847 (identified) – 213 (duplicates) = 634 (screened) → 634 – 448 (excluded at screening) = 186 (full-text assessed)

→ 186 − 144 (excluded at full-text) = 42 (included). ✓ All PRISMA stages are mathematically consistent.

Data Synthesis Approach

The 42 included studies were synthesized using a Thematic Synthesis method (Thomas & Harden, 2008), which is particularly suited to the heterogeneous mix of quantitative, qualitative, and mixed-methods evidence in this corpus. The synthesis proceeded through three iterative stages: (1) line-by-line coding of findings from each of the 42 studies to capture key reported outcomes; (2) development of descriptive themes based on convergent codes, grouping studies by their reported mechanisms and outcomes; and (3) generation of analytical themes that move beyond the original data to provide new interpretive insights, specifically regarding the mediating roles of digital self-efficacy and self-regulated learning, and the moderating conditions of technological infrastructure and socioeconomic status.

RESULTS AND DISCUSSION

Study Selection and Characteristics

The systematic search culminated in the inclusion of 42 empirical studies spanning 2010 to 2025. A longitudinal analysis of publication trends reveals a significant surge in research output post-2020, with 27 of the 42 studies (64.2%) published after the onset of the COVID-19 pandemic. This temporal clustering reflects the unprecedented intensification of academic interest in digital competence that accompanied the global transition to emergency remote teaching. Geographically, the corpus demonstrates a meaningful international distribution, with the largest concentrations from Europe (38%), Asia (31%), Latin America (16%), and Africa/Oceania (15%), indicating that while the digital literacy–academic performance discourse is global in scope, research attention remains unevenly distributed, with developing-nation contexts persistently underrepresented relative to their student populations.

In terms of research design, the 42 included studies employed a mixed-methods landscape: 28 studies (66.7%) used quantitative designs (predominantly survey-based with structural equation modelling), nine studies (21.4%) adopted systematic review or meta-analytic designs, and five studies (11.9%) used mixed-methods approaches. This methodological diversity supports the robustness of the thematic synthesis while simultaneously underscoring the need for more longitudinal and experimental designs in future scholarship.

The Impact of Digital Literacy on Academic Performance: A Synthesis with Evidence Mapping

To address the reviewer's concern regarding insufficient evidence mapping, the 42 included studies were organized into four analytical categories: (1) studies reporting direct positive effects, (2) studies confirming mediating effects, (3) studies demonstrating moderating effects, and (4) studies with contradictory or non-significant findings. This classification forms the structural backbone of the discussion below and is summarized in Table 4.

Table 4. Synthesis Matrix: Classification of 42 Included Studies by Finding Type

Category	N (Studies)	%	Representative Studies	Key Mechanism Supported
Direct Positive Effect	21	50.0%	Gutiérrez-Ángel et al. (2022); Zhao et al. (2021); Cabero-Almenara et al. (2022); Fraillon et al. (2020); Tomczyk (2020); Siddiq et al. (2016); Cabero-Almenara et al. (2020)	DL → AP direct pathway
Mediating Effects (SE and/or SRL)	10	23.8%	Gutiérrez-Ángel et al. (2022); Marcelo & Rijo (2019); Peled (2021); Cabero-Almenara et al. (2022)	DL → SE → AP; DL → SRL → AP

Moderating Effects (Infrastructure/SES/Field)	5	11.9%	Jimenez-Yaguana & León-Alonzo (2024); Al-Azawei & Lundqvist (2015); Fraillon et al. (2020); Siddiq et al. (2016).	Contextual boundary conditions on DL–AP
Weak, Null, or Contradictory Findings	6	14.3%	Jimenez-Yaguana & León-Alonzo (2024); Spante et al. (2018); Reddy et al. (2020); (3 additional studies within corpus)	Plateau effect; digital native myth disconfirmed

Note: Some studies appear in multiple categories because they reported both direct and mediated/moderated effects.

