

Digital Literacy and Critical Thinking Skills of Physics Education Students: An Empirical Analysis and Educational Implications

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Abstract: This study aims to examine the levels of digital literacy and critical thinking skills among physics education students as prospective science educators, as well as to provide an empirical basis for improving instructional practices. A quantitative descriptive approach was used, involving 31 undergraduate students through a purposive sampling technique. Data were collected using validated instruments consisting of a digital literacy test based on five competency areas—information and data literacy, communication and collaboration, digital content creation, digital safety, and problem solving and a critical thinking test covering five indicators: focusing on questions, analyzing arguments, inductive reasoning, deductive reasoning, and evaluating definitions. The results indicate that both digital literacy and critical thinking skills are categorized as low. Students demonstrate relatively higher performance in communication and collaboration (28.3%) and deductive reasoning (24.1%), while the lowest achievements are observed in digital content creation and digital problem-solving (15.1%), as well as inductive reasoning (12.2%). These findings suggest that students tend to function as passive users of digital technology, with limited ability to critically evaluate information and construct knowledge. This study contributes to the field of physics education by providing an integrated profile of digital literacy and critical thinking within a specific disciplinary context. The findings underscore the urgent need for pedagogical innovations, particularly technology-integrated and inquiry-based learning approaches, to enhance higher-order thinking skills in the digital learning environment.

Keywords: Critical Thinking; Digital Literacy; Higher-Order Thinking Skills; Physics Education.

Abstrak: Studi ini bertujuan untuk meneliti tingkat literasi digital dan keterampilan berpikir kritis di kalangan mahasiswa pendidikan fisika sebagai calon pendidik sains, serta untuk memberikan dasar empiris untuk meningkatkan praktik pengajaran. Pendekatan deskriptif kuantitatif digunakan dengan melibatkan 31 mahasiswa S1 dengan menggunakan teknik *purposive sampling*. Data dikumpulkan menggunakan instrumen yang telah divalidasi yang terdiri dari tes literasi digital berdasarkan lima area kompetensi - literasi informasi dan data, komunikasi dan kolaborasi, pembuatan konten digital, keamanan digital, dan pemecahan masalah—dan tes berpikir kritis yang mencakup lima indikator: fokus pada pertanyaan, menganalisis argumen, penalaran induktif, penalaran deduktif, dan evaluasi definisi. Hasil menunjukkan bahwa literasi digital dan keterampilan berpikir kritis dikategorikan rendah. Mahasiswa menunjukkan kinerja yang relatif lebih tinggi dalam komunikasi dan kolaborasi (28,3%) dan penalaran deduktif (24,1%), sedangkan pencapaian terendah diamati dalam pembuatan konten digital dan pemecahan masalah digital (15,1%), serta penalaran induktif (12,2%). Temuan ini menunjukkan bahwa siswa cenderung berfungsi sebagai pengguna pasif teknologi digital, dengan kemampuan terbatas untuk mengevaluasi informasi secara kritis dan membangun pengetahuan. Studi ini berkontribusi pada bidang pendidikan fisika dengan menyediakan profil terintegrasi literasi digital dan berpikir kritis dalam konteks disiplin ilmu tertentu. Temuan ini menggarisbawahi kebutuhan mendesak akan inovasi pedagogis, khususnya pendekatan pembelajaran yang terintegrasi teknologi dan berbasis

inkuiri, untuk meningkatkan keterampilan berpikir tingkat tinggi dalam lingkungan pembelajaran digital.

Kata Kunci: Literasi Digital, Berpikir Kritis, Pendidikan Fisika, Keterampilan Berpikir Tingkat Tinggi.

INTRODUCTION

The rapid changes in higher education in the era of digital technologies have greatly influenced skills required from university graduates, especially those studying education sciences. Today, students should not only find information but think critically, combine various ideas and apply the received information in a proper way that is meaningful and important. 21st-century education requires students to have adaptive competencies, including critical thinking, creativity, collaboration, communication, and digital literacy skills to face the challenges of increasingly complex technological developments and global change (OECD, 2018). Under such circumstances, digital literacy and critical thinking have become two essential skills which need to be developed at the same time.

Digital literacy refers to an individual's ability to use technology properly. The concept of digital literacy is not only about skills in using various types of digital technology, but also includes understanding, evaluating, creating and interacting skillfully and properly in applying digital media in a wise and effective manner (Eshet, 2012). This idea includes both technical skills, skills in thinking and social skills when using digital technologies. The implementation of technology in education not only requires the ability to use digital devices, but also the ability to analyze information critically, evaluate learning resources, and solve problems effectively in a digital learning environment (Marselina et al. 2025). In the context of higher education institutions, digital literacy skills become crucial because the modern process of teaching and learning becomes increasingly dependent on using various technologies, such as learning management systems (LMS), simulations, e-books, digital labs, and various learning resources available on the Internet. Students who are proficient in technologies tend to adapt more easily to technological changes and use technology effectively as an educational tool (Tang and Chaw, 2016).

