PENGEMBANGAN INSTRUMEN PENILAIAN LITERASI DIGITAL PADA PEMBELAJARAN FISIKA DI ERA SOCIETY 5.0

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ABSTRACT

The development of digital technology in the Society 5.0 era requires assessment instruments capable of accurately measuring students' digital literacy within authentic physics learning contexts. Digital literacy has become an essential competency for accessing, evaluating, creating, and communicating information through digital technologies while solving scientific problems. However, instruments specifically designed to assess digital literacy in physics learning remain limited. This study aimed to develop and validate a digital literacy assessment instrument for senior high school students studying kinematics. A Research and Development (R&D) approach adapted from the Borg and Gall model was employed. Instrument development was guided by the DigComp 2.1 framework, encompassing five dimensions: information and data literacy, communication and collaboration, digital content creation, digital safety, and problem solving. Data were collected through needs analysis, expert validation, pilot testing, and large-scale field testing involving senior high school students. Instrument quality was evaluated using Aiken's V for content validity, Exploratory Factor Analysis (EFA) for construct validity, Cronbach's alpha for internal consistency, and the Rasch model for item fit, person reliability, item reliability, and Differential Item Functioning (DIF). The findings demonstrated high content and construct validity, excellent reliability, satisfactory model fit, and no significant bias across gender or school origin. Teachers and students also perceived the instrument as practical, clear, and easy to administer. Overall, the developed instrument is a valid, reliable, and practical tool for assessing students' digital literacy in physics learning and supports technology integrated assessment practices in senior high school science education.

***Keywords**: digital literacy, physics education, assessment tools, the Rasch model, Society 5.0*

ABSTRAK

Perkembangan teknologi digital pada era Society 5.0 menuntut tersedianya instrumen penilaian yang mampu mengukur literasi digital peserta didik secara akurat dalam konteks pembelajaran fisika yang autentik. Literasi digital menjadi kompetensi penting agar peserta didik mampu mengakses, mengevaluasi, menciptakan, dan mengomunikasikan informasi melalui teknologi digital dalam memecahkan masalah ilmiah. Namun, instrumen yang secara khusus dirancang untuk mengukur literasi digital pada pembelajaran fisika masih terbatas. Penelitian ini bertujuan mengembangkan dan memvalidasi instrumen penilaian literasi digital bagi peserta didik SMA pada materi kinematika. Penelitian menggunakan pendekatan Research and Development (R&D) yang diadaptasi dari model Borg dan Gall. Pengembangan instrumen mengacu pada kerangka DigComp 2.1 yang mencakup lima dimensi, yaitu literasi informasi dan data, komunikasi dan kolaborasi, kreasi konten digital, keamanan digital, serta pemecahan masalah. Data dikumpulkan melalui analisis kebutuhan, validasi ahli, uji coba terbatas, dan uji lapangan skala besar yang melibatkan peserta didik SMA. Kualitas instrumen dievaluasi menggunakan indeks Aiken's V untuk validitas isi, Exploratory Factor Analysis (EFA) untuk validitas konstruk, koefisien alpha Cronbach untuk reliabilitas internal, serta model Rasch untuk menganalisis kesesuaian butir, reliabilitas person, reliabilitas butir, dan Differential Item Functioning (DIF). Hasil penelitian menunjukkan bahwa instrumen memiliki validitas isi dan konstruk yang tinggi, reliabilitas yang sangat baik, kesesuaian model yang memadai, serta tidak menunjukkan bias berdasarkan gender maupun asal sekolah. Guru dan peserta didik juga menilai instrumen praktis, jelas, dan mudah digunakan. Dengan demikian, instrumen yang dikembangkan valid, reliabel, dan praktis untuk mengukur literasi digital peserta didik dalam pembelajaran fisika.

Kata Kunci: literasi digital, pendidikan fisika, instrumen penilaian, model Rasch, Society 5.0.

A. Introduction

The development of digital technology has transformed various aspects of life, including the world of education. In the Society 5.0 era, technology is no longer viewed merely as a means of conveying information, but also as a vital component in generating solutions centered on human needs. Therefore, the education system is required to prepare students so that they possess competencies aligned with technological advancements while also being able to utilize technology critically, creatively, and responsibly. One of the key competencies of focus is digital literacy, as this skill plays a vital role in supporting learning success while preparing students to face the challenges of the 21st century.

