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MAPPING AND MEASURING DIGITAL LITERACY IN SECONDARY EDUCATION THROUGH SYSTEMATIC LITERATURE REVIEW OF PSYCHOMETRIC AND IMPLICATION

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Abstract: *The rapid advancement of digital technology has profoundly transformed education and other aspects of life. In the 21st century, digital literacy has become a core competence for secondary school students to navigate academic, social, and professional environments. However, assessment efforts remain inconsistent, as most instruments are designed for university students or teachers. This study aims to identify and analyze research on digital literacy assessment instruments for secondary education through a Systematic Literature Review (SLR) following the PRISMA protocol. Guided by the PICOS framework, 22 articles published between 2021 and 2025 were selected from six international databases (Scopus, ERIC, Google Scholar, SpringerLink, Garuda, and DOAJ Indonesia). The findings demonstrate a rapid increase in research on digital literacy assessment, with the DigComp 2.1 and UNESCO MIL frameworks being the most widely adopted, while several countries, including Indonesia, have developed localized models. Psychometric analyses reveal a methodological shift toward modern approaches such as the Rasch Model, Confirmatory Factor Analysis (CFA), and Aiken's V, ensuring stronger construct validity. These findings underscore significant implications for curriculum development, educational policy, and learning strategies. Overall, this study strengthens the conceptual and psychometric foundations of digital literacy assessment and offers strategic guidance for developing valid, reliable, and contextually grounded instruments to enhance education in the digital era.*

Keywords: *Digital Literacy, Psychometric, Secondary Education.*

INTRODUCTION

The development of digital technology had had a significant impact on various aspects of life, including education. In the 21st century, digital literacy is considered an essential competency that students must possess. The transitional stage in the formation of academic, social, and professional identities occurs during secondary education, therefore students at this level require strong digital literacy competencies (Afandi et al., 2024). Digital literacy not only includes technical skills related to operating digital devices but also encompasses critical thinking, social aspects, and ethical awareness in searching for, evaluating, producing, and communicating information responsibly (Irhandayaningsih, 2022). In line with the importance of digital literacy, systematic efforts are needed to understand the extent to which secondary school students' digital literacy competencies can be measured accurately. Moreover, digital literacy has become a critical issue in contemporary social and educational context due to the increasing exposure of learners to misinformation, vyber risk, and uncontrolled digital content (Isnaini et al., 2025). The rapid integration of digital technologies in learning environments, demands that students not only access information but also evaluate its credibility, manage their digital presence and participate responsibly in digital communities.

Although the urgency of digital literacy has been widely discussed, efforts to map and assess digital literacy among secondary school students still encounter various challenges. Several studies have developed digital literacy instruments; however, many of these tools were designed for university students, educators, or the public, making them less suitable for the characteristics and needs of secondary school learners (Yang et al., 2025). This mismatch may lead to biased measurement results, low validity, and limited usefulness for curriculum development or instructional planning. Furthermore, most existing measurement instruments rely heavily on selfreport methods

and lack strong psychometric evidence to ensure their validity and reliability (Pan et al., 2025). The need for valid and reliable assessment tools is increasingly urgent, as the results of digital literacy evaluations can be used to map students' competencies and inform educational policy (Pikul Nampadsa, 2022). These conditions indicate that, despite being recognized as a key 21st century competence, digital literacy still lacks robust evaluative tools supported by strong psychometric evidence.

Various studies have attempted to develop digital literacy assessments for secondary learners. Delita et al (2022) measured digital literacy skills among high school students using a questionnaire based instrument emphasizing technical and evaluative skills. Pikul Nampadsa (2022) developed digital literacy indicators and norms specifically for high school students in Thailand, highlighting the importance of contextually relevant indicators. Meanwhile, Ma et al (2024) designed an internet literacy scale for high school students in China, covering operational, evaluative, and ethical dimensions. Although these instruments demonstrate meaningful progress in digital literacy assessment, ensuring that they are valid, reliable, and fair for secondary students requires deeper psychometric examination.

Despite the growing number of studies on digital literacy, the literature still presents substantial variation in the dimensions measured, validation methodologies, and geographical or cultural contexts in which the instruments were developed. This variation creates a knowledge gap regarding the relevance, validity, and reliability of these instruments for secondary education settings. Therefore, this study employs a Systematic Literature Review (SLR) to map digital literacy assessment instruments used in secondary education, evaluate the psychometric quality supporting their validity and reliability, and identify the implications of digital literacy research for secondary school learning.