In the process of learning physics, the skills in using technologies efficiently become crucial since the learning process in physics often requires the use of certain technologies to facilitate the process of comprehending concepts, analyzing information, and conducting virtual experiments (OECD, 2018). Many concepts in physics tend to be complex due to their abstract nature and thus require the use of interactive digital media to facilitate the process of comprehension of the material (Wieman, Adams, and Perkins, 2008). Using simulations, digital laboratories, and learning applications allows students to understand physical phenomena better and make sure they relate to the real world (Ton de Jong, Marcia C. Linn, and Zacharias C. Zacharia, 2013). Moreover, due to technological advances in education, students are able to analyze and explore science individually using different digital platforms Law, et. all, 2018). Thus, the skills of being digitally literate are essential for students majoring in physics because of the significant changes in the learning process caused by technological advances (Ng, 2012). Physics education students must have adequate digital literacy skills to integrate technologies into the learning process and into their future professional activity as future educators (Falloon, 2020). They have



to be proficient in using a variety of sources of digital learning including simulations, virtual laboratories, online learning platforms, and tools for scientific analysis. Being digitally literate will help students adapt to new technologies in the field of education and improve the quality of learning they currently receive and are going to give in the future as educators. Digital literacy implies more than just knowing how to use digital devices, but also includes the ability to access, evaluate, create, and communicate information effectively in digital environments (Eshet-alkalai 2004). Digital literacy also involves skills in finding, checking, creating, and sharing information wisely and responsibly. The idea is supported by recent studies (Carretero, Vuorikari, and Punie, 2017; Falloon, G., 2020; van Laar et al., 2020; Ng., 2012). The recent researches highlight the fact that digital literacy includes more sophisticated levels of comprehension of the processes involved. Thinking clearly, acting responsibly online and managing complicated information (van Deursen, Helsper, and Eynon, 2016; Georgopoulou et al., 2025)) are some of the features of digital literacy.

Along with the skills in using technologies, the skills in thinking logically become essential for learning physics. The Partnership for Twenty-First Century Skills identifies critical thinking among other essential skills that should be developed by students in order to address the challenges that the modern world poses. Critical thinking is the ability of a person to analyze, evaluate and understand various pieces of information in a structured and logical manner in order to be able to make a decision or come up with a solution to a problem based on evidence (Facione, 2015). In the process of learning physics, the skills in thinking critically become crucial since one should comprehend physical laws, analyze natural phenomena, develop hypotheses, and solve problems relying on evidence-based data. Students with well-developed skills in critical thinking can analyze information, develop reasonable solutions to problems and act logically while considering the matter under discussion. The development of skills in critical thinking during the process of learning physics is crucial because it facilitates understanding of relations between different concepts, analysis of experimental results, developing evidence-based arguments and reasoning. Learning physics is not limited to memorizing formulas and physical laws but also aims to promote skills in thinking. Critical thinking skills are considered one of the most important criteria in assessing the success of contemporary education. Critical thinking represents a high-level form of thinking involving analyzing of something, evaluating whether it is true or false, making decisions on the basis of the obtained results. This is crucial for sciences and problem solving (Ennis, 2011 n.d.; Facione, 2015). In today's digital world, critical thinking becomes even more crucial. One has to go through a vast amount of information to understand what sources one can trust and which cannot be relied upon (Butler, 2024; Halpern et al., 2019). In the process of learning physics, critical thinking is important because concepts in physics are often complex and abstractive and students are not required to simply learn formulas but also comprehend theories behind them and apply them in the real world setting. Therefore, critical thinking represents one of the key indicators of successful education in physics at university.

Digital literacy and critical thinking skills have much in common and strongly correlate with each other in the process of technology-assisted learning (Falloon, 2020; Ng 2012) . Proficiency in digital literacy contributes to the development of



critical thinking skills because students are required to access various sources of information, compare available data, assess the credibility of information, and transform it into useful knowledge (Eshet-alkalai, 2004). At the same time, critical thinking skills are important for helping learners not only use technology passively but also use it selectively and reflectively in evaluating the information provided (Facione 2015). In digital learning environments, students with strong critical thinking abilities tend to analyze information more effectively, identify misinformation, and make reasoned decisions based on evidence. Several studies indicate that learners who demonstrate good proficiency in digital skills tend to be better at critical thinking than others because they are accustomed to evaluating the information in depth (Kivunja, 2015; Lazonder et al., 2019).

The fact that people who are good at using digital devices tend to think critically shows that these skills are interdependent and should be learned at once to promote better learning experience in the age of digital era. At the same time, the skills in critical thinking imply reflection and logical reasoning while working with information and developing opinions, identifying cause-effect relationships and making sound and logical conclusions on the basis of information. During physics education process, it is crucial to include skills in digital learning and critical thinking skills since ideas in physics can be difficult to grasp and a growing number of students resort to technologies such as simulation, virtual laboratory, and modeling software to study physics. Using technologies in educational environment promotes comprehension of ideas and raises relevant questions because people begin to think critically and ask questions when they also reflect on what they are learning (Makransky et al. 2021; Smetana and Bell 2012). Physics teachers who are future educators need not only to understand physics concepts but create and organize activities that promote students' critical thinking and digital learning.

