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Digital Literacy among University Students in Indonesia: A Systematic Review of Measurement, Academic Applications, and Evidence on Learning Outcomes

Abriadi Muhara[1]*, Hasmawaty[2], Syakhruni[3], Andi Adam[4], Aliem Bahri[5]
[1,2,3]Makassar State University
[4,5]Muhammadiyah University of Makassar
Corresponding Author: Abriadi Muhara abriadi@unm.ac.id

A R T I C L E I N F O

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A B S T R A C T

Digital literacy supports students' academic activities, but research varies in its definitions, instruments, and outcome indicators. This review synthesises definitions and measurement approaches, academic applications and their enablers and barriers, and associations with learning processes and outcomes among university students in Indonesia. Reporting follows PRISMA 2020. A Scopus search identified 208 records, reduced to 129 after restriction to 2016–2025. Filters for article document type, English language, journal source type, and All Open Access yielded 72 records. Applying inclusion and exclusion criteria resulted in 35 articles for extraction and synthesis. The review used ten extraction components and a structured synthesis addressing three research questions, distinguishing constructs, assessment methods, psychometric evidence, research designs, and outcomes. Findings reveal conceptual variation across digital literacy, digital competence, digital skills, and digital readiness, with self-report as the predominant measurement approach. Academic applications include information management, writing, collaboration, content creation, independent learning, and evaluation of artificial intelligence outputs. Lecturer and peer support, instructional design, and resource availability accompany barriers involving connectivity, devices, time, and information credibility. Digital literacy shows positive associations with several learning processes and outcomes, although relationships are not consistently direct or uniform. The predominance of cross-sectional designs and self-report measures, limited comparison groups, and inconsistent reporting constrain causal inference. The review highlights the need for multidimensional measurement, performance assessment, and complete methodological reporting.

INTRODUCTION

Students' academic activities increasingly depend on digital resources, devices, and spaces for interaction. Students use digital technologies to search the literature, access materials, write, communicate with lecturers, collaborate with peers, and produce various outputs (Limba et al., 2026; Yumiarty, 2026). Academic requirements therefore extend beyond device operation to evaluating information credibility, integrating sources, communicating knowledge, and considering security and ethics. The studies reviewed in this article show that these requirements arise across fields, including teacher education, English language education, accounting, engineering, entrepreneurship, and environmental learning (Ng et al., 2023; Tsani & Sufirmansyah, 2025).

Nevertheless, existing research does not define digital literacy consistently. Some studies use digital literacy, while others refer to digital competence, digital skills, or digital readiness. These terms overlap but emphasise different aspects (Campos & Scherer, 2023; Simanjuntak, 2022). Competence may encompass knowledge, skills, and attitudes; skills may refer more specifically to technology-use practices; and readiness may combine capabilities with access, comfort, and willingness to adapt. These differences affect indicator selection and the scope of research conclusions. Treating the terms as equivalent without examining instrument content therefore risks inappropriate comparisons (Johnson & Jensen, 2024; Otto et al., 2021).

Conceptual frameworks also contribute to measurement variation (Cruchinho et al., 2024; Iliescu et al., 2024). (Siddiq et al., 2023) organise digital literacy into information and data, communication and collaboration, content creation, safety, and problem-solving. The literature also addresses awareness, attitudes, resource management, knowledge construction, and communication (Siddiq et al., 2023; Tınmaz et al., 2022). Other studies draw on the International ICT Literacy Panel, Hague and Payton, Falloon, or frameworks adapted to disciplinary contexts. Even when studies cite the same framework, adaptation and item removal can produce instruments with different coverage. Citing a framework in the theoretical background does not necessarily establish that measurement covers all its dimensions (Johnson & Jensen, 2024; Wang et al., 2023).