This study aims to identify and analyze digital literacy assessment instruments for secondary school students through a systematic literature review. The findings are expected to provide theoretical contributions to the development of a conceptual framework for digital literacy and practical insights for designing valid and reliable assessment tools. Furthermore, the study is intended to serve as a reference for educators, researchers, and policymakers in designing more effective and contextually relevant strategies for enhancing students' digital literacy. The novelty of this study lies in its specific focus on mapping assessment instruments for secondary education and its emphasis on analyzing their psychometric quality. This approach differs from prior studies, which often focus only on conceptual aspects or indicator development without an in depth analysis of validity and reliability. Therefore, this study is expected to contribute new insights to educational evaluation, particularly in the context of measuring digital literacy among secondary school students.

RESEARCH METHODOLOGY

This study employs a Systematic Literature Review (SLR) approach designed to obtain a comprehensive overview of digital literacy assessment instruments used in secondary education. This approach was selected because it enables the generation of transparent and replicable evidence synthesis (Brignardello Petersen et al., 2025). The focus of the study was structured using the PICOS framework (Population, Intervention, Comparison, Outcomes, Study Design) to clarify the scope of the review and formulate systematic and measurable analytical boundaries. The *Population* includes secondary school students (junior and senior high school or equivalent), as digital literacy skills develop significantly at this level and play a crucial role in 21st century learning readiness. The *Intervention* focuses on the development, adaptation, and validation of digital literacy assessment instruments in the form of questionnaires, tests, or rubrics. The *Comparison* involves analyzing differences in quality and psychometric evidence across instruments, including aspects of validity, reliability, and measurement model fit. The *Outcomes* are directed toward evaluating the quality of the assessments, their alignment with international standards, and their implications for secondary school learning. The *Study Design* includes studies on the development, validation, and empirical testing of digital literacy instruments published between 2021 and 2025.

The literature search was conducted on 6 October 2025 using national and international databases, including Scopus, ERIC, Google Scholar, SpringerLink, Garuda, and DOAJ Indonesia. The search employed a combination of the following keywords: "digital literacy", "digital competence", "scale", "instrument", "assessment", "validation", "secondary education", "high school", "validity", "reliability", "psychometric", "Rasch model", and "Item Response Theory (IRT)". These keywords served as filters to help the databases or search engines match relevant articles to the topic, thereby increasing search efficiency and accuracy (Pottier et al., 2024). The search was limited to journal articles published between 2020 and 2025, with the additional criteria that the articles must be peer reviewed, available in full text, and accessible through open access.

To ensure that only relevant and high quality studies were included in the analysis, this research established specific inclusion and exclusion criteria. The inclusion criteria consisted of: (1) publications focusing on the development, adaptation, or validation of digital literacy assessment instruments; (2) studies involving secondary level students, such as junior and senior high school or equivalent; (3) articles presenting psychometric evidence, including validity, reliability, or analytical results derived from the use of the assessment instrument; (4) manuscripts available in full text form; and (5) articles published in peer reviewed educational journals (Carlsson et al., 2024). The exclusion criteria included: (1) articles in the form of conference proceedings, editorials, or non peer reviewed reports; (2) studies discussing digital literacy solely at a conceptual level without employing an assessment instrument; and (3) studies focusing on teachers, university students, or the general public instead of secondary

school learners.

The SLR procedure in this study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) guidelines, which emphasize traceability across the stages of identification, screening, eligibility assessment, and final article inclusion (Johnson et al., 2022). The research instrument consisted of a data extraction sheet used to document key information from each selected study. The extracted data included authors and publication year, study title, methodology, sample/population, main variables, research findings, and study limitations.