Previous researches show that there is a great difference between the extent to which students use various tools of digitalization and the degree to which they can analyze what they see online critically. Numerous studies indicate that despite many opportunities that the Internet provides for studying something, students do not always know how to evaluate information critically or how to come up with arguments (Darmawati and Mustadi, 2023; García-Pérez, et al. n.d.,2021). Many times, students accept everything found online without analyzing it critically thus limiting themselves in gaining knowledge (Aliyyah, Prasetyo, and Widayarsi 2025). Such pattern is consistent with the broader picture, which indicates that the use of technology does not mean people are skilled at thinking critically about it (van Deursen, Helsper, and Eynon 2016; Karnita et al. 2025; López-Meneses et al. n.d., 2020; Yuan, Yu, and Liu, 2025).

Although many studies were carried out regarding digital literacy and critical thinking, very few of them consider both concepts together in general settings, not mentioning the field of education, let alone teaching physics. There has been little research conducted in higher education in Indonesia in this particular subject. There has been a lack of attention paid to exploring the initial points at which these skills begin to emerge so that one may develop better teaching techniques. It is important to get information about initial points because it helps to develop a new approach to learning that integrates use of technology and critical thinking. Previous researches have already shown the importance of getting this information through diagnostic



studies that could facilitate developing efficient teaching techniques in training future educators and teaching sciences, technologies, engineering, and mathematics (Instefjord Elen; and Munthe Elaine 2017; Redecker and Punie n.d., 2017).

Therefore, this preliminary study aims to give clear information about skills in technology use and critical thinking skills among future physics educators. In order to achieve this goal, three tasks need to be performed: (1) Describe digital literacy levels among students, (2) Analyze critical thinking skills, and (3) Identify initial correlations between digital literacy and critical thinking skills. The main goal is to understand how digitally literate students are, to examine their skills in critical thinking and identify correlations that occur initially.

RESEARCH METHODS

This study used a digital literacy and critical thinking skills approach to examine the current status of digital literacy and critical thinking skills among Physics Education students. This approach was used to obtain a snapshot of the current state of students and was conducted in September 2024. The study also examined the characteristics of the research variables without any changes to the participants, which also serves as a starting point for research to develop new learning approaches in physics education, particularly with digital technology and 21st-century skills. The results of this study will provide insight into what students can do and can help design better learning strategies. The study involved 31 Physics Education students at a university in East Nusa Tenggara Province, Indonesia. Students were selected because they possessed characteristics important to this study. The participants were selected using a purposive sampling technique because they possessed characteristics considered relevant and important to the objectives of this study. They had to be in the same semester, meaning they had sufficient experience with digital technology in learning. They also had to have taken courses such as General Physics and Introduction to Computer Science. Students also had to agree to participate in the study. The number of students in this study was sufficient to examine trends and relationships between variables.

Data were collected using two tools: a digital literacy test and a critical thinking skills test. The digital literacy test was based on a framework that encompassed all aspects of competency required by today's students. This test has 20 multiple-choice questions that assess five competency areas: finding and using digital information, communicating and collaborating with others through digital technology, creating digital content, maintaining online security, and solving problems in digital environments. The critical thinking skills test also has 20 multiple-choice questions that assess five indicators: understanding questions, evaluating arguments, drawing general conclusions based on facts, drawing logical conclusions based on principles, and evaluating definitions. These indicators were chosen because they are important for developing thinking skills in physics education. Each question in the test has a scoring system: a correct answer receives a score of 1 and an incorrect answer a score of 0. The maximum score for each test is 20. This scoring system facilitates data analysis. The following table shows aspects of digital literacy and critical thinking skills.



Table 1. Indicators of Digital Literacy Skills

No.	Competency Area	Description
1	Finding and Using Digital Information	Ability to search, access, evaluate, and utilize digital information effectively and critically.
2	Communication and Collaboration Through Digital Technology	Ability to interact, communicate, and collaborate with others using digital platforms and technologies.
3	Creating Digital Content	Ability to create, modify, and share digital content responsibly using various digital tools.
4	Maintaining Online Security	Ability to protect personal data, privacy, and digital devices while using online technologies.
5	Solving Problems in Digital Environments	Ability to identify and solve technical or information-related problems in digital contexts.

Table 2. Indicators of Critical Thinking Skills

No.	Indicator	Description
1	Understanding Questions	Ability to identify and interpret the meaning of problems or questions accurately.
2	Evaluating Arguments	Ability to analyze the validity, relevance, and strength of arguments or statements.
3	Drawing General Conclusions Based on Facts	Ability to formulate conclusions from factual evidence and available information.
4	Drawing Logical Conclusions Based on Principles	Ability to apply logical reasoning and scientific principles to make conclusions.
5	Evaluating Definitions	Ability to examine and assess the accuracy and clarity of definitions or concepts.

