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First Year Pre-Service Teachers' Self-Perception of Digital and Scientific Literacy: Implication for Course Design

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ABSTRACT
Teachers in the 21st century are expected to be mastering 21st century skills, so pre-service teachers need to be prepared to become professional teachers starting from the education period while studying at university. Mastery of digital and scientific literacy is considered to be the core of the literacy required in 21st century education. This research is a quantitative study using the survey method. The subject of this research is first year science education students at a university in Magelang, totaling 141 students. Descriptive statistics were employed to investigate the digital and scientific literacy. Based on the results of the study, it can be concluded that pre-service teachers' self-perception of digital and scientific literacy are in the medium category, which means that there is a need to develop effective course designs for promoting both literacies among preservice teachers in order to support the quality of teacher education in Indonesia.

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1. INTRODUCTION

The 21st century is characterized by the rapid development of information and communication technology (ICT) and brings changes in all aspects, including education. The 21st century education framework emphasises the need to be mastering 21st century skills that are expected to help improve academic achievement in schools and adapt to the changing and evolving times (Partnership for 21st Century Learning, 2019; Tindowen et al., 2017). 21st century skills refer to professional skills in the era of globalization and digitalization, which are broken down into several broad categories including: 1) learning and innovation skills (critical thinking, creative thinking, communication, and collaboration), 2) information, media, and technology skills, and 3) life and career skills (Borowski Teresa, 2019; Gelen, 2018; Kereluik et al., 2013).

Teachers in the 21st century are expected to be mastering 21st century skills so it is necessary to prepare to become professional teachers starting from the education period of pre-service teachers while studying at the university (Lestari & Rahayu, 2023; Muis, 2021). Mastery of information and communication technology skills is considered one of the important factors in mastering 21st century skills (Mahmud & Wong, 2022; Valtonen et al., 2017), because its use has a positive impact on learning outcomes (Latip et al., 2022; Soeprijanto et al., 2022). However, recent findings show that the use of information technology is not yet enough to improve the quality of learning, so digital literacy is needed to achieve this goal (Zeng et al., 2022). Apart from the use of technology, there are two other important aspects, namely conceptual skills and operational competences, which are basic prerequisites for students to be fully involved in digital contexts at the social, cultural and professional levels (Miranda et al., 2018). Digital literacy is believed by many educators to be at the core of literacy, not just seen as a supplementary element in lesson planning and implementation (Cassidy et al., 2016). In addition, learning in the 21st century also emphasises the need for scientific literacy as one of the skills that need to be mastered from the 16 skills identified by the World Economic Forum (WEFUSA, 2015).

Digital literacy refers to a conceptual framework that combines skills in using technology with information literacy skills in the process of searching, acquiring, combining, organising, presenting and evaluating information in the context of a digital environment (Kaeophanuek et al., 2018; Meyers et al., 2013). Meanwhile, scientific literacy refers to the skill of making decisions about problems in everyday life and considering the development of technological advances, information, and science (Suwono et al., 2022). These

skills include understanding the nature of science, information management skills, and communicating and collaborating with others (Ke et al., 2021).

The importance of digital literacy and scientific literacy in 21st century education requires student teachers to master them to help the process of thinking, learning, communicating, working together, and working with their respective creativity as a provision for entering the world of work. However, various studies show that students' digital and scientific literacy are still low. In Indonesia, especially the province of Yogyakarta, research on the digital literacy of upper secondary students shows that students' digital literacy skills are still at a very low level and are influenced by their level of education (Perdana et al., 2019). This also evidenced by students' failure to utilize technology for academic improvement, despite having a tech-savvy background (Tewari & Birla, 2018). Rizal et al. (2020) reported that the digital literacy of first-semester students in aspects of data and digital information, as well as digital content creation, is in a low category. Meanwhile, for the communication and collaboration aspect, competency is in the medium category. Another study shows that the digital literacy of students in the third year in the aspect of functional skills and beyond is at a very good level, while in the other seven aspects, it is in the good category (Dinata, 2021).