Differences in assessment methods further limit comparability. Self-report questionnaires assess participants' perceptions of their capabilities or practices, whereas knowledge tests assess responses to specified problems (Rohim, 2021; Shewchuk et al., 2023). Performance tests, observations, and artefact assessments provide evidence of students' actions or products, while interviews explain their experiences and reasoning. Each method has strengths and limitations (Rohim, 2021). Positive self-perceptions, for example, do not necessarily reflect accurate source evaluation. Conversely, successfully producing one digital artefact does not represent every dimension of digital literacy. Findings should therefore be interpreted according to the type of evidence collected (Nguyen & Habók, 2023; Suri et al., 2025).

Academic applications of technology should also be distinguished from platform use alone. E-portfolio studies document information organisation, link

embedding, and multimedia content creation (Boholano et al., 2022; Lu, 2021). Other examples include video production in microteaching and information-management practices among postgraduate students. These examples identify specific academic practices. By contrast, social media use frequency or acceptance of artificial intelligence alone does not demonstrate digital competence. Technology use can support learning while also involving distraction, credibility concerns, access constraints, and ethical challenges (Rochim, 2024; Setyarini et al., 2025).

The relationship between digital literacy and learning also requires careful examination. (Manubey et al., 2022) found an association between digital literacy and research competence, but not critical thinking. (Rosyid et al., 2024) reported an association with online engagement and an indirect association with accounting competence. These findings indicate that relationships may vary by outcome and analytical pathway. In intervention studies, improvements in digital literacy should also be distinguished from changes in other academic outcomes. Changes following learning activities do not, by themselves, establish causal effects, particularly without a comparison group (Dyantyi-Gwanya et al., 2025; Wisudojati et al., 2024).

These issues indicate a need for synthesis that retains the connections among concepts, measurement, practices, and outcomes (Martella et al., 2023). Reviews that merely summarise literacy levels or count significant findings risk overlooking differences in instruments and research designs. This review therefore organises the evidence around three interrelated research questions (Friedrich et al., 2024; Suri et al., 2025).

Table 1. Research questions and contributions of the synthesis

Research question	Review focus	Intended contribution
RQ1. How do studies define and measure digital literacy?	Constructs, dimensions, assessment, validity, and reliability	Clarify measurement equivalence and limitations.
RQ2. How do students apply digital literacy, and what enables or hinders its use?	Academic activities, practices, tools, and contextual factors	Identify applications supported by evidence.
RQ3. How is digital literacy associated with learning processes and outcomes, and how strong is the evidence?	Outcomes, analytical role of the construct, designs, estimates, and appraisal	Distinguish associations, changes, and causal claims.

These three areas allow the review to explain key patterns while identifying variation and uncertainty in the available evidence. Its contributions include distinguishing construct terminology, evaluating alignment between claims and assessment methods, and integrating quantitative and qualitative findings. This

approach aims to help researchers select appropriate measurement methods and support educators in designing digital literacy development integrated with concrete academic activities.

METHODOLOGY

Review Design and Research Questions

This study uses a systematic literature review (SLR) approach, with reporting guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020. The guideline supports transparent reporting of identification, screening, eligibility assessment, and inclusion. The review addresses three research questions concerning definitions and measurement of digital literacy; academic applications and their enablers and barriers; and associations with learning processes and outcomes among university students in Indonesia.

Information Sources and Search Strategy

The literature search used Scopus and initially identified 208 records. Restricting publication years to 2016–2025 reduced this number to 129. The search strategy, including search fields and Boolean operators, used the following expression: ("digital literac*" OR "digital competenc*" OR "digital skill*") AND (student* OR undergraduate* OR postgraduate* OR "pre-service teacher*" OR "preservice teacher*" OR "teacher candidate*") AND ("higher education" OR universit* OR college* OR "tertiary education" OR "teacher education") AND Indones* AND NOT ("systematic review" OR "systematic literature review" OR "literature review" OR "meta-analysis" OR metaanalysis OR bibliometric*).

Filters were then applied sequentially for document type Article, language English, source type Journal, and access status All Open Access. After all filters, 72 records remained for assessment against the inclusion and exclusion criteria. The reductions of 79 records after the year restriction and 57 after the combined filters represent differences in search results, rather than full-text exclusions or reports that could not be retrieved.