Prior to the research, the tests were revised to ensure proper understanding within the Indonesian cultural context. The quality of the tests was checked by experts in physics education learning evaluation and digital literacy. The tests were also checked for reliability and validity. The data were analyzed in stages. First, descriptive statistics were used to obtain an overview of students' digital literacy and critical thinking skills. The analysis included calculating scores, achieving percentages, and categorizing the distribution of abilities for each indicator. Then, the relationship between literacy and critical thinking skills was analyzed. The results indicate that the data are normally distributed, meaning parametric statistics can be used. Correlation analysis indicates the direction and strength of the relationship between the two variables.

The research procedure is presented in a flowchart for ease of understanding. The figure shows the research steps, from preparing the test to writing the research report. This will help make the research process more transparent and produce valid and reliable data for future innovations in digital technology-based physics education. This research on digital literacy and critical thinking skills was used to examine students' performance in terms of digital literacy and critical thinking skills in Physics Education. This study used statistics to obtain an overview of students' digital literacy and critical thinking skills. Then, the study analyzed the relationship between literacy and critical thinking skills. This research will help design learning strategies for Physics Education students and develop learning methods in Physics Education, particularly with digital technology and 21st-century skills.



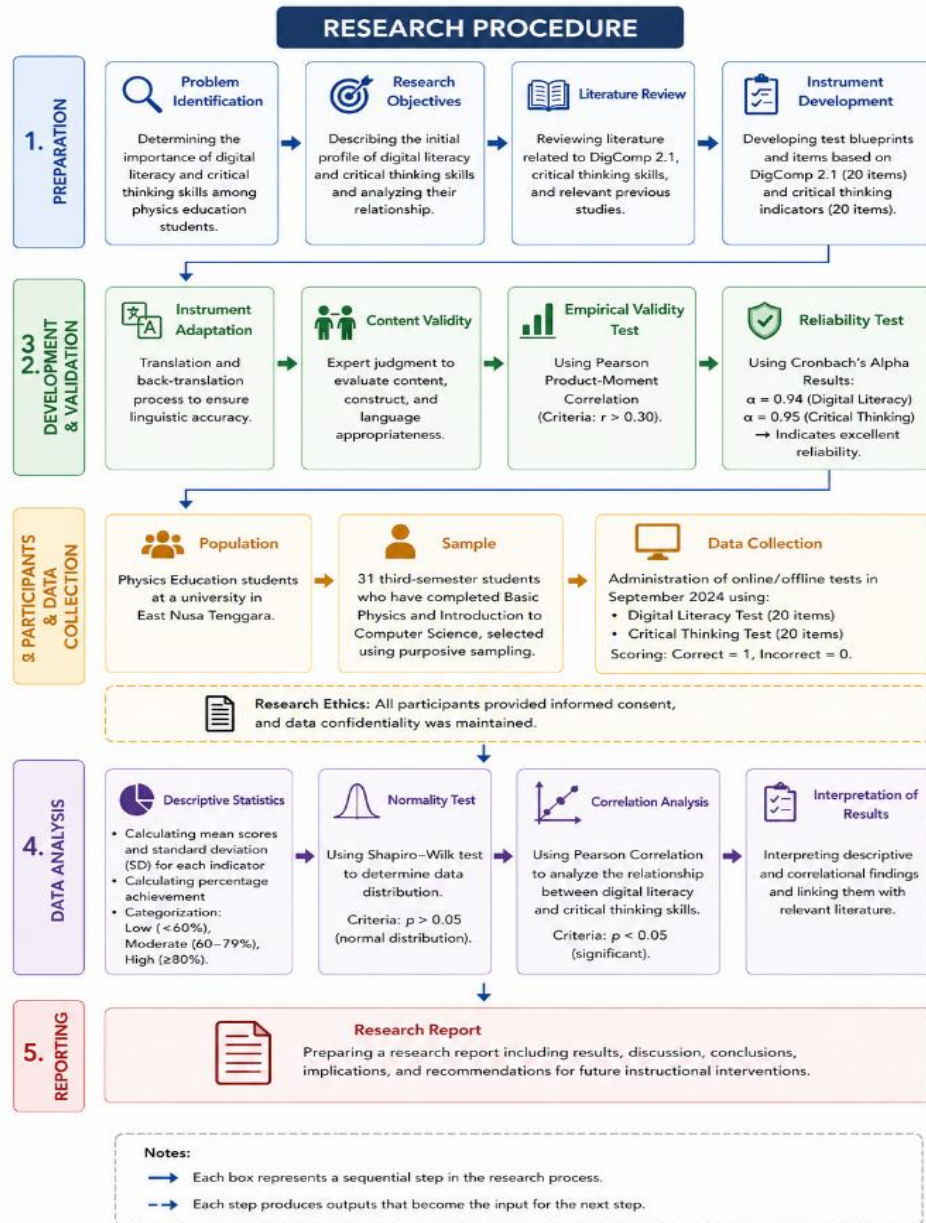


Figure 1. Research Procedure Flowchart of the Study

All participants provided informed consent prior to data collection, and the confidentiality of their responses was strictly maintained throughout the study.