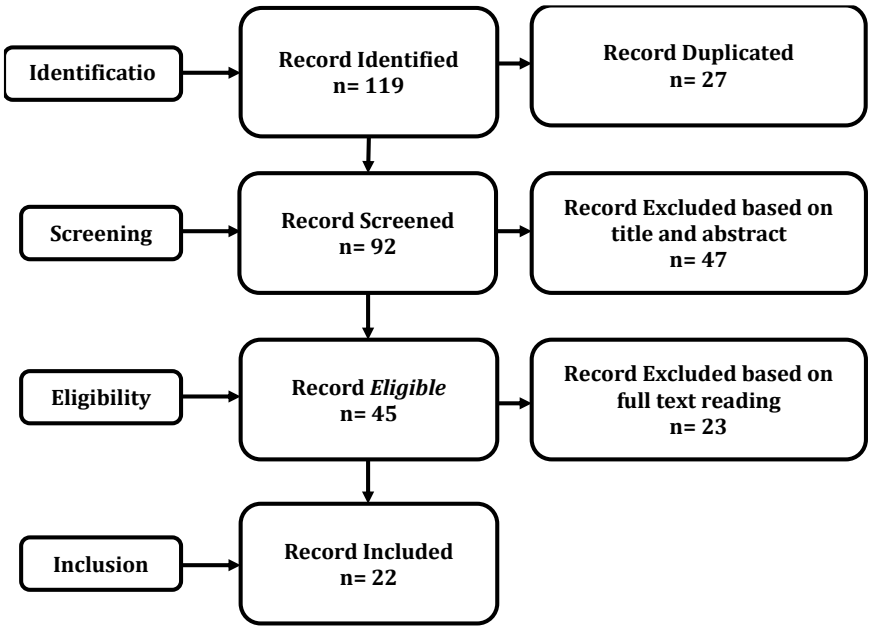

Figure 1. PRISMA Flow Diagram

The final stage of this study is data synthesis. Data were analyzed using a narrative synthesis approach by comparing findings across studies and presenting them in a comparative table of instruments, which includes their characteristics, strengths, weaknesses, and empirical evidence. This approach allows the identification of general patterns, critical differences, and existing research gaps, thereby providing recommendations for the development of new instruments that are more suitable for the context of digital literacy among secondary school students.

RESULTS AND DISCUSSION

Results

This study involved 22 selected articles from six national and international databases (Scopus, ERIC, Google Scholar, SpringerLink, Garuda, and DOAJ Indonesia) published between 2021 and 2025. The findings are presented based on three main focuses: digital literacy mapping, psychometric quality, and the implications of assessment results for secondary school learning.

1.1 Digital Literacy Mapping

The analysis of the 22 articles reveals that research on measuring digital literacy at the secondary education level has experienced rapid growth from 2021 to 2025. Most studies originated from East and Southeast Asia, particularly Indonesia, Thailand, and South Korea, with several others coming from Latin America, such as Peru, Colombia, and Mexico. The frameworks used varied across regions, ranging from DigComp, UNESCO to various local frameworks.

Table 1. Mapping of Digital Literacy

Year	Country	Main Variable (Framework)	Type of Instrument
2025	Thailand	DigComp 2.1	Likert Scale
2022	Thailand	DigComp Adaptation	Norm referenced Test
2022	Türkiye	Data Literacy Framework	Likert Scale
2024	Türkiye	Digital Literacy Framework	Questionnaire
2025	Hong Kong	DigComp 2.1	Performance based
2024	Canada	Canadian Digital Literacy Curriculum Framework	Survey + Curriculum
2023	China	Internet Literacy Framework (ILF)	Questionnaire
2025	Philippines	UNESCO Digital Competence Framework	Likert Scale
2024	Indonesia	DigComp 2.1	Questionnaire
2025	Indonesia	DigComp 2.1	Likert Scale
2023	Indonesia	Science Digital Literacy Framework	Test

Year	Country	Main Variable (Framework)	Type of Instrument
2023	Indonesia	Rasch based Digital Literacy Model	Test
2023	Indonesia	Physics HOTS based Literacy Framework	Test
2024	Indonesia	DigComp 2.1	Test
2023	Indonesia	Rasch based Digital Literacy Model	Likert Scale
2023	Indonesia	Multiple Representation Framework	Test
2024	Korea	Scientific Digital Literacy Model	Test
2024	India	Indian Digital Literacy Framework	Test
2022	Peru	ECODIES (European Digital Competence)	Questionnaire
2023	Peru	UNESCO MIL	Questionnaire
2024	Colombia	DigComp 2.1	Questionnaire
2024	Mexico	DigComp 2.1	Questionnaire

1.2 Psycometric Quality

The analysis of the 22 selected articles shows that most of the instruments have undergone strong psychometric validation processes. The combination of classical and modern measurement approaches indicates a shift toward more robust and multidimensional evidence based validation of digital literacy assessment instruments.