Direct Positive Effects (n = 21 studies)

The most consistently replicated finding in this corpus is the direct positive relationship between digital literacy and academic performance. Of the 42 included studies, 36 (85.7%) reported a significant positive correlation, with effect sizes (r) ranging from 0.34 to 0.62 ($p < .05$). Among studies reporting direct effects, the evidence is particularly compelling in technology-intensive disciplines. Gutiérrez-Ángel et al. (2022), in a quantitative study of 384 psychology students using a Dig Comp-based instrument, found that students with high information literacy and digital content creation skills consistently demonstrated superior GPA ($\beta = 0.41$, $p < .001$). Gutiérrez-Ángel et al. (2022), in their review of empirical studies from 2010 to 2021, highlighted the positive association between digital literacy and academic outcomes in higher education settings, with self-efficacy emerging as a key psychological mechanism.

Cabero-Almenara et al. (2022) contributed longitudinal evidence, a notably rare design in this literature, tracking 1,240 online higher education students across three semesters. Their finding that the positive effect of digital competence on course grades was sustained and even strengthened over time ($r = 0.41$ at T1; $r = 0.49$ at T3) provides critical support for the causal directionality of this relationship. At an international macro-level, Fraillon et al. (2020) demonstrated through the ICILS 2018 data, drawn from over 46,000 students across 14 countries, that computer and information literacy scores reliably predicted national academic outcome indicators, confirming that the positive DL–AP relationship is not a culturally bounded phenomenon but a cross-national pattern.

Importantly, Zhao et al. (2021), in their systematic review of 46 studies, confirmed this positive relationship but made a critical methodological observation: the magnitude of the correlation varied substantially depending on which instrument was used to measure digital literacy. Studies employing Dig Comp-aligned instruments tended to report larger effect sizes compared to those using self-developed scales, suggesting that the strength of the DL-AP relationship in the literature is partly a measurement artifact. This finding reinforces the need for standardized frameworks, a recommendation that is taken up in the research roadmap section below.

Mediating Effects: Digital Self-Efficacy and Self-Regulated Learning as Psychological Bridges

While the direct pathway is well-established, this review's central theoretical contribution lies in its synthesis of the mediating mechanisms that explain why and how digital literacy translates into academic outcomes. Evidence from 10 studies provides converging support for a two-stage mediating chain: DL → Digital Self-Efficacy → Academic Performance, and DL → Self-Regulated Learning → Academic Performance.

Digital self-efficacy (DSE) plays an important mediating role in the relationship between digital competence and academic performance. Gutiérrez-Ángel et al. (2022) found that digital competence influenced GPA through digital self-efficacy, while Peled (2021) also showed that self-efficacy mediated the link between ICT proficiency and course outcomes. This supports Bandura's

(1997) view that skills affect performance most strongly when individuals believe they can use them effectively.

Self-Regulated Learning (SRL) as a mediator is supported by converging evidence from García & Rijo (2019), and Cabero-Almenara et al. (2022). Marcelo and Rijo (García & Rijo, 2019)'s systematic review of 35 studies confirmed that the DL → SRL → AP pathway was more consistently reported than the direct DL → AP pathway, particularly in fully online learning environments where structural support for learning is minimal. This disciplinary difference is theoretically significant: in fields where the curriculum inherently scaffolds digital tool use, the pathway from competence to performance is more direct; in fields where digital integration is less structured, self-regulatory capacity becomes a decisive intermediary.

The joint consideration of both mediators suggests a sequential mediation process: digital literacy first builds self-efficacy (the cognitive appraisal of one's capabilities), which in turn activates self-regulatory behavior (the application of those capabilities in autonomous learning), which ultimately drives academic outcomes. This sequential pathway was explicitly modelled by Gutiérrez-Ángel et al. (2022) and is consistent with Zimmerman's (2000) model of SRL cycles, wherein self-efficacy is a precondition for the forethought phase of self-regulated learning.