RESULTS AND DISCUSSION

The results of this preliminary study consist of descriptive statistics, analysis of each indicator in the digital literacy and critical thinking skills variables, and analysis of the relationships between the variables. The following are the results and discussions of each.

A. Descriptive Statistics

In general, the results of the statistical description of this preliminary research can be seen in Table 3, Table 4, and Table 5.

Table 3. Digital Literacy Scores by Indicator

No.	Indicator	Total Score	Percentage (%)	Category
1	Finding and Using Digital Information	27.8	22.4	Low
2	Communication and Collaboration	35.1	28.3	Low
3	Creating Digital Content	18.7	15.1	Low
4	Maintaining Online Security	28.5	23.0	Low
5	Solving Problems in Digital Environments	18.7	15.1	Low
	Overall Mean	25.7	29.03	Low

Table 4. Critical Thinking Skills Scores by Indicator

No.	Indicator	Total Score	Percentage (%)	Category
1	Understanding Questions	29.8	24.0	Low
2	Evaluating Arguments	26.4	21.3	Low
3	Drawing General Conclusions Based on Facts (Inductive Reasoning)	15.1	12.2	Low
4	Drawing Logical Conclusions Based on Principles (Deductive Reasoning)	29.9	24.1	Low
5	Evaluating Definitions	22.3	18.0	Low
	Overall Mean	24.7	27.90	Low

Table 5. Students' Digital Literacy and Critical Thinking Scores

Variable	Mean (%)	Category
Digital Literacy	29.03	Low
Critical Thinking	27.90	Low

The data in Table 5 shows that students' digital literacy and critical thinking skills remain low.

- The digital literacy rate reached 29.03%.
- The critical thinking skills score was 27.90%.

This indicates that although students use technology in school, they are unable to utilize it effectively and critically. They are somewhat better at digital activities such as accessing and sharing information, but their digital skills remain weak. They lack analytical or judgmental skills. This low score in critical thinking is truly alarming. Students appear to have difficulty analyzing arguments in depth and assessing the information presented objectively. This is a problem in physics learning, where critical thinking and problem-solving skills are crucial. Research shows a discrepancy between how students utilize digital devices and their skills in using them effectively. To address this issue, educators need to develop lesson plans that integrate technology and stimulate critical thinking skills. Various methods that can be implemented include project-based learning, inquiry-based learning, and the use of simulation tools that encourage participation and problem-solving skills.

B. Analysis by Indicators

The results of preliminary research for each indicator in the digital literacy and critical thinking skills variables can be seen in the following Table 6.

Table 6. Achievement by Indicator

Variable	Indicator	Mean (%)	Category
Digital Literacy	Information & Data Literacy	31.2	Low
	Communication & Collaboration	34.1	Low
	Digital Content Creation	27.3	Low
	Safety	30.5	Low



Variable	Indicator	Mean (%)	Category
Critical Thinking	Problem Solving	29.4	Low
	Focus on Question	30.1	Low
	Analyze Argument	32.0	Low
	Inductive Reasoning	25.2	Low
	Deductive Reasoning	27.6	Low
	Evaluate Definition	28.3	Low

Digital Literacy (DigComp 2.1)

1. Information and Data Literacy

According to the results, pupils' scores were deemed low because of their poor knowledge and skills in information and data literacy (31,2%). This implies that students still find it hard to locate relevant information and evaluate the authenticity of online resources. The constraint implies that students frequently rely on readily available material without questioning its accuracy. This limitation suggests that students tend to rely on readily available information without critically assessing its validity. In the context of physics education, this condition may hinder students' ability to interpret scientific data accurately and develop evidence-based understanding.

2. Communication and Collaboration

Although still considered low, the students' score of 34.1% in communication and cooperation is the highest among all digital literacy metrics. The conclusion is that students are more accustomed to engaging in digital interaction and exchange of information. However, this ability appears to be limited to everyday speech and not in great intellect. Students' use of digital platforms is insufficient to engage in cooperative problem-solving or knowledge development, as demonstrated by the findings. However, this ability seems to be confined only to basic communication and not in significant academic cooperation. This indicates that students might be using the internet at times, but may not engage in collaborative problem-solving or knowledge-building.

3. Digital Content Creation

Digital content creation had the lowest rate of digital literacy, measuring 27.3%. The message is that students are not equipped to create, modify or present digital content. This results in students being more inclined to use technology and not actively creating."'. The inability to use physical objects or images as visual aids can hinder students' ability to comprehend physics concepts beyond the physical world.

4. Safety

With a score of 30.5%, the safety indication was classified as low. This finding suggests that students are not sufficiently informed of responsible online actions, ethical information use, and digital security. This ignorance could put students at danger for things like false information, plagiarism, and improper use of data. This condition focusses on how important it is to incorporate digital ethics and safety into the educational process in order to promote responsible technology use.