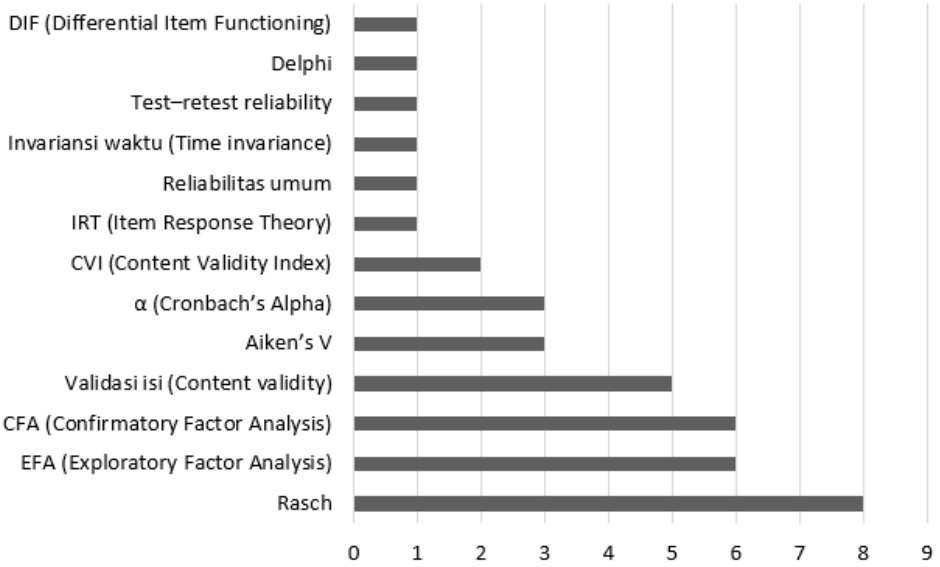

Figure 2. Psycometric Quality Diagram of Digital Literacy

1.3 Implications of Research Findings

The findings indicate that the assessment results of digital literacy have implications for various aspects, including theoretical, methodological, practical, curricular, policy related, and future research aspects.

Table 2. Implication of Reasearch Finding

Aspect	Implications
Theoretical	Confirms that digital literacy is multidimensional, covering information, communication, content, safety, and problem solving.
Methodological	Rasch, CFA, and Aiken's V approaches have been proven effective for validating instrument constructs and reliability.
Practical (Learning)	Instruments can be used for diagnostic assessment and planning technology based learning.
Curriculum	DigComp and UNESCO MIL domains can be adapted into teaching modules and curriculum assessment.
Policy	National policies are needed regarding digital literacy standards.
Future Research	It is necessary to develop digital literacy instruments based on modern test theory that are more specific to scientific fields, as well as conduct cross cultural validation testing across various student populations.

Discussion

2.1 Mapping Digital Literacy

The analysis of 22 selected articles shows that research on the measurement of digital literacy at the secondary school level has grown rapidly from 2021 to 2025. The findings indicate an increasing global awareness of the importance of digital competence in responding to the digital transformation occurring in the education sector. Research conducted by Carretero et al (2022), digital literacy encompasses not only the technical skills required to operate digital devices but also includes cognitive, social, and ethical dimensions in using technology critically, creatively, and responsibly. Geographically, the studies show that digital literacy research is concentrated in regions such as Asia (Indonesia, Thailand, and Korea) and Latin America (Peru, Colombia, and Mexico), while representation from African or European contexts remains limited. This geographical imbalance indicates that although publication volume has expanded, the global evidence base is still uneven an may limit cross cultural generalization of dgital literacy frameworks and measurement tools.

The mapping of studies and developments in digital literacy frameworks reveals a tendency to adopt the DigComp 2.1 framework as the primary reference. This framework has been widely adopted by various countries, including Thailand, Hong Kong, Colombia, Mexico, and Indonesia. The high use of DigComp 2.1 indicates that it is considered comprehensive and flexible for measuring and developing digital competence across different educational contexts (Mieg et al., 2024). Several countries also choose to adapt the framework locally to match their sociocultural characteristics and educational policies, for example Canada and Indian. This demonstrates that digital literacy cannot be applied uniformly across countries; instead, it must be contextually adjusted (Hilhamsyah et al., 2025).

The diversity of main variables (frameworks) used across countries such as DigComp 2.1, UNESCO MIL, Rasch based Digital Literacy Model, Science Digital Literacy Framework, and Multiple Representation Framework indicates that digital literacy remains dynamic and context dependent. Differences in framework selection across regions also reflect varying levels of maturity in national digital education policies. Countries such as Indonesia and Thailand actively adapt global frameworks like DigComp and UNESCO MIL into their local educational contexts. This can be seen in the study by Son & Ha (2025), who developed the Scientific Digital Literacy Model to measure the digital literacy abilities of secondary students in the context of scientific practice. This shows that digital literacy is increasingly linked to specific academic disciplines, not merely general technological abilities.