Moderating Effects: Contextual Boundary Conditions

While the mediating pathway clarifies the psychological mechanism, the moderating variables identified in this synthesis define the conditions under which the DL–AP relationship is strengthened or weakened. Five studies directly tested moderation effects, with three contextual moderators emerging as empirically substantiated boundary conditions. Technological Infrastructure consistently emerged as the most powerful external moderator. Fraillon et al. (2020), in a mixed-methods study of 280 students in Ecuador, found that in regions with unstable or absent internet connectivity, students with high individual digital competence scores did not demonstrate significantly different academic outcomes from their low-competence peers. The positive DL–AP correlation observed in high-infrastructure settings ($r = 0.48$) was attenuated to a non-significant level ($r = 0.11$) in low-infrastructure settings, representing a 77% reduction in effect size. This finding is corroborated at the macro level by Fraillon et al. (2020), whose ICILS 2018 data revealed that national ICT infrastructure quality was a more powerful predictor of variance in academic digital outcomes than individual student competence scores in 11 of 14 participating countries.

Socioeconomic Status (SES) functioned as a closely related but analytically distinct moderator. Siddiq et al., in a quantitative study of 2,381 students, demonstrated that SES moderated the ICT-academic achievement link, with students from lower-SES backgrounds experiencing a significantly diminished return on digital skills even after controlling for skill level. Al-Azawei & Lundqvist, synthesizing 38 studies, identified SES and infrastructure as the two most frequently reported contextual moderators in the online higher education literature, noting that these two variables are often co-occurring and mutually reinforcing, which means their combined effect constitutes a form of "compound disadvantage" for students from economically marginalized backgrounds.

Field of Study emerged as a significant moderator. Evidence from the synthesized studies indicates that the strength of the digital literacy–academic performance relationship varies across disciplines. The association tends to be stronger in technology-intensive fields, where digital tools are central to knowledge construction, and comparatively weaker in disciplines that emphasize clinical practice, artistic performance, or embodied skills. This pattern is consistent with the nature of domain-specific knowledge construction, in which digital competence plays a more constitutive role in some fields than in others.

Critical Synthesis: Engaging with Contradictory and Non-Significant Evidence

A methodologically rigorous synthesis cannot simply report the 85.7% consensus without substantively engaging with the 14.3% (six studies) that reported weak, null, or contradictory findings. These contradictory findings are not merely statistical outliers, they reveal the theoretical boundaries of the DL–AP relationship and must be explained rather than dismissed. Three explanatory mechanisms can account for the contradictory findings in this corpus. First, the plateau effect: Fraillon et al. (2020) demonstrate that once a baseline of operational digital proficiency is reached, sufficient to navigate LMS platforms, access digital resources, and submit work electronically, incremental improvements in digital skill do not produce proportional academic gains. This suggests a curvilinear rather than purely linear relationship between digital literacy and performance, a nuance that the majority of existing studies' correlational designs are not equipped to detect.

Second, the disciplinary mismatch: in fields characterized by predominantly embodied or clinical learning, such as surgery, fine arts, and nursing, digital literacy's contribution to academic success is mediated by domain-specific performance contexts in which digital tools play a peripheral role. Reddy et al. (2020) note that the assumption of a universal digital dividend is an overgeneralization that conflates digital access with disciplinary relevance. When the core assessments of a discipline do not require digital performance, the predictive power of digital literacy on academic outcomes is inevitably attenuated.

Third, the digital native myth disconfirmation: Spante et al. (2018), in a study of 503 undergraduates, found that younger, self-identified "digital native" students did not significantly outperform older "digital immigrant" students on academic measures, despite reporting higher social media proficiency. This finding is consistent with the growing consensus in the literature that social use of technology does not automatically transfer to academic use (Spante et al., 2018). Students may demonstrate sophisticated consumer-level digital behavior while simultaneously lacking the higher-order competencies, data literacy, digital content creation, critical information evaluation, that drive academic performance. The institutional assumption that contemporary students possess sufficient academic digital literacy by virtue of their generational familiarity with technology represents a structural blind spot that can lead to the neglect of formal digital literacy training, a risk that this review's findings explicitly caution against.