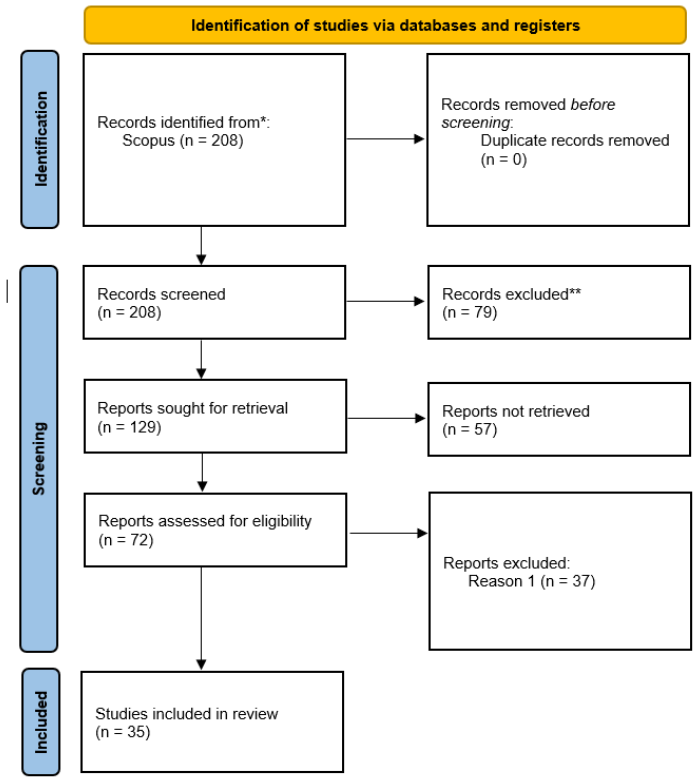


Figure 1. Search and Selection Flow Based on the Available Counts

Eligibility Criteria

Articles were considered relevant if they reported empirical research involving university students in Indonesia and provided evidence for at least one research question. Pre-service teachers were included in the target population. For mixed populations, the contribution of university student data had to be identifiable; multinational studies had to specify participation from Indonesia. In multinational psychometric research, combined findings were labelled separately and were not interpreted as Indonesia-only estimates. Self-report studies remained eligible, but interpretation considered the type of evidence used.

Related constructs were considered when their instruments covered relevant digital capabilities. Platform use, device ownership, or training recommendations alone did not meet the criteria. Non-empirical articles, reviews, bibliometric studies, and publications outside the specified types were excluded. Career or technology-acceptance outcomes did not automatically warrant exclusion if an article also contributed to digital literacy measurement. However, these outcomes were separated from academic outcomes in the synthesis. Unclear abstract information prompted full-text examination rather than immediate exclusion.

Study Selection and Dataset Status

The 72 articles were assessed against the predefined inclusion and exclusion criteria. Assessment considered the university student population in Indonesia,

the empirical nature of the research, the relevance of digital literacy or related constructs, and contributions to at least one research question. Technology or platform use alone was insufficient without evidence of relevant capabilities, practices, or measurement.

Selection involved title and abstract screening followed by full-text examination against the eligibility criteria. The final selection summary indicated that 35 articles were included in extraction and synthesis, while 37 of the 72 records were not included in the final corpus. Counts at each stage, full-text availability, and exclusion reasons were recorded. Figure 1 summarises the available counts.

Data Extraction

Data were extracted using ten components: article identification; participants and context; design and analysis; definitions, frameworks, and dimensions; instruments and assessments; validity and reliability; academic applications; enablers and barriers; learning processes and outcomes; and methodological appraisal and evidence limitations. Each article should be linked to a unique identifier using its title and DOI. The author extracted the data, and unreported information was recorded as unavailable.

Appraisal and Synthesis

Methodological appraisal covered design, sampling, confounding, measurement, comparison groups, methodological integration, and reporting completeness. The synthesis drew on limitations documented in the extraction. Because formal domain-level appraisal was not fully documented, findings were not presented as formal evidence-certainty categories.