5. Problem Solving

Students' use of digital technologies to solve problems was rated as low at 29.4%. This implies that pupils are still unable to use digital tools to address problems in an efficient manner. It seems that they just use technology for simple



purposes rather than for strategic purposes. This restriction may have a substantial impact on students' capacity to apply ideas in practical situations in physics classes, where problem solving is a fundamental skill.

In general, the results of preliminary research for indicators on the digital literacy variable can be seen in Figure 2.

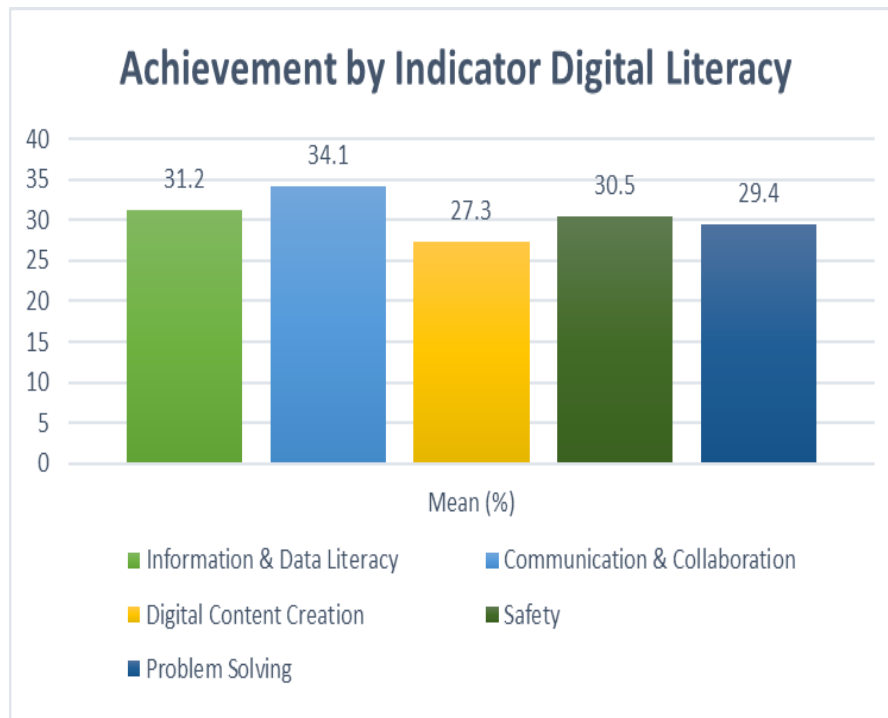


Figure 2. preliminary research results based on Digital Literacy Indicators

Critical Thinking

1. Focus on Question

A low level of performance was indicated by the 30.1% concentration on questions score. This implies that kids struggle to recognise the primary issue or comprehend the purpose of a question. Such a restriction could result in problems being misinterpreted and inefficient approaches to problem-solving. The ability to precisely characterise an issue is an essential initial step in the reasoning process in scientific learning.

2. Analyze Argument

Although it is still in the low range, students' argument analysis score of 32.0% is comparatively higher than other critical thinking metrics. This suggests that while students may be able to comprehend arguments to some extent, their evaluation of their validity may be shallow. This shows that while pupils can identify material, they are still unable to critically analyse its logical structure.

3. Inductive Reasoning

Inductive reasoning received the lowest critical thinking score (25.2%). This suggests that pupils find it difficult to make generalisations based on particular information or observations. Since generalisation from experimental results is essential in physics teaching, this flaw is especially problematic. The outcome

implies that pupils might rely more on memorisation than on thinking to build knowledge.

4. Deductive Reasoning

27.6% of students performed poorly when it came to deductive reasoning. This may indicate that students struggle that reflect broad concepts to particular circumstances. Students being unable to make the connection between academic knowledge and real-world application is a sign of a conceptual comprehension gap. This ability is essential in physics to solve issues and forecast results.

5. Evaluate Definition

The definitions examination yielded a score of 28.3%, which is likewise in the bottom range. This implies that pupils are not very good at evaluating definitions and concepts. Students may so accept knowledge without challenging its veracity or applicability. Misconceptions can result from this state, particularly in subjects like physics that call for exact conceptual knowledge.

In general, the results of preliminary research for indicators on the critical thinking skills variable can be seen in Figure 3.