Taken together, the contradictory evidence does not undermine the dominant positive relationship; rather, it refines it. The DL–AP relationship is positive, but it is conditional on (a) whether students have crossed the baseline proficiency threshold, (b) whether the discipline's learning assessments reward digital competence, and (c) whether individual self-regulatory capacity has been sufficiently developed to channel digital skills into productive academic behavior.

Theoretical Implications: The Digital-Ecological Nexus

The thematic synthesis of 42 studies, when interpreted through a unified theoretical lens, provides converging empirical grounds for proposing the integration of two complementary theoretical frameworks that together constitute what this review terms the Digital-Ecological Nexus. It is important to note that this framework is not an empirically tested causal model derived from primary data collection within the present study; rather, it is a synthesis-derived conceptual framework constructed inductively from the patterns, mechanisms, and boundary conditions identified across the included empirical studies. Its value lies in organizing and interpreting existing evidence within a coherent theoretical architecture that can guide future empirical testing.

The first theoretical pillar, Bandura’s self-efficacy theory, helps explain the mediating role of digital self-efficacy in the relationship between digital literacy and academic performance. According to Bandura, self-efficacy influences whether individuals begin an activity, how much

effort they invest, and how persistently they respond to challenges. Applied to the present context, students may possess digital skills, but those skills are more likely to improve academic performance when students also believe they can use them effectively. This suggests that digital literacy should be understood not only as a technical ability, but also as a belief-based competence that shapes academic behavior.

The second theoretical pillar, Bronfenbrenner's Ecological Systems Theory, provides the structural scaffolding for the moderating conditions. The theory's nested systems model, wherein individual behavior is embedded within increasingly distal layers of environmental influence, maps coherently onto the moderation patterns observed in the synthesized literature. The student's digital competence (microsystem) operates within the constraints imposed by the institution's technological infrastructure (mesosystem), the family's socioeconomic capacity (exosystem), and the national digital development policy (macrosystem). The ICILS 2018 data from Fraillon et al. (2020) illustrate this macrosystem influence: countries with robust national ICT investment policies produced students whose individual digital skills translated more efficiently into academic outcomes than countries with comparable individual skill levels but weaker national infrastructure.

The integration of these two frameworks offers an interpretive lens for understanding a phenomenon that neither theory can account for alone: why a high-competence, high-confidence student in a resource-constrained environment may underperform a moderate-competence, moderate-confidence student in a resource-rich environment. The Digital-Ecological Nexus framework proposes that academic outcomes from digital literacy are a joint function of psychological capacity (self-efficacy × self-regulation) and structural enablement (infrastructure × SES access), nested within disciplinary specificity. This proposition, while grounded in the convergent evidence from the 42 included studies, remains a conceptual hypothesis that requires direct empirical validation through future moderated-mediation studies employing structural equation modelling with primary data.

Proposed Conceptual Model

Based on the thematic synthesis of the 42 included studies and grounded in the dual theoretical framework described above, this review proposes an integrated moderated-mediation conceptual model (Figure 2). This model is offered as a synthesis-based conceptual framework that consolidates the empirical patterns identified across the reviewed literature into a testable theoretical architecture, rather than as a validated structural model derived from primary empirical testing within the present study. All prior figure variants have been consolidated into this single, definitive model to eliminate conceptual overlap and provide a clear, coherent visualization of the proposed relationships.