For RQ1, analysis involved grouping constructs, comparing definitions, mapping dimensions, classifying assessments, and examining psychometric evidence. RQ2 used thematic grouping of academic activities and factors at student, instructional, institutional, and infrastructure levels. Empirical findings were distinguished from recommendations and conceptual accounts.

For RQ3, learning processes, academic outcomes, digital literacy development, and related outcomes were separated. Correlations, regressions, SEM estimates, within-group changes, and between-group comparisons were analysed separately. Mixed-methods components were not counted as independent studies. Narrative sensitivity analysis compared conclusions when studies with prominent reporting problems were set aside; it did not involve recalculating effects. Meta-analysis was not undertaken because heterogeneity in constructs, outcomes, estimation methods, and limited precision information prevented defensible pooling.

RESEARCH RESULT

The Scopus search identified 208 records. Restriction to publication years 2016–2025 reduced this number to 129, and document, language, source, and open-access filters left 72 records. The final selection summary listed 35 articles for extraction and synthesis. Each article's contribution to the research questions

was determined by its reported data and analyses; not every article provided evidence for all three questions.

Definitions and Measurement

The reviewed studies used various construct terms, including digital literacy, digital competence, digital skills, digital readiness, and specialised constructs. Identified dimensions included information, communication, content creation, safety, problem-solving, culture, and pedagogical application. Several articles did not provide explicit definitions, and theoretical frameworks did not always correspond directly to operational dimensions.

Self-report questionnaires were the most common measurement approach in the extraction table. Other approaches included cognitive tests, observation, video tasks, interviews, and e-portfolio analysis. Validation of technology-acceptance instruments was not treated as digital literacy validation. Reported psychometric evidence primarily concerned internal consistency, content evaluation, and factor analysis. Test–retest reliability, measurement error, and invariance information were not recorded in the extraction. Some entries reported Aiken's V values exceeding one or score categories inconsistent with the item counts and scales. These discrepancies require verification against the original articles before interpretation.

Academic Applications

Students used digital capabilities to search for and evaluate sources, write, collaborate, create content, and learn independently. E-portfolios and video production provided concrete product-based evidence. Interviews described literature management and verification of AI outputs. Reported support included lecturer guidance, peer collaboration, activity planning, and resource access. Identified barriers involved internet connectivity, data allowances, devices, time, distraction, and information credibility. However, some entries classified as factors were recommendations or methodological issues and were therefore not counted as empirical barriers.

Associations with Learning

The evidence indicated positive associations with several learning processes and outcomes, although patterns were not consistent across studies. Differences in outcomes and methods limited direct comparisons of estimate magnitudes.

Table 2. Summary of evidence on associations and changes

Study	Main finding	Interpretive limitation
Indah et al. (2022)	Research competence: r = 0.566; critical thinking: r = 0.011	Bivariate associations; findings differ by outcome.
Rosyid et al. (2025)	Engagement: $\beta = 0.564$; direct association with accounting competence not significant	An indirect pathway through engagement was reported as significant.

Lukitasari et al. (2022)	Association with learning outcomes: r = 0.505; R^2 = 0.255	Does not indicate the proportion of outcomes caused by digital literacy.
Indriyani et al. (2023)	Writing R^2 = 0.930 for digital literacy and collaboration jointly	The independent contribution of digital literacy is unavailable.
Maspiroh et al. (2025)	Digital literacy gains: 20.92 versus 3.46 points	A test of between-group change is unavailable.
Yuvita et al. (2025)	Video score: 59.52 to 87.05	No comparison group.
Elvi Rahmi et al. (2025)	Between-group difference in mindset; d = 1.21	Effect of the instructional package, not digital literacy alone.

DISCUSSION

Research on digital literacy in Indonesian higher education operationalises the construct in different ways. This variation affects the evidence as a whole, from capability profiles to associations with learning. Instruments labelled as measures of digital literacy may assess technology-use frequency, perceived capability, readiness, or performance. Differences in scores across studies therefore do not necessarily indicate differences in students' capabilities. Synthesis should consider the substance of the construct and the meaning of the responses measured.

