



Students' Environmental Knowledge Learning in the Era of Industrial Society 4.0 Reviewed from Digital Literacy Capability

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ABSTRAK

Tantangan pembelajaran pengetahuan lingkungan pada era masyarakat industri 4.0 ditengah penerapan pembelajaran hybrid yaitu rendahnya kemampuan literasi digital. Penerapan pembelajaran hybrid menuntut mahasiswa memiliki kemampuan literasi digital, dimana mahasiswa harus mampu memahami konteks nyata yang disajikan dalam bentuk digital. Penelitian ini bertujuan untuk menganalisis pengaruh literasi digital terhadap pengetahuan lingkungan. Penelitian menggunakan pendekatan kuantitatif, metode survei, dengan teknik analisis regresi. Sampel sebanyak 50 mahasiswa yang mengikuti mata kuliah pengetahuan lingkungan yang dipilih secara acak. Teknik pengambilan data menggunakan instrumen tes untuk mengukur pengetahuan lingkungan, sedangkan instrumen non tes digunakan untuk mengukur kemampuan literasi digital. Hasil penelitian menunjukkan bahwa literasi digital memiliki pengaruh positif terhadap pengetahuan lingkungan. Semakin tinggi literasi digital mahasiswa, maka semakin tinggi pula pengetahuan lingkungan. Temuan menyebutkan kemampuan literasi digital memiliki kontribusi sebesar 40% terhadap pengetahuan lingkungan. Hasil penelitian ini memberikan implikasi pada penguatan kemampuan literasi digital mahasiswa, dan digitalisasi pembelajaran pengetahuan lingkungan di era digital dan industry 4.0.

ABSTRACT

The challenge of learning environmental knowledge in the era of industrial society 4.0 amidst the implementation of hybrid learning is low digital literacy capability. The implementation of hybrid learning requires students to have digital literacy capability, where students must be able to understand the real context presented in digital form. This research aims to analyze the effect of digital literacy on environmental knowledge. The research uses a quantitative approach, survey method, with regression analysis techniques. A sample of 50 students taking environmental knowledge courses were selected randomly. The data collection technique uses test instruments to measure environmental knowledge, while non-test instruments are used to measure digital literacy capability. The research results show that digital literacy has a positive influence on environmental knowledge. The higher a student's digital literacy, the higher their environmental knowledge. The findings state that digital literacy capability contribute 40% to environmental knowledge. Environmental knowledge learning can be improved by strengthening students' digital literacy so they can follow the flow of implementing hybrid learning. The results of this research have implications for strengthening students' digital literacy capability, and digitizing environmental knowledge learning.

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1. INTRODUCTION

Society in the industrial era 4.0, where digital technology is the main key, is a challenge in various fields, including learning in higher education. In the context of the industrial era 4.0, digital literacy is a necessary ability for all users of digital devices, as they are not only able to use these gadgets but also possess a range of sophisticated abilities (Isnah et al., 2022; Yanzi et al., 2019). The ability of students to use digital platforms is one of the skills students must have to be able to face the new era of the 21st century (Laar et al., 2017; Rohmah et al., 2022). The lecturer's role is to direct, guide and provide tools that students can use from valid and trusted sources. Learning in the digital era is increasingly flexible, students can manage their learning independently. Learning uses online media such as zoom meetings and google meet, supported by the application of e-learning and learning management systems. Lecturers can upload learning materials and give assignments to students easily. Higher education is a formal institution that is expected to be able to produce competent personnel who are ready to face the world of work which is increasingly developing along with advances in technology. Students' digital literacy capability are still not evenly distributed in every dimension, where the ability to use technology and information and data literacy is quite good, while communication, critical thinking and digital security skills are still lacking (Rahmatulloh & Napis, 2023; Yusuf et al., 2020). These results show efforts to map digital literacy capability.