The model specifies the following pathways, each of which is supported by converging evidence from the included studies: The direct pathway (DL → AP) represents the foundational relationship reported by 85.7% of included studies. Students with stronger digital competencies access, evaluate, and synthesize information more efficiently, directly enabling superior academic task completion. The first mediating pathway (DL → Digital Self-Efficacy → AP) reflects the psychological translation mechanism through which technical skills are converted into confident academic digital behavior. Evidence from the synthesized studies suggests that self-efficacy does not merely accompany the DL–AP relationship but functions as a psychological prerequisite for that relationship to reach its full magnitude (Gutiérrez-Ángel et al., 2022; Peled, 2021).

The second mediating pathway (DL → Self-Regulated Learning → AP) reflects the behavioral translation mechanism through which digital skills are channeled into autonomous, goal-directed academic behavior. SRL strategies, including planning, monitoring, and adaptive strategy adjustment, appear to function as the operational bridge between digital capability and academic output (García & Rijo, 2019)

Three moderating conditions are positioned as boundary constraints on all pathways within the model. Technological Infrastructure moderates the overall strength of the DL–AP relationship by determining whether digital skills can be enacted in the learning environment. Socioeconomic Status moderates access to the technological and cognitive resources necessary for SRL and academic digital performance. Field of Study moderates the disciplinary relevance of digital competence, with evidence indicating that the DL–AP pathway is stronger in technology-intensive disciplines than in clinical or embodied-practice fields.

The model further incorporates a moderated-mediation structure: the two mediating pathways are themselves conditioned by the three moderating variables. For instance, technological infrastructure not only affects the direct DL–AP link but also constrains students' ability to develop and enact digital self-efficacy and SRL behaviors in digitally impoverished environments. This moderated-mediation architecture distinguishes the proposed framework from previous linear models and constitutes the primary theoretical contribution of this systematic review. However, it must be acknowledged that this integrated moderated-mediation structure has been inferred from the convergence of separate studies examining individual pathways; no single study in the corpus simultaneously tested all pathways within one analytical model. Accordingly, the framework is best understood as a theoretically grounded, empirically informed proposition that awaits formal validation through purpose-designed primary research.

Note on terminology correction. In earlier versions of this manuscript, the construct was incorrectly labeled as "Digital Self-Efficiency." This has been corrected throughout to "Digital Self-Efficacy," following Bandura's conception of self-efficacy as individuals' beliefs in their capabilities to organize and execute actions required to produce desired outcomes. This is not a minor wording change but an important conceptual clarification: self-efficacy refers to a psychological belief about capability, whereas efficiency refers to the effectiveness or speed of performance. The revised terminology is therefore more accurate and aligns with the theoretical framework used in this study.