The predominance of self-report limits interpretation of positive findings. Students may view technology use as easy or beneficial without demonstrating accurate information evaluation. Measuring predictors and outcomes through self-report also creates potential common method bias; however, this synthesis did not test whether that bias affected the findings. High internal consistency does not, by itself, establish the validity of performance measurement. Task and artefact evidence can complement this information, although it is usually obtained in more bounded contexts. Multiple methods may help assess alignment between perceptions and actual capabilities.

Academic applications show digital skills in activities with specific purposes and products. E-portfolio, microteaching, and writing studies illustrate tool use, information management, and content creation. Lecturer and peer support were reported during these activities, while internet access, devices, and time posed constraints. These findings emphasise the importance of instructional design and access conditions. Factors presented only as recommendations, however, cannot be treated as empirically demonstrated influences.

Associations with learning outcomes require interpretation specific to each outcome. Rosyid's findings suggest that engagement can serve as an intermediate pathway in a statistical model. Indah's findings indicate that an association with research competence does not necessarily extend to critical thinking. These findings do not support the assumption that digital literacy offers uniform benefits across all outcomes. Differences in dimensions, tasks, contexts,

and measurement should be examined as possible explanations rather than disregarded through pooling.

Intervention studies provide more direct evidence of change, but their evidential strength varies. The entrepreneurship intervention included a comparison group and baseline analysis, whereas the microteaching study assessed performance repeatedly without a comparison group. The RADEC study showed descriptively different gains, but separate within-group tests did not establish a difference in effects. Moreover, improvement in digital literacy is an outcome in its own right. Without additional measurement, it cannot justify conclusions about higher grades, greater subject mastery, or improved writing quality.

This review is limited by its search coverage and the available evidence. Searching only Scopus and restricting inclusion to English-language and open-access articles may exclude relevant Indonesian-language research, journals outside Scopus, and subscription-only articles. The synthesis also depends on extraction accuracy; some entries do not clearly distinguish findings, recommendations, and conceptual accounts. Domain-level appraisal documentation and information on estimate precision remain incomplete. Narrative sensitivity analysis does not replace formal risk-of-bias assessment. Conclusions are therefore restricted to associations and practices supported by the data, rather than certainty about causal effects.

CONCLUSIONS AND RECOMMENDATIONS

This review shows that studies of digital literacy among university students in Indonesia use diverse definitions and measurement approaches. The construct encompasses information management, communication, content creation, safety, and problem-solving. Instrument coverage, however, does not always align with the conceptual framework cited. Self-report is the most widely used approach, whereas performance tests, observation, and artefact analysis provide evidence more closely tied to the context of capability use. Available psychometric evidence primarily supports internal consistency and the structure of particular instruments, rather than equivalence across all measures.

Students apply digital capabilities to source searching, research, writing, collaboration, content creation, and independent learning. These applications are supported by activity design, lecturer guidance, peer interaction, and resource and technology availability. Reported constraints include connectivity, devices, data allowances, limited time, distraction, and information quality. Nevertheless, not all factors in the extraction originate from empirical testing or participants' experiences. Empirical findings should therefore be distinguished from recommendations.

The relationship between digital literacy and learning depends on the outcome examined. Several studies report positive associations with engagement, research competence, and learning outcomes, while others find indirect associations or non-significant results. Interventions show capability development in particular contexts but have not isolated digital literacy's contribution from other pedagogical components. The available evidence is

therefore insufficient to establish a causal relationship between digital literacy and academic achievement in general.

Universities should integrate digital literacy development into academic tasks with defined objectives. Activities such as literature searching, source verification, collaborative writing, material production, and evaluation of AI outputs can be designed to produce assessable outcomes. Assessment should cover processes and products, including source accuracy, the rationale for information selection, content quality, and ethical considerations. Technical support should accompany academic guidance.

Researchers should select instruments aligned with construct definitions and research objectives. Reporting should include retained items, scales, scoring methods, category thresholds, assessor identities or qualifications, and sources of validation evidence. Longitudinal studies and interventions with comparison groups can clarify temporal relationships. Analyses should also account for baseline capability and confounding and report confidence intervals. Mixed-methods studies should explain how qualitative findings complement or test interpretations of quantitative results.