In the digital era, all information or knowledge is available digitally. This requires students' ability to obtain, explore, process and present knowledge in the form of information, data, facts regarding learning material. This condition is both a challenge and an opportunity in the world of education, especially learning environmental knowledge in universities. In the digital era, learning no longer needs to be done in the classroom, no need to interact with objects directly, this can be made possible with advances in digital technology (Agustini et al., 2019; Wangi et al., 2018). In learning environmental knowledge, it can be done without having to interact directly with the real environment. One of the efforts of the digital literacy movement is to familiarize students in schools with skills in carrying out digital literacy activities. Apart from that, digital literacy capability in Indonesia are still low. This is referred to based on the results of the 2015 Program for International Student Assessment (PISA), Indonesia's reading or literacy level is ranked 62nd (Ismawati et al., 2023; Pratama et al., 2019). The literacy level according to PISA is a benchmark for educators and lecturers to always pay attention to digital literacy capability in the industrial era 4.0 or the digital transformation period.

Digital transformation in environmental knowledge learning. This development has an increasingly open impact, the spread of information and knowledge throughout the world across the boundaries of distance, place, space and time (Arima et al., 2021; Made et al., 2022). However, the problem that arises is that students' ability to obtain information using various forms of media is still limited. Other studies said that the latest trend in the digital era now is paperless, where all activities that use paper in this era are changing to digital data storage in the form of electronic files and changing them to e-book form (Baby & Saeed, 2020; Cholily et al., 2019). There are many factors so that environmental knowledge learning can take place effectively and efficiently without having to interact directly with the real environment. Students must have the ability to surf in cyberspace, with valid and trusted sources, the ability to use various digital applications as learning resources, so that students can gain sufficient knowledge. This ability is known as digital literacy ability. The ability to gain good knowledge without having to interact directly with real objects or environments. However, during the transition period of hybrid learning with digital-based learning designs, there are still shortcomings in various aspects. Environmental knowledge learning that should be provided in real environmental conditions must be presented digitally. The lecturer directs students to obtain various information from digital sources related to learning environmental knowledge, but it is not yet in line with the students' abilities, given the provision of digital literacy capability (Cole & Feng, 2015; Rizaldi et al., 2020). Lecturers are limited in presenting or delivering learning materials from digital sources that can facilitate students in learning environmental knowledge digitally that represents real environmental conditions.

Digital literacy is a form of ability to obtain, understand and use information originating from various sources in digital form. The research results showed that results revealed that digital literacy had significant effects on communication skills, research skills and confidence of the students and insignificant effect (Abbasi et al., 2018; Tratnik et al., 2024). The capability digital literacy instrument has been effectively used to measure and predict student learning outcomes (Ervianti & R., 2023; Lukitasari et al., 2022). The research results show that there is a significant influence between digital literacy on the choice of learning media for social studies teachers. The findings of the research provide insight for educators in their task of increasing digital literacy not only in society but also among students (Samani et al., 2020; Triawang & Kurniawan, 2021). Meanwhile, for digital literacy the variables are not much different from metacognitive skills which are dominated by students with high category digital literacy capability. Digital literacy has a direct effect on core competencies and learning strategies have an indirect effect on the influence of digital literacy on core competencies. Digital literacy can increase the effect of core competencies when mediating learning strategies (Anthonysamy et al., 2020; Kim, 2019; Sukarno & Widdah, 2020).

According to previous study the industrial revolution is defined as emphasizing the element of speed in the availability of information, namely an industrial environment where all entities can always be connected and able to share information easily with each other (Schwab, 2019). Online lectures are a learning system that can be done anytime and anywhere by utilizing information technology via smartphones, gadgets, or laptops and the internet. Lecturers no longer have to go to conventional classes and no longer worry about students being late in learning. Online lectures can also provide a solution for universities that have a large number of students but do not have adequate or insufficient classrooms to accommodate students to carry out the teaching and learning process (Priyambudi & Murdani, 2020; Suprianto et al., 2020). The industrial revolution 4.0 is here to provide a new face to the world of education. Educational development is now placing more emphasis on creating a generation that is not only competent in terms of knowledge, but also a generation that has strong skills and will also be technologically literate. So that education can produce human resources who are skilled and have the ability to adapt to technological advances. This is one of the foundations for the emergence of 21st century education (Chai & Kong, 2017; Ritonga et al., 2021).