On the other hand, research examining digital literacy skills of pre-service biology teachers shows that students' overall scientific literacy is moderate (Adi et al., 2020). Other research investigates the scientific literacy levels of prospective elementary school teachers in the first and fourth years of teacher preparation programs show that students at both levels have low levels of scientific literacy (Cavas et al., 2013). Regarding this condition, researchers seem to have reached the context that prospective teachers with low levels of scientific literacy cannot be expected to grow scientifically literate individuals or implement the science curriculum effectively (Al Sultan et al., 2018)

This condition is in line with the results of observations on pre-service science teachers during teaching and learning in a university, especially in the first year of study. The need to improve students' digital literacy is indicated by the lack of students' abilities related to the ability to identify the information needed, the ability to choose quality information sources on digital media, the ability to convey the information obtained to others, the ability to rewrite the information obtained in their own language, and the ability to quote online references ethically using the correct format. Another thing that was observed was the variety of misconceptions in basic science concepts and the weak ability of students to interpret scientific data and information presented during the learning process.

Based on the description above, improving digital and scientific literacy for pre-service teachers is needed to improve the quality of education in the 21st century. However, information related to the pre-service teacher's self-perception of the two literacies is limited, so further identification is needed to give valuable insights into the development of effective teacher education course design. Thus, the purpose of this study is to describe the pre-service teachers' self-perception of digital and scientific literacy in their first year and first semester of their program at a university.

2. RESEARCH METHOD

This research was a descriptive quantitative study that uses online survey method to describe pre-service teachers' perception of digital and scientific literacy. The subjects of this research were four classes of first-year students of Science Education department, Faculty of Teacher Training and Education at a university in Magelang, Central Java. The total number of students surveyed online in 2023 was 141 students using total population sampling technique. Digital literacy and scientific literacy data were measured by a self-assessment questionnaire instrument using a 5-point rating on a Likert scale. This measurement was chosen because according to researchers, one of the most accurate ways to assess someone's digital literacy skills is by asking them to carry out a self-evaluation (Chinien & Boutin, 2011). The digital literacy instrument was modified from previous research and contained 15 statements in 3 (three) digital literacy domains, namely technical, cognitive, and socio-emotional (Suwono et al., 2022). The scientific literacy instrument was also modified from previous research and contained 30 statements in 5 (five) domains, namely the nature and function of science, habits of mind, interest in science, the teaching of scientific literacy, and ethics in science (Baharuddin et al., 2021). The questionnaire data obtained was then analyzed in three stages, namely data reduction, data display, and drawing conclusions (Miles & Huberman, 1994). The results of the data analysis were described in 3 (three) qualitative categories, namely low, medium, and high (Igbokwe, 2016).

Table 1. Qualitative Categories Digital and Scientific literacy

Persentase (%)	Kategori
<60	Low
60 – 79	Medium
≥ 80	High

3. RESULT AND DISCUSSION

The results of this study are pre-service teachers' perceptions of digital and scientific literacy obtained from the analysis of survey data using a 5-point rating on a Likert scale. The following are the results of the data analysis presented in Table 2 and Table 3.

Table 2. Student perceptions of digital literacy

Digital Literacy Indicators	Percentage	Description
Technical domain		
1. I use digital technology and devices to support learning	84,25	High
2. I am competent in using application software such as email, search engines and web browsers	71,49	Medium
3. I know how to solve technical problems related to digital technology tools	54,18	Low
4. I keep up to date with the digital tools and applications used in learning	71,91	Medium
5. I am familiar with the process of uploading, downloading and installing applications	78,30	Medium
Average	**72,03**	**Medium**
Cognitive domain		
6. I am familiar with online resources such as websites and online databases	73,62	Medium
7. I can browse, search and use information from trusted online databases	62,98	Medium
8. I know when to change my search strategy or stop searching when using trusted websites and online databases	64,54	Medium
9. I evaluate the credibility of digital information before using it	60,57	Medium
10. I can integrate information coming from different online sources to solve problems	68,09	Medium
Average	**65,96**	**Medium**
Socio-emotional Domain		
11. I include the citation/information of the owner of the information whose ideas I used	70,50	Medium
12. I am aware of the consequences of using someone else's copyrighted work without permission	81,70	High
13. I share files such as documents, videos and audios legally with others	65,53	Medium
14. I am able to work online with my peers to find a solution to a problem	75,32	Medium
15. I comply with etiquette and social norms appropriate for online communication	84,11	High
Average	**75,43**	**Medium**