Overall, the findings support digital literacy development integrated with academic tasks and assessed through appropriate methods. Programme implementation should include evaluation of processes, products, and student access. Interpretation of benefits must consider outcomes, measurement methods, and research designs. Stronger evidence requires transparent reporting, validated measurement, comparison groups, and adequate observation periods to assess changes in learning.

REFERENCES

Boholano, H. B., Sanchez, J. M. P., Balo, V. T. M., & Navarro, T. M. M. (2022). Utilization of e-Portfolios in Teacher Education Institutions of Higher Education in Central Visayas, Philippines. *International Journal of Information and Education Technology*, *12*(9), 912–920. https://doi.org/10.18178/ijiet.2022.12.9.1701

Campos, D., & Scherer, R. (2023). Digital gender gaps in Students' knowledge, attitudes and skills: an integrative data analysis across 32 Countries. *Education and Information Technologies*, *29*(1), 655–693. https://doi.org/10.1007/s10639-023-12272-9

Cruchinho, P., López-Franco, M. D., Capelas, M. L., Almeida, S., Bennett, P. M., Silva, M. M. da, Teixeira, G., Nunes, E., Lucas, P., & Gaspar, F. (2024). Translation, Cross-Cultural Adaptation, and Validation of Measurement Instruments: A Practical Guideline for Novice Researchers. *Journal of Multidisciplinary Healthcare*, 2701–2728. https://doi.org/10.2147/jmdh.s419714

Dyantyi-Gwanya, N., Mavenge, L., Ncanywa, T., & Asaleye, A. J. (2025). Digital literacy and chemistry proficiency among first-year university students in Eastern Cape, South Africa. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1630306

Friedrich, A., Schreiter, S., Vogel, M., Becker-Genschow, S., Brünken, R., Kühn, J., Lehmann, J., & Malone, S. (2024). What shapes statistical and data literacy research in K-12 STEM education? A systematic review of metrics and instructional strategies. *International Journal of STEM Education*, *11*(1). https://doi.org/10.1186/s40594-024-00517-z

Iliescu, D., Greiff, S., Ziegler, M., Nye, C. D., Geisinger, K. F., Sellbom, M., Samuel, D. B., & Saklofske, D. H. (2024). Proliferation of measures contributes to advancing psychological science. *Communications Psychology*, *2*(1), 19. https://doi.org/10.1038/s44271-024-00065-w

Johnson, T., & Jensen, J. (2024). Research methods challenges: A case study of preparedness in The Bahamas. *Jàmbá Journal of Disaster Risk Studies*, *16*(1), 1565. https://doi.org/10.4102/jamba.v16i1.1565

Limba, F. T. G., Razilu, Z., & Fajriani, A. (2026). ANALISIS PEMANFAATAN TEKNOLOGI DALAM PEMBELAJARAN DI ERA DIGITAL: STUDI LITERATUR REVIEW. *LEARNING Jurnal Inovasi Penelitian Pendidikan Dan Pembelajaran*, *6*(3), 2119–2127. https://doi.org/10.51878/learning.v6i3.11690

Lu, H. (2021). Electronic Portfolios in Higher Education: A Review of the Literature. *European Journal of Education and Pedagogy*, *2*(3), 96–101. https://doi.org/10.24018/ejedu.2021.2.3.119

Manubey, J., Koroh, T. D., Dethan, Y. D., & Banamtuan, M. F. (2022). Pengaruh Literasi Digital terhadap Hasil Belajar Mahasiswa. *EDUKATIF JURNAL ILMU PENDIDIKAN*, *4*(3), 4288–4294. https://doi.org/10.31004/edukatif.v4i3.2590

Martella, A. M., Martella, R. C., Yatcilla, J., Newson, A., Shannon, E. N., & Voorhis, C. (2023). How Rigorous is Active Learning Research in STEM Education? An Examination of Key Internal Validity Controls in Intervention Studies. *Educational Psychology Review*, *35*(4). https://doi.org/10.1007/s10648-023-09826-1