Additionally, Indonesia demonstrates more contextualized development of digital literacy with the emergence of science based instruments such as the Physics HOTS based Literacy Framework, integrating digital competence with higher order thinking skills. Sillat et al (2021) emphasize that digital literacy assessments that integrate specific disciplinary contexts can enhance ecological validity and the relevance of assessments to the needs of modern curricula. Thus, digital literacy is not viewed merely as general technological proficiency but as mastery of scientific competence and critical thinking required for 21st century learning. Specifically in the Indonesian context, the variety of frameworks that emerged between 2023 and 2025 reflects an active research dynamic with diverse directions of development. Studies that utilized DigComp 2.1 indicate a desire to align with global standards, whereas field based frameworks and Rasch based models reflect deeper methodological exploration that aligns with the needs of the national curriculum (Hidayat et al., 2025).

Research conducted in Indonesia is currently in an experimental phase of developing scientifically valid digital literacy frameworks that are compatible with national learning characteristics. Overall, studies from 2023 to 2025 demonstrate two complementary directions of development: international standardization through frameworks such as DigComp 2.1 and UNESCO MIL, and national contextualization through local adaptations and the development of field specific frameworks. Therefore, the development of digital competence should not only be globally measurable but also relevant to the local, social, and curricular needs of each country (Jung et al., 2024).

The analysis of instrument types across the 22 reviewed articles shows that the instruments used to measure digital literacy at the secondary school level are also diverse, with a major tendency toward the use of questionnaires and performance based tests. In addition, studies also employed Likert scales, norm referenced tests, and surveys integrated with national curricula, depending on the measurement goals and educational contexts of each country. This diversity of instrument types illustrates researchers' efforts to obtain a comprehensive understanding of students' digital abilities. Questionnaires were the most widely used instrument in various studies conducted in Indonesia, the Philippines, China, and Peru. These questionnaires were generally developed using frameworks such as UNESCO. According to Sillat et al (2021), questionnaires offer high flexibility for cultural and linguistic adaptation and are efficient for measuring cognitive and behavioral dimensions related to digital technology use.

Another notable type of instrument is performance based tests, which are implemented in Hong Kong, Korea, and several European countries. These tests measure students' actual abilities in completing digital tasks, such as verifying the credibility of sources, analyzing data, or using productivity software (Muslimatul Husna & Agus Kurniawan, 2023). In addition, Likert scales are also frequently used to assess students' perceptions, attitudes, and

self confidence toward their digital abilities. This instrument is highly favored due to its convenience for measuring perceptions with large numbers of respondents. Research by Avinç & Doğan (2024) indicates that Likert scales are effective in describing students' levels of confidence and digital readiness, although the results still require psychometric analyses such as Rasch to improve reliability and objectivity.

Several studies in Indonesia used objective test instruments such as Rasch based tests and science digital literacy based tests. These instruments assess cognitive abilities while analyzing item characteristics to ensure construct validity. Research has shown that applying the Rasch model provides a more objective measurement scale, identifies item difficulty levels, and increases instrument reliability in the context of digital literacy measurement at the secondary school level. A combined methodological approach such as the integration of questionnaires with Likert scales has become a new trend in digital literacy research. This approach is considered ideal for providing a comprehensive picture of students' digital literacy across affective, cognitive, and psychomotor domains, thus producing a more representative measurement of students' actual abilities in the digital era.

2.2 Psycometric Quality

Despite the growing attention to digital literacy in secondary education, this review also identifies several structural limitations in prior studies. First, psychometric validation is often underreported or limited, primarily because many researches prioritize rapid instrument deployment rather than rigorous measurement construction. As note in recent methodological reviewrs, validation procedures are frequently simplified to internal consistency testing Cronbachs Alpa, while advanced approaches such as Rasch modeling, CFA, DIF, or longitudinal validation remain limited in application. This gap suggest that assessment practices may be progressing faster than the methodological infrastructure needed to ensure measurement validity dan fairness.

The direction of digital literacy research in various countries shows a transition from general approaches toward discipline specific approaches that integrate technology, science, and critical thinking skills. In line with these developments, the analysis of 22 research articles also indicates that most instruments used in digital literacy studies have undergone strong psychometric validation processes using a combination of classical and modern approaches. Based on Figure 2, the Rasch Model is the most dominant method used in the instrument validation process, followed by explanatory factor analysis (EFA), confirmatory factor analysis (CFA), as well as Aiken's V and content validity index (CVI). According to Tomczyk et al (2023), the development of digital literacy instruments has shifted from classical paradigms toward modern test theory based measurement approaches, which are able to provide more accurate, precise, and objective results regarding students' abilities.

To provide a clearer understanding of the validation techniques used across the reviewed studies, the following table summarizes the primary psychometric methods, their functions, strengths, limitations, and typical applications.