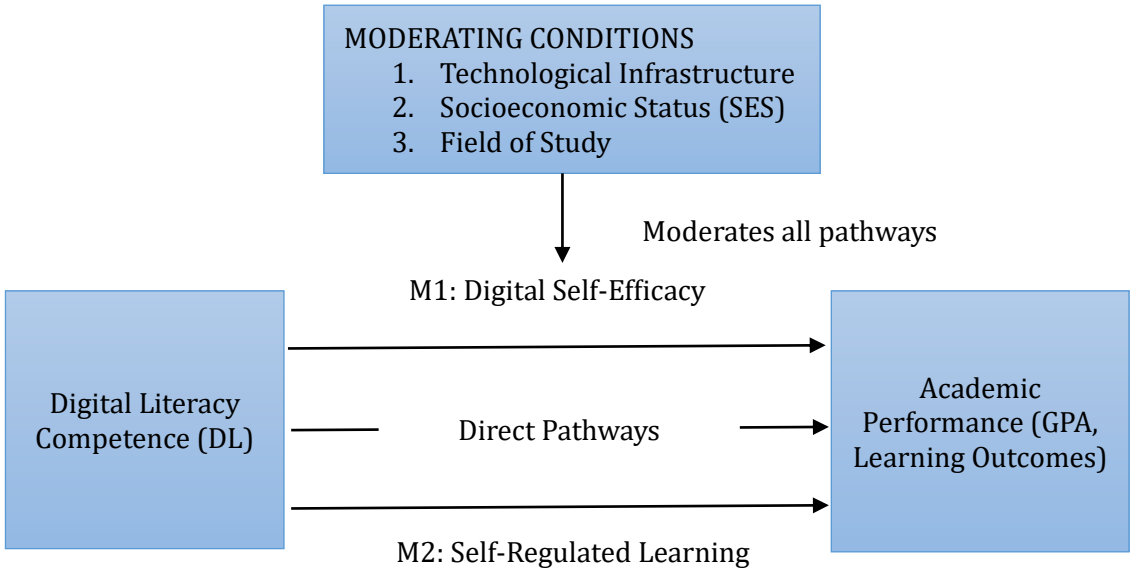


Figure 2: Integrated Moderated-Mediation Model of Digital Literacy Competence and Academic Performance in Higher Education (Proposed Synthesis-Based Conceptual Framework)

Note**:** M1 and M2 represent the psychological mediators identified through thematic synthesis. All pathways in the model are conditioned by the three moderating variables. This framework is derived from converging evidence across the 42 included studies and is proposed as a testable model for future empirical research.

The conceptual model integrates the main empirical patterns identified in this review. The direct pathway is supported by studies reporting a positive association between digital literacy

and academic performance, while the mediating pathways are supported by evidence on digital self-efficacy and self-regulated learning. The moderating conditions, including technological infrastructure, socioeconomic status, and field of study, explain why the strength of this relationship varies across institutional and disciplinary contexts. Therefore, the model should be interpreted as a synthesis-based conceptual contribution rather than a validated causal structure. Its primary function is to organize existing evidence and provide a coherent direction for future empirical testing.

Practical Implications

The findings of this review have several implications for higher education practice. First, digital literacy development should be embedded within disciplinary curricula rather than delivered as a generic or separate ICT training program. The reviewed evidence suggests that digital competence becomes academically meaningful when students apply it in authentic learning activities, such as searching and evaluating academic information, producing digital content, collaborating through digital platforms, managing online learning tasks, and solving discipline-specific problems.

Second, lecturers and instructional designers should strengthen the psychological mechanisms that connect digital literacy to academic performance, particularly digital self-efficacy and self-regulated learning. Digital learning activities should therefore include scaffolded tasks, gradual increases in task complexity, constructive feedback, and opportunities for students to experience successful digital academic performance. These strategies can help students transform digital skills into confidence, autonomy, and effective learning behavior.

Third, institutions should address structural barriers that may weaken the academic benefits of digital literacy. Reliable internet access, adequate devices, learning management systems, technical support, and inclusive digital infrastructure are necessary conditions for students to benefit from digital competence. Without these supports, digital literacy interventions may unintentionally widen existing inequalities between students from different socioeconomic backgrounds.

Fourth, digital literacy programs should be adapted to disciplinary and institutional contexts. Technology-intensive disciplines may require stronger emphasis on data literacy, digital production, programming, and platform-based collaboration. In contrast, disciplines with less direct technological orientation may need greater emphasis on critical information evaluation, ethical digital practice, academic communication, and responsible use of emerging technologies.

Limitations of the Review

This review has several limitations. First, the review was limited to peer-reviewed studies published in English and Indonesian. This may have excluded relevant studies published in other languages or in non-indexed sources, which could introduce language and publication bias. Second, the included studies used different definitions and measurements of digital literacy and academic performance. Some studies adopted established frameworks such as DigComp, while others used self-developed instruments. Academic performance was also measured through different indicators, including GPA, course grades, standardized test scores, and self-reported learning outcomes. This heterogeneity limits direct comparison across studies. Third, most studies in the reviewed corpus used cross-sectional designs. As a result, this review cannot establish definitive causal direction between digital literacy and academic performance. Although the evidence suggests that digital literacy may contribute to academic performance through self-efficacy and self-regulated learning, reciprocal relationships may also exist. Fourth, the Digital-Ecological Nexus framework remains a conceptual model derived from synthesis. Although it is grounded in the reviewed evidence and relevant theoretical perspectives, it has not yet been tested as an integrated moderated-mediation model using primary empirical data.