Ng, D. T. K., Leung, J. K. L., Su, J., Ng, C. W., & Chu, S. K. W. (2023). Teachers' AI digital competencies and twenty-first century skills in the post-pandemic world. *Educational Technology Research and Development*, *71*(1), 137–161. https://doi.org/10.1007/s11423-023-10203-6

Nguyen, L. A. T., & Habók, A. (2023). Tools for assessing teacher digital literacy: a review. *Journal of Computers in Education*, *11*(1), 305–346. https://doi.org/10.1007/s40692-022-00257-5

Otto, A., Göpfert, C., & Thieken, A. H. (2021). Are cities prepared for climate change? An analysis of adaptation readiness in 104 German cities. *Mitigation and Adaptation Strategies for Global Change*, *26*(8). https://doi.org/10.1007/s11027-021-09971-4

Rochim, A. A. (2024). Kecerdasan Buatan: Resiko, Tantangan Dan Penggunaan Bijak Pada Dunia Pendidikan. *Antroposen Journal of Social Studies and Humaniora*, *3*(1), 13–25. https://doi.org/10.33830/antroposen.v3i1.6780

Rohim, D. C. (2021). Konsep Asesmen Kompetensi Minimum untuk Meningkatkan Kemampuan Literasi Numerasi Siswa Sekolah Dasar. *Jurnal VARIDIKA*, *33*(1), 54–62. https://doi.org/10.23917/varidika.v33i1.14993

Rosyid, A., Kawedar, W., Ghozali, I., & Aryani, A. T. D. (2024). The effect of digital literacy on operational accounting competencies: The mediating role of online learning engagement. *Multidisciplinary Reviews*, *8*(1), 2025023. https://doi.org/10.31893/multirev.2025023

Setyarini, N. D. A. P. R. L., Werang, B. R., & Ariawan, I. P. W. (2025). Literasi Digital, Kedisiplinan, dan Komitmen Kerja terhadap Kinerja Guru. *Journal of Education Action Research*, *9*(2), 269–278. https://doi.org/10.23887/jear.v9i2.92800

Shewchuk, S., Wallace, J. A., & Seibold, M. (2023). Evaluations of training programs to improve capacity in K*: a systematic scoping review of methods applied and outcomes assessed. *Humanities and Social Sciences Communications*, *10*(1). https://doi.org/10.1057/s41599-023-02403-5

Siddiq, F., Røkenes, F. M., Lund, A., & Scherer, R. (2023). New kid on the block? a conceptual systematic review of digital agency. *Education and Information Technologies*, *29*(5), 5721–5752. https://doi.org/10.1007/s10639-023-12038-3

Simanjuntak, M. M. (2022). Analisis Urgensi Penggunaan Literasi Digital dalam Pelaksanaan Pendidikan pada Masa Pandemi di Sekolah Menengah Pertama. *EDUKATIF JURNAL ILMU PENDIDIKAN*, *4*(2), 2599–2608. https://doi.org/10.31004/edukatif.v4i2.2547

Suri, N. A., Festiyed, F., Azhar, M., Yerimadesi, Ahda, Y., & Alberida, H. (2025). Measuring what matters: a systematic review and VOSviewer-based bibliometric approach to digital literacy assessment instruments, competency dimensions and challenges in education. *Research in Learning Technology*, *33*. https://doi.org/10.25304/rlt.v33.3413

Tınmaz, H., LEE, Y.-T., Fanea-Ivanovici, M., & Baber, H. (2022). A systematic review on digital literacy. *Smart Learning Environments*, *9*(1), 21. https://doi.org/10.1186/s40561-022-00204-y

Tsani, I., & Sufirmansyah, S. (2025). Aligning Students' Competencies with Global Workforce Standards: A Discrepancy Evaluation Model (DEM) Perspective. *Jurnal Intelektual Jurnal Pendidikan Dan Studi Keislaman*, *15*(2), 303–324. https://doi.org/10.33367/ji.v15i2.7876