The influence of digital literacy in learning in the era of industrial society 4.0 is important to carry out research, so that it can become input material for stakeholders, policy makers and lecturers in designing environmental knowledge learning by paying attention to the digital literacy abilities of students in the FMIPA

Mathematics Education study program at Indraprasta PGRI University who are currently taking environmental education courses. The novelty of this research includes digital literacy capability and their relationship to learning environmental knowledge, which has not yet been carried out much study and research. An environmental knowledge instrument was developed which is useful for knowing the extent of environmental knowledge that students have. Research on digital literacy and its influence on environmental knowledge is important to carry out during the transition period when hybrid learning is implemented, as a consideration for lecturers in designing digital learning that is able to facilitate students in learning about the environment in the digital era. The findings from this research can be used as a reference and input for policy makers in implementing hybrid learning, equipping students with digital literacy capability, preparing infrastructure, including digital materials and resources that can be easily accessed by students. This research aims to analyze the influence of students' digital literacy capabilities on environmental knowledge, and determine the map of digital literacy abilities of mathematics education study program students, FMIPA, Indraprasta PGRI University.

2. METHOD

The research uses a quantitative approach, survey method with simple regression analysis techniques. The research sample was mathematics education students in the even semester of the 2022/2023 academic year, 50 Mathematics Education students from FMIPA, Indraprasta University PGRI who were chosen randomly. The data collection technique uses a questionnaire to measure digital literacy with 23 statements developed or modification, digital literacy instrument that show in [Tabel 1](#), which has been tested for the validity and reliability of the instrument on 20 respondents.

Tabel 1. Grids for Digital Literacy Questionnaire.

Dimension	Indicator
Information and Data Literacy	1. Able to access, filter, download and store data, information, content 2. Able to access various digital media using the device 3. Able to direct the search for data, information, content according to needs
Critical thinking	1. Able to find out the truth of data, information and content 2. Able to compare various sources 3. Able to obtain, process and understand material in the LMS
Using technology	1. Able to use digital devices, internet access, modem and wifi 2. Able to use digital applications, computer programs and software
Communicate	1. Able to write or convey questions, responses or answers 2. Write opinions/opinions or responses on digital media
Security	1. Able to back up data 2. Able to use antivirus 3. Able to create password

The results of the instrument reliability test obtained a fairly high reliability coefficient, namely 0.96. Thus, digital literacy instruments can be used to collect data on student digital literacy abilities from predetermined respondents. Test instrument in the form of multiple choice questions with 30 questions to collect environmental knowledge data which has been tested for the validity and reliability of the instrument on 28 respondents. The following dimensions are used in the environmental knowledge instrument, as presented in [Table 2](#).

Tabel 2. Grids for Environmental Knowledge Tes.

Dimension	Indicator
Water	1. Water quality suitable for consumption 2. Electrical conductivity/water conductivity
Air	1. Types of air purifiers 2. Air pressure 3. Positive impact of wind 4. Air pollution 5. Environmental acoustics
Land	1. Soil properties 2. The effect of fertilizer use on nutrients 3. Capillarity phenomenon
Voice/Sound	Sound intensity

Dimension	Indicator
Weather	1. Rainfall 2. Air pressure difference
Waste	Reuse, recycle, & reduce
Natural Disaster	1. Organic and inorganic waste 2. Negative impact of using CFC gas 3. Global Warming 4. Earthquake
Renewable energy	1. Reuse, recycle and reduce relate to energy 2. Environmental sustainability 3. Renewable energy

The results of the instrument reliability test obtained a fairly high reliability coefficient, namely 0,89. Thus, environmental knowledge instruments can be used to collect data on student digital literacy abilities from predetermined respondents. Data analysis includes descriptive statistics to determine the distribution and concentration of data, as well as inferential analysis to test hypotheses, after going through a series of analysis requirements tests including: (1) normality test with Kolmogorov Smirnov, (2) regression linearity test, and (3) multicollinearity test. Meanwhile, test the hypothesis using regression.