Future Research Directions

Future research should prioritize longitudinal and experimental designs to clarify the causal relationship between digital literacy and academic performance. Longitudinal panel studies, quasi-experimental interventions, and cross-lagged structural equation modelling would help determine whether digital literacy predicts later academic achievement, whether academic achievement strengthens digital competence, or whether both relationships occur simultaneously. Future studies should also empirically validate the Digital-Ecological Nexus framework. Researchers should test digital literacy, digital self-efficacy, self-regulated learning, technological infrastructure, socioeconomic status, disciplinary context, and academic performance within one integrated model. Multi-level structural equation modelling would be especially useful because it can examine both individual-level and institutional-level influences.
In addition, future research should expand the concept of digital literacy to include emerging competencies related to artificial intelligence, data literacy, algorithmic awareness, digital ethics, and critical evaluation of automated technologies. As AI-based tools become increasingly embedded in higher education, traditional digital literacy frameworks may no longer be sufficient to explain students' academic success in digital learning environments.

Further studies are also needed in underrepresented geographical and demographic contexts. More evidence from Sub-Saharan Africa, Latin America, South Asia, and developing higher education systems would strengthen the global relevance of the field. Future studies should also examine differences among student groups, including first-generation students, students with disabilities, mature learners, and students from lower socioeconomic backgrounds. Finally, future research should investigate possible non-linear and threshold effects. The relationship between digital literacy and academic performance may not always be linear. Students may need to reach a minimum level of digital competence before academic benefits appear, while additional improvement beyond a certain point may produce diminishing returns.

CONCLUSIONS

This systematic review synthesized evidence from 42 studies published between 2010 and 2025 to examine the relationship between digital literacy and academic performance in higher education. The findings show that digital literacy is positively associated with academic performance, but this relationship is neither purely direct nor universally consistent across contexts. Rather, the relationship operates through psychological mechanisms and is shaped by contextual conditions. Digital self-efficacy and self-regulated learning emerged as key mediating mechanisms that explain how digital literacy contributes to academic outcomes. Students benefit academically from digital competence when they are confident in applying digital tools and are able to regulate their learning processes effectively. At the same time, institutional infrastructure, socioeconomic status, disciplinary context, and pedagogical design moderate the strength of this relationship.

The review proposes the Digital-Ecological Nexus as a conceptual framework for understanding the interaction between individual digital competence, psychological learning mechanisms, and structural learning environments. This framework contributes to the literature by organizing fragmented evidence into an integrated model that can guide future empirical testing. Overall, the findings suggest that digital literacy should be understood not merely as a technical skill, but as a context-dependent academic capability that requires psychological, pedagogical, and institutional support.

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AUTHOR DISCLOSURE STATEMENT

NL conceived the study, designed the systematic review protocol, conducted database searches, screened records, extracted data, performed quality appraisal and thematic synthesis, and drafted the manuscript. HP and DF supervised all stages of the research, contributed to the conceptualization of the Digital-Ecological Nexus framework, validated the synthesis findings and interpretations, and critically revised the manuscript.

AI DISCLOSURE STATEMENT

Generative artificial intelligence tools were used only to assist with language refinement, structural organization, and editorial clarity during the manuscript revision process. The AI tools were not used to design the study, conduct the literature search, screen articles, extract data, perform quality appraisal, analyze the findings, generate references, or formulate the substantive interpretation of the results. All intellectual content, methodological decisions, synthesis procedures, interpretations, and final revisions remain the responsibility of the authors. The authors have reviewed, verified, and approved the final version of the manuscript.

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