Wang, D. Y., Wong, E. L., Nilsén, P., Chung, V. C. H., Tian, Y., & Yeoh, E. (2023). A scoping review of implementation science theories, models, and frameworks — an appraisal of purpose, characteristics, usability, applicability, and testability. *Implementation Science*, *18*(1), 43. https://doi.org/10.1186/s13012-023-01296-x

Wisudojati, B., Iswadi, M. K., Aminullah, A. M., & Laelatunnufus, A. (2024). Peningkatan Keterampilan Literasi Berpikir Kritis Pada Pada Siswa Sekolah Menengah Melalui Integrasi Tekhnologi Pendidikan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(3), 1815–1821. https://doi.org/10.29303/jipp.v9i3.2629

Yumiarty, Y. (2026). PENGARUH LITERASI TEKNOLOGI, PEMANFAATAN AI DAN PRESTASI AKADEMIK TERHADAP LINGKUNGAN BELAJAR. *TEACHING Jurnal Inovasi Keguruan Dan Ilmu Pendidikan*, *6*(3), 2706–2718. https://doi.org/10.51878/teaching.v6i3.14541

Appendix A

Article Identification and Record Reconciliation

Table A1 lists the 35 records in the supplied extraction dataset. IDs A01–A35 follow the original row order and are appendix identifiers, not the repeated S01 identifiers in the source. The reported final corpus of 35 articles. Table A1. Identification of the 35 extraction records.

ID	First author and year	Article title	DOI
A01	Sutrisno (2025)	Assessing students' readiness for artificial intelligence-based project learning to strengthen local wisdom values in Indonesia	10.1080/2331186X.2025.2582948
A02	Khaerudin (2025)	Smart education for a sustainable future: Integrating IoT and big data in sustainability-based learning	10.1016/j.joitmc.2025.100638
A03	Ketut Susiani (2025)	Development and Initial Psychometric Properties of Digital Literacy and Resilience Scale among University Students	10.18178/ijiet.2025.15.7.2339
A04	Abdul Wahid (2025)	Promoting Learners' Autonomy through Metacognitive, Higher-Order Thinking Skills and Digital Literacy of Indonesian Private Universities	10.22521/edupij.2025.16.204
A05	Antonius Setyadi (2025)	Risk management, digital technology literacy, and modern learning environments in enhancing learning innovation performance: A framework for higher education	10.1007/s10639-025-13380-4
A06	Saberina Hasibuan (2025)	Bridging cognitive skills and environmental awareness: critical and creative thinking as predictors of digital ecoliteracy	10.3389/feduc.2025.1705676
A07	Rakhdiny Sustaningrum (2025)	Student utilization and perceptions of AI technology for academic purposes: a mixed-method analysis	10.1080/2331186X.2025.2553835
A08	Ulfia Rahmi (2022)	The role of support system, digital literacy and learning strategy on learning outcomes for preservice teachers in a blended learning environment	10.9743/JEO.2022.19.3.5
A09	Dian Rachmawati (2024)	Empowering Futures: Unveiling the Impact of Career Readiness on Job Seeker and Creator through Self-Efficacy	10.7160/eriesj.2024.170403
A10	Elvi Rahmi (2025)	Bridging Entrepreneurship Education and Digital Transformation: A Novel Experiential Learning Model for Entrepreneurial Mindset Development	10.26803/ijlter.24.4.29

A11	Lamberthus J. Lokollo (2024)	Harnessing Social Media for Independent Learning: Insights from Higher Education Students	10.62754/joe.v4i1.6219
A12	Murtono (2025)	Adaptive Curriculum, Digital Literacy, and Global Collaboration for Enhancing Multicultural Competence in Higher Education	10.26803/ijlter.24.8.13
A13	Michael Ricky Sondak (2025)	Bridging Parental Influence and Entrepreneurship Education: The Role of Entrepreneurial and Digital Competencies in Shaping Entrepreneurial Career Aspirations	10.1177/21582440251367512
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