The urgency of digital literacy has been addressed in various education policies, both at the international and national levels. In Indonesia, Law No. 20 of 2003 on the National Education System emphasizes that education must produce individuals who are knowledgeable, creative, independent, and capable of adapting to advancements in science and technology (Pemerintah Republik Indonesia, 2003). In line with this, Regulation of the Minister of Education and Culture No. 22 of 2016 on Process Standards emphasizes the importance of utilizing technology in the learning process as part of strengthening 21st century competencies (Kementerian Pendidikan dan Kebudayaan, 2016). The implementation of the Merdeka Curriculum further reinforces the role of digital literacy as a core competency that supports lifelong learning, critical thinking, collaboration, creativity, and students' readiness to face the digital transformation.

Digital literacy is no longer defined merely as the ability to operate technological devices or access the internet. Digital literacy is a set of competencies that includes the ability to search for, select, evaluate, manage, create, and communicate information through digital media in an effective, ethical, and responsible manner. In addition, digital literacy also includes the ability to protect personal data, understand digital media ethics, and utilize technology to solve various problems. Thus, digital literacy is a crucial competency in developing students who are capable

of independent learning, critical thinking, and adapting to the rapid pace of technological advancement.

Various studies indicate that students' digital literacy levels in Indonesia still require attention. Commonly identified issues include limited ability to evaluate the credibility of digital information, distinguish scientific information from invalid information, manage personal data security, and utilize technology to support the learning process. Similar conditions are also found at the higher education level, suggesting that digital literacy skills have not developed optimally since secondary school. These findings indicate the need for systematic efforts to both measure and improve students' digital literacy skills through assessment tools appropriate to the learning context.

In physics education, digital literacy plays an increasingly important role because technological advancements have transformed the way students learn scientific concepts. Various digital media, such as interactive simulations, virtual laboratories, visualization software, online learning platforms, and data acquisition systems, have been widely utilized in the learning process. The use of these technologies enables students to explore abstract concepts, analyze experimental data, interpret physical phenomena, and develop conceptual understanding through more meaningful scientific activities. Therefore, digital literacy in physics education is not only related to the ability to use technology but also encompasses the ability to access scientific information sources, evaluate digital information, interpret data, and use technology to solve physics problems.

Although the use of technology in physics education is on the rise, assessment practices in schools are still dominated by the measurement of conceptual mastery and cognitive learning outcomes. Preliminary observations and interviews with physics teachers indicate that various digital media have been used in instruction, such as instructional videos, simulations, online platforms, and internet based learning resources. However, students' ability to use these technologies effectively, critically, and responsibly has not yet been measured using structured instruments. As a result, teachers do not have comprehensive information about students' digital literacy levels

and therefore face difficulties in designing learning strategies tailored to their needs.

Several previous studies have developed digital literacy instruments based on various conceptual frameworks. For example, the e-LIT instrument developed by Karitas and Suwartono (Karitas & Suwartono, 2023) measures the dimensions of information and data literacy, communication and collaboration, digital competencies, digital security, and problem solving. Research by Son and Ha (Son & Ha, 2025) also confirms that digital literacy in science education has characteristics that differ from digital literacy in general because it is closely related to scientific processes, such as data collection, analysis, interpretation, and the presentation of scientific information. Although they make important contributions, most of these instruments remain general in nature and thus do not fully capture the digital competencies required in physics learning such as the ability to analyze experimental graphs, interpret simulation data, evaluate digital scientific sources, or use technology to solve physics problems.

In addition to contextual fit, the quality of an instrument is also determined by its psychometric characteristics. A good instrument must possess adequate validity, reliability, objectivity, and accuracy to produce reliable information. In educational research, the Rasch Model is one of the most widely used modern approaches because it provides detailed information on item characteristics, respondent ability, model fit, and potential bias in each instrument item. Compared to classical approaches, the Rasch Model provides a stronger foundation for evaluating instrument quality, resulting in more objective and accurate measurement results.

Although some studies have utilized the Rasch Model in the development of digital literacy instruments, most still focus on general contexts and have not been specifically designed for physics learning at the high school level. Furthermore, there have not been many studies that integrate the DigComp 2.1 framework with authentic physics learning activities. These circumstances indicate a need to develop assessment instruments that not only measure digital literacy in

general but are also capable of capturing the digital competencies that are truly necessary for physics learning.

Based on the above description, this study aims to develop and validate a digital literacy assessment instrument for high school physics instruction on kinematics, based on the DigComp 2.1 framework. The validity, reliability, and psychometric quality of the instrument were evaluated through expert validation, Exploratory Factor Analysis (EFA), reliability analysis, and the Rasch model. The resulting instrument is expected to serve as a valid, reliable, objective, and practical measurement tool for identifying students' levels of digital literacy while supporting the implementation of physics instruction that is relevant to the demands of the Society 5.0 era..