Tabel 3. Summary of Psychometric Methods in Digital Literacy Assessment

Method	Main Function	Key Strength	Limitation	Typical Usage
Cronbach's Alpha	Internal consistency	Simple and widely accepted	Does not test construct validity	Most common in questionnaire-based studies
Aiken's V	Content validity (expert judgment)	Useful in early instrument development	Subjective and expert-dependent	Initial validation during framework localization
CFA	Tests factor structure and construct validity	Supports complex, multidimensional models	Requires large samples and advanced analysis	Used when adopting DigComp or UNESCO MIL
Rasch Model	Converts ordinal responses to interval metrics and analyzes item functioning	Detects item difficulty, misfit, and invariance	Requires specialized expertise	Applied in scale refinement and performance-based testing
DIF Analysis	Assesses item fairness across groups	Ensures equity and cultural neutrality	Rarely used and requires Rasch/IRT modeling	Limited to advanced methodological studies
Test - Retest	Stability over time	Demonstrates temporal consistency	Requires repeated testing	Used in longitudinal tracking

Longitudinal Modeling	Monitors developmental progression	Supports policy and curriculum evaluation	Time-consuming and complex	Emerging trend in multi-year digital literacy studies

The table indicates that Cronbachs Alpha remains the most widely used method for assessing internal consistency in questionnaire based studies, while Aikens V is frequently applied in early development for content validation. CFA is used when adopting frameworks such as DigComp or UNESCO MIL, whereas the Rasch Model is dominant in detecting item difficulty and misfit. DIF analysis appears in more advanced studies to ensure fairness across groups. Methods such as test–retest and longitudinal modeling are used to measure stability and developmental progression over time. Overall, the table reflects a shift from simple reliability testing toward more rigorous and theory-driven validation approaches in digital literacy research.

The Rasch method has become the most dominant tool in psychometric research on digital literacy. This approach provides estimates of respondent ability and item difficulty on a single linear scale (logit scale), so the measurement results are not dependent on specific sample characteristics. This makes the Rasch model ideal for assessing digital competencies that are multidimensional and contextual. The study by Avinç & Doğan (2024) shows that the Rasch model is effective in developing multidimensional digital literacy scales because it can identify misfitting items and accurately analyze differences in individual ability levels. EFA and CFA are also widely used as complementary approaches. EFA functions to identify factor structures from empirical data when the theoretical model is unclear, whereas CFA tests the suitability of a predetermined factor structure based on theory. The study by Ocy & Sarifah (2025), shows that a combination of EFA and CFA can produce a valid measurement model.

Other commonly used methods include Aiken's V and CVI, applied during the early stages of digital literacy instrument development. These techniques involve expert judgment on the relevance of indicators and items to the theoretical construct. Research conducted by Lukitasari et al (2022), shows that combining Aiken's V with the Rasch model produces strong content and construct validity in developing digital literacy instruments for science. Other methods such as Cronbach's Alpha remain popular reliability indicators, especially in early validation stages. The advantage of this method lies in its simplicity, although it may produce artificially high reliability values simply due to many items rather than item quality. Therefore, recent studies recommend combining classical reliability measures with the Rasch model to yield more precise and unbiased estimations (Tomczyk et al., 2023).

Several other techniques such as DIF, Delphi, and test–retest reliability are used in smaller studies but play important roles in ensuring instrument fairness and stability. DIF ensures that items function equally across different respondent groups, such as gender and educational background (Avinç & Doğan, 2024). The Delphi method, used in the study by Tomczyk et al (2023) is effective for obtaining expert validation during the early design of the theoretical construct. Meanwhile, the test–retest method is applied to assess score stability over time. Test–retest studies require two rounds of data collection, making the process time consuming (Zulaikha, 2025). Among the various psychometric approaches used in digital literacy research, the Rasch Model is the method with the greatest potential for future digital literacy instrument development. Rasch also provides in depth analyses such as item fit and DIF to ensure that each item function fairly across different respondent groups.

A study conducted by Avinç & Doğan (2024) shows that the Rasch model can produce digital literacy instruments that are more precise and unbiased compared to classical approaches. Their study explains that Rasch is effective in identifying misfitting items, improving measurement accuracy, and providing a strong basis for item revision in the instrument development stage. Consistent with the findings of Tomczyk et al (2023), digital literacy assessment using modern test theory can handle categorical and multidimensional data in a more scientific manner than traditional/classical approaches. The use of Rasch in educational research increased significantly during 2021–2025 due to its ability to provide valid, reliable, and unbiased measurements across various contexts.