Table 3. Student Perceptions of Scientific Literacy

Scientific Literacy Indicators	Percentage	Description
The nature and function of science		
1. Science has a significant relationship with human life	89,36	High
2. Science is influenced by civilisation and local culture	81,13	High
3. Scientific research should improve human life	84,11	High
4. The use of science and technology always involves solving social problems	76,45	Medium
5. If a scientific problem is very complicated and there is no clear solution, it is necessary to revisit and examine the causes of the complexity of the problem	86,95	High
6. Studying science can develop one's spirituality	74,33	Medium
Average	**82,05**	**High**
Habits of mind		
7. When studying a natural phenomenon, I try to find patterns or sequences of data	71,06	Medium
8. I analyse data carefully to formulate correct conclusions	82,41	High
9. When studying a natural phenomenon, I seek related information from a variety of sources	81,13	High
10. I develop or use existing scientific procedures to explain a natural	75,03	Medium

	phenomenon		
11.	When studying a natural phenomenon, I compare and evaluate information to determine which is the most appropriate	77,02	Medium
	Average	**77,33**	**Medium**
Interest in science			
12.	I consider science an important subject to teach	84,25	High
13.	I have a strong motivation to learn science	75,74	Medium
14.	I have a positive attitude towards science because it involves teaching interesting material	78,01	Medium
15.	Science helps everyone to have a better life	88,23	High
16.	Science helps me to understand the phenomena happening around me	85,53	High
	Average	**82,35**	**High**
The teaching of scientific literacy			
17.	I always discuss with my peers and lecturers when learning science	75,32	Medium
18.	I do lab work/experiments/research projects in science learning in class	82,84	High
19.	I use technology to support my learning process	86,38	High
20.	The science learning process that I receive, helps me in making decisions	77,16	Medium
21.	The science learning process that I receive, helps me in making decisions	75,74	Medium
	Average	**79,49**	**Medium**
Ethics in science			
22.	The study of science does not need to be done systematically	71,63	Medium
23.	The study of science does not need to be linked to global impacts	69,08	Medium
24.	The study of science does not need to be linked to other research findings	70,35	Medium
25.	When reviewing science, I sometimes skip or omit research procedures	66,67	Medium
	Average	**69,43**	**Medium**

Based on the results of data analysis in Table 2, it shows that in general, the digital literacy of science education students is categorized as medium, both in the technical domain, cognitive domain, and social-emotional domain. Furthermore, an indicator of the technical domain is categorized as low, relating to the ability to overcome technical problems related to digital technology tools. In the cognitive domain, the percentage of indicators related to the ability to evaluate the credibility of digital information is 60.57%, which means that the percentage is close to the low category. In the social-emotional domain, the overall category is medium, with two indicators that have been categorized as high. This means that there is a need to improve students' abilities in all three domains of scientific literacy. These abilities include mastery of technical and operational aspects to use digital tools to solve problems in everyday life, especially in learning activities; the ability to search, evaluate, select and use appropriate digital information to complete learning-related tasks; and the ability to use digital tools responsibly in communicating, socialising and learning (Ng, 2012).