B. Method

This study employed a Research and Development (R&D) approach adapted from the Borg and Gall model to develop a digital literacy assessment instrument for high school physics courses on kinematics . The development procedure was simplified into eight stages: needs analysis, information gathering, instrument design, expert validation, instrument revision, limited pilot testing, field testing, and refinement of the final product. The needs analysis stage was conducted through observation of the learning process as well as interviews with teachers and students to identify the conditions for implementing digital literacy and the need for an assessment instrument suited to the characteristics of physics learning. In addition, a literature review on digital literacy, educational assessment, physics learning, and the Digital Competence Framework for Citizens (DigComp 2.1) was used as the basis for formulating indicators and developing instrument items.

The study was conducted at several public high schools in Semarang, Central Java. The research subjects were 11th grade students who had studied kinematics. A pilot study involving 34 students was conducted to evaluate the instrument's readability, clarity of language, and content appropriateness. Subsequently, the field test involved 201 students selected using cluster sampling to obtain empirical data for testing the instrument's psychometric

characteristics. Purposive sampling was used during the needs analysis and preliminary testing phases to ensure that the selected respondents aligned with the instrument's development objectives.

The main research instrument was a digital literacy questionnaire consisting of 35 statements on a five point Likert scale. The items were developed based on the five dimensions of digital literacy in the DigComp 2.1 framework, namely information and data literacy, communication and collaboration, digital content creation, digital safety, and problem solving. As supporting instruments, the study also utilized interview guidelines and a usability questionnaire to gather feedback from teachers and students regarding the ease of use of the instrument.

The content validity of the instrument was assessed by experts in physics education, educational evaluation, and digital literacy. The assessment focused on the appropriateness of the indicators, the clarity of the language, and the relevance of the items to the context of physics learning. The validation results were analyzed using Aiken's V index, with a minimum value of 0.67 as the acceptability criterion. Construct validity was analyzed using Exploratory Factor Analysis (EFA) through the Kaiser Meyer Olkin (KMO) test, Bartlett's Test of Sphericity, and factor loadings. The instrument's reliability was calculated using Cronbach's Alpha, while item validity was determined through item total correlations.

Data analysis was conducted using both qualitative and quantitative methods. Data from observations, interviews, and feedback from validators were analyzed through data reduction, categorization, and interpretation to refine the developed instrument. Quantitative data were analyzed using the Classical Test Theory (CTT) approach and the Rasch Model. Rasch analysis was used to evaluate item fit, person reliability, item difficulty levels, and Differential Item Functioning (DIF) to detect potential bias based on gender or school background. The practicality of the instrument was analyzed descriptively based on feedback from teachers and students after the instrument was used in the classroom. All analysis results were used as the basis for determining the instrument's validity, reliability, objectivity, and

suitability before its implementation in physics instruction in the Society 5.0 era.

C.Result and Discussion

The results of the needs analysis indicate that the use of digital technology has become an integral part of physics instruction in high school. Based on observations and interviews with teachers, various digital media such as instructional videos, interactive simulations, virtual laboratories, online learning platforms, and internet based information sources have been used to support the learning process. Students also use digital devices to search for information, complete assignments, and understand abstract physics concepts. However, the assessment process conducted by teachers is still dominated by measuring conceptual mastery, while students' digital literacy skills have not been systematically assessed. This situation indicates a gap between the implementation of technology in learning and the availability of assessment instruments capable of comprehensively measuring digital literacy competencies.

Based on the results of this needs analysis, a digital literacy assessment instrument was developed in accordance with the Digital Competence Framework for Citizens (DigComp 2.1). The instrument consists of 35 items covering five main dimensions: information and data literacy, communication and collaboration, digital content creation, digital security, and problem solving. All items were designed based on physics learning activities in the kinematics curriculum so that they could assess students' ability to utilize digital technology in authentic learning situations. This contextual approach was chosen because measuring digital literacy yields more accurate results when tailored to the characteristics of the subject being studied.

The content validation results show that all items in the instrument meet the validity criteria, with an Aiken's V value greater than 0.67. The validators stated that the indicators align with the construct of digital literacy, the language used is easy to understand, and each statement is relevant to physics learning activities. These validity scores indicate that the instrument effectively represents the

competencies being measured and is therefore suitable for administration to students.

In addition to meeting content validity criteria, the instrument also demonstrated a very high level of reliability. A Cronbach's Alpha value of 0.954 and an Intraclass Correlation Coefficient (ICC) of 0.954 indicate that the instrument possesses excellent internal consistency. This means that each item contributes relatively consistently to the measurement of the digital literacy construct, resulting in more stable and reliable measurement results.