2.3 Implications of Research Findings

The findings of this study show that digital literacy assessment has significant theoretical, methodological, and practical implications. Theoretically, the results confirm that digital literacy is a multidimensional construct involving information management, communication, content creation, safety, and critical problem solving, aligning with Tomczyk et al (2023) who emphasize that it extends beyond technical skills to include ethical and critical dimensions. Methodologically, the need for stronger and ongoing validation is evident, particularly as rapid technological advancements such as AI literacy, cybersecurity, and data ethics risk making existing instruments outdated. Practically, these insights highlight the importance of continually updating assessment tools to ensure alignment with evolving competencies and educational needs.

From a methodological perspective, the results show that the Rasch Model, CFA, and Aiken's V are effective approaches used in the process of construct validation and reliability testing of digital instruments. These three

approaches provide complementary strengths, where the Rasch Model analyzes item fit with respondent ability, CFA ensures the alignment of factor structures with theory, and Aiken's V measures content validity based on expert agreement. A combined approach is important because it provides a comprehensive picture of the psychometric quality of an instrument. Research by Feng & Sumettikoon (2024) also used the Rasch and CFA approaches to measure teachers' digital literacy in China, and the results showed that both techniques were able to validate the dimensions of digital competence accurately and reliably. The combination of Rasch, CFA, and Aiken's V can be considered a best practice in developing modern digital literacy instruments that are adaptive to educational contexts.

In addition, teacher professional development programs should include training in digital literacy assessment to ensure that educators not only understand the conceptual framework but can also apply instruments accurately, interpret results appropriately, and use them to inform instructional decisions. Strengthening teachers' assessment literacy is essential to prevent misuse and misinterpretation of student performance. From a practical standpoint, the developed digital literacy instrument can serve as a diagnostic tool to identify students' competency levels, support grouping for targeted programs such as digital safety training or content management, and function as a self-reflection mechanism for students to recognize their strengths and areas for improvement. Through effective assessment implementation, teachers can design more adaptive technology-based learning experiences aligned with students' digital needs.

To address these challenges, national education ministries can play a key role in standardizing and institutionalizing assessment benchmarks based on validated frameworks such as DigComp, UNESCO MIL, or contextually adapted local models, ensuring assessment practices remain systematic, equitable, and aligned with curriculum reforms. From a curriculum perspective, the findings indicate that the competency domains outlined in DigComp and UNESCO MIL can be integrated into teaching modules and assessment systems, reinforcing policy directions that position digital literacy as a core 21st century competency. Incorporating DigComp's five key domains information and data literacy, communication and collaboration, content creation, safety, and problem solving can enrich national curricula by promoting ethical awareness, social responsibility, and critical digital thinking. As highlighted by Tomczyk et al (2023), successful implementation of DigComp in teacher education programs demonstrates its relevance and effectiveness in shaping comprehensive and contextualized digital competence development.

From a policy perspective, this study provides insights into the importance of strengthening national policies regarding measurable and sustainable digital literacy standards. These standards aim to ensure consistency in training, assessment, and certification of digital competencies across all educational levels. According to Zulaikha (2025), most teachers in Indonesia are technically capable but lack cognitive and ethical digital competencies. Therefore, national policies need to emphasize the strengthening of critical thinking and ethical responsibility in technology use. These policies must also align with UNESCO guidelines to support the enhancement of teachers' capacities in media and information literacy to achieve inclusive, reflective, and digitally competitive education (Rahman et al., 2023). With comprehensive national policies, educational institutions will have clearer direction in preparing human resources who are adaptive to digital transformation.

Future assessment directions should emphasize hybrid measurement approaches that combine performance based tasks with self-report scales to produce more authentic representations of students' digital competence, while longitudinal research is needed to track how digital literacy develops across grade levels and changing technological and curricular contexts. Emerging technologies also introduce new possibilities, particularly AI driven adaptive testing, which can personalize item difficulty in real time to increase measurement precision and engagement. From a research perspective, this study underscores the need for more responsive instruments aligned with modern learning environments, with Avinç & Doğan (2024) noting that Rasch modeling offers substantial potential for creating precise and unbiased assessments, making modern test theory approaches increasingly essential. Developing discipline-specific tools, such as those tailored for science or physics learning contexts, is also important to ensure relevance and ecological validity. Furthermore, cross-cultural validation must be prioritized to ensure fairness across diverse linguistic and technological backgrounds, as highlighted by Tomczyk et al (2023) who emphasize that differences in access and digital experience can influence item interpretation and require DIF analysis. Through methodological innovation, cross cultural testing, and integration of adaptive technologies, future research can advance more comprehensive, context-sensitive, and globally relevant digital literacy assessment models.