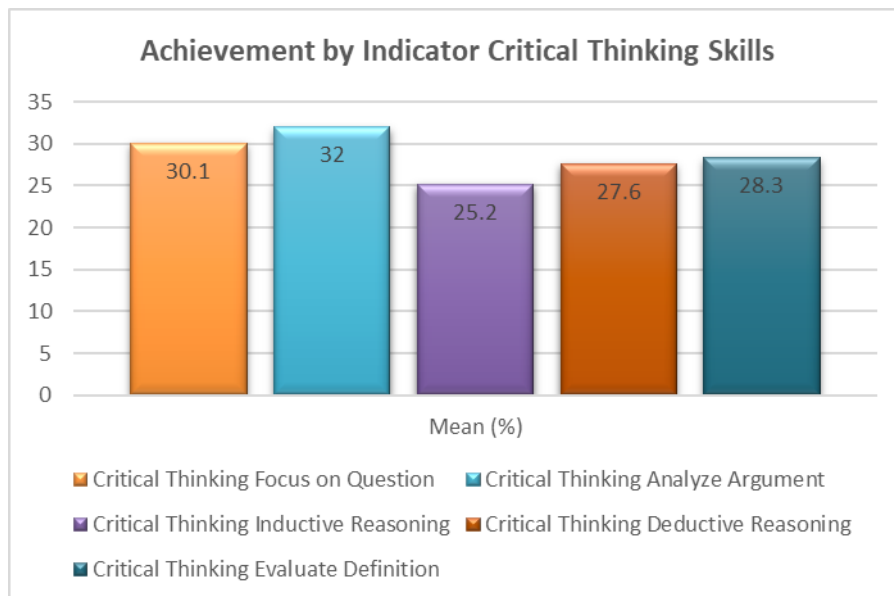


Figure 3. preliminary research results based on Critical Thinking Skill Indicators

C. Normality Test

The results of the Shapiro–Wilk test show that:

- Digital Literacy: $p > 0.05$
- Critical Thinking: $p > 0.05$

The results of the Shapiro–Wilk test indicate that both digital literacy and critical thinking data are normally distributed ($p > 0.05$). Therefore, the assumption of normality is fulfilled, allowing the use of parametric statistical analysis, particularly Pearson correlation.

D. Correlation Analysis

The research data obtained were subjected to a Pearson correlation analysis in order to determine the relationship between digital literacy and students' critical

thinking skills. This analysis was to ascertain the direction of the relationship, the strength and its statistical significance. The correlation analysis result is as follows:

• $r = 0,46$ • $p < 0,05$. Digital literacy and critical thinking abilities have a statistically significant moderately favourable link according to the Pearson correlation study ($r = 0.46$, $p < 0.05$). This research suggests that increasing digital literacy is connected with an improvement in students' critical thinking ability, however the relationship is not very strong.

The results indicate that students' digital literacy and critical thinking skills are generally at a low level. Critical thinking abilities were 27.90%, while digital literacy was 29.03%. Both ratings are low, indicating that students have yet to establish adequate competence in these areas. Digital content creation received the lowest score among digital literacy areas, while communication and collaboration received the highest, according to a more thorough analysis based on indicators. Students' analysis of arguments was comparatively stronger when it came to critical thinking, whereas inductive reasoning was the weakest indicator. The Shapiro-Wilk test results verified that the data had a normal distribution ($p > 0.05$). Consequently, a moderately favourable link between digital literacy and critical thinking abilities was found using Pearson correlation analysis ($r = 0.46$, $p < 0.05$).

This preliminary research found that physics students lack excellent digital literacy and critical thinking skills. Even while they utilise digital technology, it does not help them develop their thinking skills as much as it could. They're good at using digital technologies to communicate and share information, but they're not particularly good at creating digital material. This indicates people are mostly using digital technology to absorb information rather than to generate new knowledge. This is a concern since simply using digital technology does not imply that you are skilled at it; you must be able to make us it to think critically and solve problems. In physics, the ability to reason scientifically is extremely crucial. The study discovered that pupils are particularly suffering with inductive reasoning, which is the capacity to accept patterns and draw conclusions based on data. This is a major issue because it is an essential component of studying physics. It appears that the current method of teaching kids is insufficient for developing their analytical and reasoning skills. We must consider how we may modify our teaching methods to assist students in developing these skills, allowing them to recognise their full potential in physics and other topics. For example, we should do more to encourage students to generate their own digital content, such as movies or podcasts, demonstrating their mastery of physics principles.

Additionally, we could help students strengthen their critical thinking abilities by make us of more interactive and collaborative digital technologies. We may assist students in becoming more active producers of digital knowledge rather than merely passive consumers by implementing these adjustments. Overall, the research indicates that in order to help children develop these crucial abilities, we need examine how we teach critical thinking and digital literacy more closely and make some adjustments. They will benefit from this in all facets of their lives, not just physics.