Table 1. Content Validity and Reliability Results

Parameter	Result	Interpretation
Aiken's V	>0,67	Valid
Cronbach's Alpha	0,954	Highly reliable
ICC	0,954	Very High

The high validity and reliability of the instrument indicate that the development process has produced items that align with the measurement objectives. These results are consistent with the study by Harlanu et al (Harlanu et al., 2023), which states that the expert validation process plays a crucial role in producing digital literacy instruments with good construct quality. That study confirms that the alignment of indicators with the competencies being measured enhances the accuracy of assessment results.

The reliability values obtained in this study are also higher than those in several previous studies. Rusilowati et al (Rusilowati et al., 2022) reported that the Physics ICT Literacy Test (PICT Test) instrument demonstrated good reliability in measuring ICT literacy in physics education. However, the instrument in this study demonstrates higher internal consistency because it was developed based on the five dimensions of DigComp 2.1, thereby comprehensively covering aspects of information literacy, digital communication, security, digital creativity, and problemsolving. This finding is supported by Yotha's (Yotha, 2025) research, which states that instruments designed based on clear and systematic indicators tend to yield higher reliability compared to instruments that focus solely on technological proficiency.

Validitas konstruk dianalisis menggunakan Exploratory Factor Analysis (EFA). Hasil analisis menunjukkan bahwa data memenuhi

seluruh persyaratan untuk dilakukan analisis faktor dengan nilai Kaiser Meyer Olkin (KMO) sebesar 0,919, sedangkan Bartlett's Test of Sphericity menunjukkan nilai signifikansi p < 0,001. Nilai tersebut mengindikasikan bahwa jumlah sampel memadai serta terdapat korelasi yang cukup antarpoin instrumen sehingga proses ekstraksi faktor dapat dilakukan. Seluruh butir memiliki nilai factor loading lebih besar dari 0,40, sehingga seluruhnya dipertahankan dalam instrumen.

Table 2. Results of Exploratory Factor Analysis

Parameter	Result
KMO	0,919
MSA	0,871–0,960
Bartlett's Test	p < 0,001
Number of Factors	2
Factor Loading	>0,40

The EFA results show that the five theoretical dimensions in the DigComp 2.1 framework empirically form two main factors. The first factor represents the use of digital technology in learning, which includes information and data literacy, communication and collaboration, digital content creation, and problem solving. The second factor describes digital security, which relates to data protection, privacy, digital identity, and ethics in the use of technology.

These findings suggest that students view most digital activities as an integrated and interconnected learning process. In contrast, the aspect of digital security is perceived as a distinct competency because it relates to individual awareness regarding the protection of personal information and the responsible use of technology. These results align with the research by Carretero et al (Carretero et al., 2022) and Vourikari et al (Vourikari et al., 2022),which explains that digital security is one of the dimensions with specific characteristics within the DigComp 2.1 framework. However, the results of this study differ from those of Son and Ha (Son & Ha, 2025), who treated most dimensions of digital literacy as independent constructs. This difference is likely due to the context of physics learning, which integrates information seeking, communication, collaboration, and problem solving activities into a single sequence of learning activities, leading students to view these competencies as part of an interconnected process.

The results of the analysis using the Rasch Model show that all items in

the instrument met the item fit criteria, with Mean Square Error of Infit and Outfit (MNSQ) values ranging from 0.50 to 1.50. These results indicate that each item is able to measure the construct of digital literacy consistently and in accordance with the measurement model used. Furthermore, a person reliability coefficient of 0.942 indicates that the instrument is highly effective at distinguishing among students' levels of digital literacy. Thus, the instrument is not only capable of identifying students with high and low proficiency but also produces stable measurements when administered to different groups of respondents.

Table 3. Rasch Analysis Results and Practicality

Parameter	Result
Infit MNSQ	0,50–1,50
Outfit MNSQ	0,50–1,50
Person Reliability	0,942
DIF by gender	Not detected
DIF by school of origin	Not detected
Student practicality	77,68%
Teacher response	Practical

The fit of all items to the Rasch Model indicates that the instrument has good psychometric quality. The absence of any misfit items suggests that all statements are able to measure the construct of digital literacy consistently. These findings reinforce the research by Sapriya et al (Sapriya et al., 2025), which states that the Rasch Model provides more comprehensive information regarding the characteristics of an instrument compared to the Classical Test Theory approach, as it simultaneously considers the relationship between respondents' ability and item difficulty. Consequently, the measurement results obtained are more objective and accurate.