The implications of this research strengthen conceptual and methodological foundations while providing strategic directions for curriculum and educational policy in an increasingly complex era of digital transformation. Measuring digital literacy through psychometric approaches can serve as a benchmark for designing learning systems that are more adaptive to technological changes and 21st century competency needs. With standardized and validated instruments, educational institutions can systematically assess and improve the digital literacy competencies of students and educators on an ongoing basis. Furthermore, the implications of this study open opportunities for future research focusing on developing digital literacy instruments that are more precise, contextual, and relevant across various fields of study using modern approaches such as the Rasch model for more accurate measurement. Future studies should also pay attention to cross cultural validity to ensure equal measurement fairness among diverse groups of learners. By expanding research in this direction, developed digital literacy instruments will contribute more significantly to supporting inclusive and globally competitive educational transformation.

CONCLUSION

The conceptual model outlines the development and implementation process of digital literacy assessment, beginning with established frameworks such as DigComp, UNESCO MIL, and local models as the foundation for instrument design. The designed instrument is then validated using psychometric methods including the Rasch Model, CFA, Aiken's V, and DIF to ensure validity, reliability, and fairness while allowing contextual adaptation to language, culture, and curriculum needs. The final stage focuses on implementation, where the validated instrument informs curriculum development, teacher assessment practices, and national education policy, ultimately supporting effective and meaningful integration of digital literacy in education.

Based on the findings from the analysis of 22 reviewed articles, it can be concluded that the mapping of digital literacy shows rapid and dynamic development across various countries, particularly during the period from 2021 to 2025. The results indicate that several countries adopted the DigComp 2.1 framework and UNESCO's Media and Information Literacy (MIL) to measure digital literacy competencies in secondary education. Each country demonstrates variations in adaptation to align with its respective social, cultural, and educational policy contexts. Indonesia is currently in an experimental phase, integrating global standards with the development of field based frameworks such as science based digital literacy. The findings of this research confirm that digital literacy enhances technical skills, as well as critical, ethical, and scientific thinking abilities that are integrated into the context of 21st century learning.

The analyzed studies show significant progress in the application of instrument validation methods. Modern approaches such as the Rasch Model, CFA, and Aiken's V have become the most dominant combination because they can provide a comprehensive picture of instrument validity and reliability. The Rasch Model excels in identifying item characteristics and respondent abilities objectively, while CFA ensures the alignment of theoretical constructs with empirical data, and Aiken's V evaluates content validity based on expert judgment. The dominance of these three methods indicates a more theoretical, precise, and measurement equity oriented approach. A multimethod approach can increase measurement accuracy and strengthen the scientific foundation for the development of digital literacy instruments across diverse educational contexts.

In terms of implications, this study makes extensive contributions to educational theory, methodology, and practice. Theoretically, the findings reinforce the view that digital literacy is a multidimensional competency encompassing technical, cognitive, social, and ethical abilities. Methodologically, the results recommend the application of a combined approach using the Rasch Model, CFA, and Aiken's V as a robust method for validating digital instruments. Practically and in terms of policy, the results can serve as a foundation for curriculum development and digital literacy assessment that align with local needs, as well as support national policies aimed at improving the digital competencies of students and educators. Furthermore, the implications of this research open opportunities for future studies, particularly the development of instruments suitable for cross regional and cross level contexts, as well as the examination of construct equivalence to ensure that instruments can be used more widely. Thus, this study enriches the conceptual foundation of digital literacy and provides strategic direction for educational development in an increasingly complex era of digital transformation.

Although this systematic review provides valuable insights into the development and validation of digital literacy assessment instruments in secondary education, several limitations should be acknowledged. The scope of reviewed studies is constrained by publication availability, language filters, and inclusion criteria, potentially excluding relevant research from non English or non indexed sources. In addition, most studies identified rely predominantly on self report questionnaires, which may not accurately reflect students actual digital performance or behavioral competencies. The variation in theoretical framework and operational definitions across studies also poses challenges for cross study comparison and limits the generalizability of findings. Therefore, future research is

recommended to incorporate mixed method and ferformance based assessment models, expands cross curtural and multinational evaluation, and conduct longitudinal studies to examine developmental progession indigital literacy. Further investigation should also consider integrating emerging domains such as artificial intelligence literacy, data privacy awareness, digital well being, and algorithmic understanding to align assessment practies with evolving technological and societal demands. Such research will contribute to the creation of more comprehensive, contextually responsive, and psycometrically robust instruments for measuring digital literacy competence in secondary education.

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