The results of this study show that students studying physics education still have inadequate levels of digital literacy and critical thinking abilities. This suggests that real cognitive growth has not yet resulted from students' exposure to digital



tools, since the use of technology alone does not automatically improve higher-order thinking skills without meaningful learning activities and pedagogical support (Falloon, 2020; Nguyen and Habók, 2024). The comparatively better communication and teamwork scores indicate that students are accustomed to using digital platforms for communication and information exchange, which aligns with the idea that today's learners are highly engaged in social and collaborative digital environments (OECD 2018 n.d.). Nonetheless, students' poor performance in creating digital material suggests that they are still viewed as passive consumers rather than active creators of digital information. This finding is consistent with the theory of digital literacy proposed by Yoram Eshet-Alkalai, which emphasizes that digital competence involves not only accessing information but also producing and critically transforming digital content (Eshet-alkalai 2004). This also confirms earlier research showing that digital participation by itself does not ensure digital competence, especially in higher-order domains such as critical evaluation, creativity, and knowledge production (Ng 2012). When it comes to critical thinking, students' inability to generalize patterns and make conclusions based on data is reflected in their low score in inductive reasoning. This is an important issue in physics education because scientific reasoning and evidence-based thinking are fundamental components of learning physics concepts and solving scientific problems. According to constructivist learning theory, students develop analytical reasoning skills when they actively engage in inquiry, experimentation, and reflective thinking processes rather than merely receiving information passively (Bransford et al., 2000). Therefore, the findings indicate that present educational techniques may not yet be sufficient to support the development of analytical and reasoning abilities required in physics learning and digital-age education.

Pearson correlation study revealed a moderate positive link between digital literacy and students' critical thinking skills ($r = 0.46$, $p < 0.05$). This research suggests that greater levels of digital literacy are connected with improved critical thinking skills. This favourable link suggests that using digital technology might improve analytical, evaluative, and reflective thinking processes during learning. Students with high digital literacy abilities can successfully search for, comprehend, evaluate, and use information to address learning difficulties. This shows that having access to a range of digital learning materials might help students acquire the ability to recognise important information and make sound decisions.

However, the modest strength of the link suggests that critical thinking abilities are impacted not just by digital literacy, but also by other factors such as teaching techniques, learning motivation, academic background, and students' learning environment. The somewhat advantageous connection between digital literacy and critical thinking suggests that these two skills are linked. Students who are more digitally literate tend to have stronger critical thinking abilities. The outcomes of this study are consistent with other prior studies that show that using digital technology in the learning process might increase students' critical thinking skills. Digital literacy in physics education helps students grasp complex ideas using virtual experiments, simulations, and visualization that enhance scientific reasoning and analytical skills. Enhancing digital literacy must thus be taken into account in education to guarantee that students' critical thinking abilities are developed in a more efficient and long-



lasting manner. This suggests that learning designs that specifically incorporate these two abilities are required.

Overall, the consistently low performance across all indicators reflects a systemic gap in students' competencies. This finding indicates that students may still experience difficulties in integrating digital skills with higher-order thinking abilities in learning activities. According to constructivist learning theory, meaningful learning occurs when students actively construct knowledge through exploration, inquiry, and problem-solving activities (Bransford et al., 2000). Therefore, learning environments should provide opportunities for students to engage actively with technology rather than merely receive information passively

This condition underscores the importance of developing innovative learning approaches, such as project-based learning and simulation-based instruction, which can simultaneously foster digital literacy and critical thinking skills. Project-based learning encourages students to investigate problems, collaborate, evaluate information critically, and produce authentic products using digital technologies (Bell 2010). Previous studies have shown that project-based learning can significantly improve students' critical thinking, problem-solving, and digital competencies because students are actively involved in inquiry-based and collaborative learning processes. In addition, simulation-based instruction has been widely recognized as an effective approach in physics education because it helps students visualize abstract concepts, conduct virtual experiments, and strengthen scientific reasoning skills (de Jong, Marcia C. Linn, and Zacharias C. Zacharia 2013). Research conducted by Carl Wieman and colleagues also demonstrated that interactive simulations improve conceptual understanding and student engagement in science learning environments (Wieman, Adams, and Perkins, 2008). Thus, integrating project-based learning with digital simulations may become a promising strategy for enhancing both digital literacy and critical thinking skills among physics education students.

CONCLUSION

This study reveals that the digital literacy and critical thinking skills of physics education students remain in the low category, with mean scores of 29.03% and 27.90%, respectively. Students demonstrate relatively better performance in communication and collaboration, but still show significant limitations in digital content creation and problem-solving. In critical thinking, deductive reasoning appears stronger, whereas inductive reasoning remains the weakest aspect, indicating difficulties in drawing conclusions from empirical evidence. Correlation analysis also shows a moderate positive relationship between digital literacy and critical thinking skills, suggesting that both competencies are interconnected but do not automatically develop simultaneously.

These findings indicate a gap between the expected competencies of prospective physics teachers and their current abilities in responding to the demands of digital-era learning. Students are still more positioned as users of technology rather than active creators of knowledge and are less accustomed to higher-order thinking processes. Therefore, transformative instructional approaches that integrate technology with active learning, such as project-based learning, inquiry-based



learning, and simulation-supported instruction, are needed to enhance students' digital literacy and critical thinking skills simultaneously.

Future studies are recommended to involve larger and more diverse samples and to employ more comprehensive assessment methods in order to obtain a deeper understanding of students' competencies. Overall, this study provides an important foundation for developing innovative pedagogical strategies to improve the quality of physics teacher education in the 21st century.

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