The Differential Item Functioning (DIF) analysis showed that there was no bias based on gender or school background. These results indicate that students' likelihood of responding to each item was not influenced by specific group characteristics but rather truly reflected their level of digital literacy. This finding is consistent with the research by Lafifa and Rosana (Lafifa & Rosana, 2024), who reported that a digital literacy instrument based on the Rasch Model is capable of producing fair measurements across different respondent groups. Similar results were also reported by Savitri et al (Savitri et al., 2026), who stated that a bias free instrument increases confidence in assessment results and

allows for its use in a broader population.

In addition to having good psychometric characteristics, the developed instrument also received positive feedback from both teachers and students. A practicality score of 77.68% indicates that the instrument is easy to understand, easy to administer, and aligned with the learning activities typically conducted in the classroom. Teachers stated that each indicator accurately describes the digital competencies required in physics learning, while students felt that the statements in the instrument align with their experiences using digital technology for learning. These results indicate that the instrument not only meets the criteria for validity and reliability but also has a high level of applicability, making it a potential tool for routine assessment in schools.

The high level of practicality of the instrument supports the findings of Rusilowati et al (Rusilowati et al., 2022), who state that instruments developed based on authentic learning activities are easier to implement than generic instruments. Similarly, Guo et al (Guo et al., 2025) emphasize that instruments designed for specific learning contexts can provide more representative information about students' competencies than generic instruments. Therefore, developing instruments tailored to the characteristics of a subject is a key factor in improving the quality of assessment.

Theoretically, the results of this study reinforce the view that digital literacy is a multidimensional competency that is not only related to the ability to use digital devices but also encompasses the ability to think critically, evaluate information, communicate and collaborate effectively, maintain digital security, and utilize technology to solve various problems. These findings support the DigComp 2.1 framework developed by Carretero et al (Carretero et al., 2022) and Vourikari et al (Vourikari et al., 2022), and align with the UNESCO Digital Literacy Framework, which identifies digital literacy as one of the key competencies that students must possess in the 21st century. In the context of physics education, these competencies are becoming increasingly important as the learning process increasingly utilizes simulations, virtual laboratories, digital

data analysis, and various technology based learning resources.

From a practical perspective, the instrument developed can be used as a tool to assess students' digital literacy levels both before and after technology based learning activities. Teachers can use the information obtained to design learning strategies that are better suited to students' needs, particularly in activities involving virtual simulations, analysis of experimental data, scientific information searches, the use of artificial intelligence, and technology based problem solving. Thus, the assessment results serve not only as an evaluation tool but also as a foundation for improving the quality of the learning process.

This study has several advantages over previous research. Karitas and Suwartono (Karitas & Suwartono, 2023) developed a digital literacy instrument for the general educational context, while Rusilowati et al (Rusilowati et al., 2022) focused more on information and communication technology literacy in physics learning. Unlike those two studies, the instrument in this study was specifically developed based on the DigComp 2.1 framework and contextualized for physics instruction on the topic of kinematics. Furthermore, the quality of the instrument was evaluated using a combination of Aiken's V, Exploratory Factor Analysis, Cronbach's Alpha, the Intraclass Correlation Coefficient, and the Rasch Model, thereby yielding more comprehensive empirical evidence regarding the instrument's validity, reliability, objectivity, and practicality. This approach offers a new contribution to the development of digital literacy assessments that are not only conceptually relevant but also possess strong psychometric qualities for application in physics education in the Society 5.0 era

D. Conclusion

This study successfully developed a digital literacy assessment instrument specifically designed for high school physics instruction on the topic of kinematics, based on the Digital Competence Framework for Citizens (DigComp 2.1). The developed instrument consists of 35 items covering five dimensions of digital literacy: information and data literacy, communication and collaboration, digital content creation, digital security, and problem solving.

The results of expert validation, exploratory factor analysis, reliability testing, and Rasch model analysis indicate that the instrument possesses excellent validity, reliability, objectivity, and practicality, making it suitable for use as a tool to measure students' digital literacy in physics education.

This instrument not only provides information on students' digital literacy levels but also serves as a foundation for teachers to design more effective technology based learning strategies tailored to students' needs in the Society 5.0 era. Compared to previously developed instruments, this one offers a more contextual approach because it integrates all dimensions of DigComp 2.1 into physics learning activities and is supported by comprehensive psychometric evidence through a combination of expert validation, Exploratory Factor Analysis, and the Rasch Model.

This study still has limitations because the instrument was developed only for kinematics material and involved students from several high schools in Semarang. Therefore, future research is recommended to test the instrument on other physics topics, at different educational levels, and across a wider geographic area. In addition, follow up research could examine the relationship between digital literacy and critical thinking skills, problem solving skills, and physics learning outcomes so that the instrument's benefits in supporting improved learning quality can be demonstrated more comprehensively.

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