Education in the 21st century requires teachers who are ready for the digital era so that students as future teachers need to have digital readiness to teach with the required competencies. Digital readiness is closely related to digital literacy which includes four categories, namely a) basic level readiness (information gathering and processing); b) advanced level readiness (information management and evaluation); c) teamwork readiness (teamwork); and d) ethical readiness (integrity awareness and social responsibility) (Horrigan, 2016). Pre-service teachers are expected to be able to master digital literacy since mastery of digital literacy is believed to help teachers in developing learning and assessment in the classroom (Widana, 2020). In addition, digital literacy is also considered to play an important role in entrepreneurship, creativity, and innovation, which are needed in this era (Martin & Grudziecki, 2006).

Pre-service teachers who are mostly young people have a tendency to be open to technology (Seibert, 2021). However, sometimes they experience problems such as lack of concentration, interaction, and socialisation, which causes 21st century skills not to be achieved optimally (Karakas et al., 2015). First-year undergraduate students generally experience challenges in utilising digital technologies that support learning (Umar et al., 2019). This condition may be the reason why digital literacy has not been achieved optimally, so various efforts are needed to overcome these problems.

Based on the results of data analysis in Table 3, it shows that in general the scientific literacy of science education students is categorized as medium with an average percentage of 78.64%. High-category domains are

the domain of the nature and function of science and the domain of interest in science. Meanwhile, medium-category domains are the domain of habits of mind, the domain of the teaching of scientific literacy, and the domain of ethics in science. All domains contribute to scientific literacy, but several studies have shown that the nature and function domain has a low contribution to scientific literacy (Suwono et al., 2022). This means that there is a need to emphasise the mastery of other domains of scientific literacy, even though the nature and function of science domain has reached a high category.

Improving scientific literacy for pre-service teachers is needed to support 21st century education in the era of the industrial revolution, which is the development of the integration of science and technology (Ibda, 2018). A possible obstacle in mastering scientific literacy is the learning process that has not involved the science process (Antika & Marpaung, 2023). Traditional lecture-based learning, commonly employed in schools, exemplifies an educational approach that does not incorporate scientific process skills. This design neglects the essential competencies that students must develop, encompassing a broad array of skills used by scientists in their work and the abilities necessary for solving scientific problems. These skills include asking questions, observing, measuring, using numbers, classifying, predicting, identifying and interpreting evidence, communicating, and explaining conclusions,. (Li et al., 2024; Simamora et al., 2020). This will have an impact on the ability to understand concepts and the ability to interpret scientific data and information presented during the learning process.

The teaching and learning experience can be enhanced by providing students with opportunities to access digital information and technology, collaborate with others, and solve problems. A study by Falloon (2020) emphasizes the importance of preparing pre-service teacher students to use digital technologies for educational purposes, finding and managing digital information, engaging in online communication, and critically evaluating digital resources. Pre-service teachers need to be equipped with digital competencies to improve teaching and learning experiences, both traditional and online, in response to changes in the educational landscape shaped by digital innovation.

Several recommendations can be considered in designing effective learning design for teacher courses. First, lecturers need to consider that most first year students may not comprehensively understand the technicalities and purpose of using digital technology. Therefore, it is important to provide adequate support and guidance to improve preservice teachers' digital skills and knowledge. Second, learning should be supported by digital platforms that provide new experiences and challenges for prospective teacher students by using various digital technologies. Third, the fact that students have used digital technology and devices to support learning, and have good awareness of the appreciation of intellectual property which leads to plagiarism, it can be a good start because according to Prior et al. (2016) self efficacy, attitude and literacy interrelated. Fourth, to improve preservice teacher scientific literacy, learning design should involves active engagement, critical thinking, problem-solving skills, and a deeper understanding of scientific concepts through inquiry-based learning, hands-on experiments, real-world applications, and collaborative projects.

4. CONCLUSION

Based on the results of this research, it can be concluded that pre-service teachers' perceptions of digital and scientific literacy are categorized as medium. This indicates that pre-service science teachers possess adequate provisions to address the demands of 21st-century education. However, there is a need to enhance both literacies to improve the quality of teacher education. This improvement is essential to enable pre-service teachers to facilitate meaningful science learning experiences for their students in the digital age.

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