3. RESULT AND DISCUSSION

Result

Descriptive Statistics

The data in this research includes descriptive data on student Digital Literacy variables and descriptive statistical data on Environmental Knowledge. The average student environmental knowledge score is 22.5 from a maximum score of 30 using the test, with a standard deviation of 4.39, while digital literacy achieved an average score of 98.7 from a total score of 125 using the questionnaire, with a standard deviation of 20.6. This parameter provides little information that shows students' digital literacy capability and environmental knowledge are good enough.

Analysis Requirements Testing

Testing of data analysis requirements in this research includes normality tests, regression linearity tests, and multicollinearity tests with assistance software IBM SPSS Statistic 22. The results of the analysis requirements testing is show in [Table 3](#).

Table 3. Analysis Requirements Testing.

No.	Requirements Analysis Tes	Parameter	Conclusion
1.	Normality	$L_{count} = 0.07 < L_{table} = 0.19$	Normal
2.	Linear Regression	$F_{count} = 1.72 < F_{table} = 2.14$	Linear
3.	Multicolinearity	$VIF = 1.0 > 1.0$	No multicollinearity

The data normality test uses a regression estimate error test with the Kolmogorov-Smirnov technique, as presented in [Table 3](#). The results of the normality test for environmental knowledge score data on digital literacy show a significance index of $0.20 > 0.05$, thus the regression estimate error data comes from a normally distributed sample. This result is strengthened by the Lilliefors index which is 0.07 below , with , at the significance level . With the results of the morality test, testing of the analysis requirements was continued with the regression linearity test.

Regression Linearity Test

The linearity test is carried out to determine whether the independent variable X and dependent variable Y are linear in the regression analysis technique. The results of linearity testing in this research are as presented in [Table 3](#). In the linearity test of the simple linear regression equation, the calculation results show the $F_{count} = 1.724$ while at the level $\alpha = 0.05$, the F_{value} is obtained table = 2.142. Because $F_{count} = 1.724 < 2.142 F_{table} 0.05;31;17$ then the simple linear regression equation model between digital literacy and environmental knowledge is acceptable. In other words, the relationship between digital literacy (X) and environmental knowledge (Y) has a linear pattern. Thus the regression model can be used to predict an increase in Environmental Knowledge. Increasing self-efficacy scores provides increased Environmental Knowledge scores. The linearity of the relationship between digital literacy (X) and environmental knowledge (Y) is depicted in the graph presented in the following [Figure 1](#).

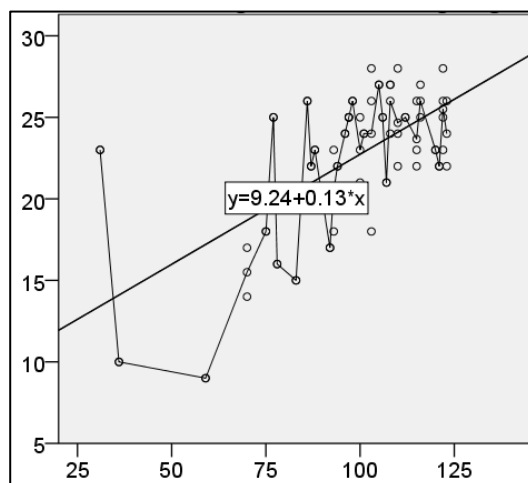


Figure 1. Linearity Graph of the Relationship between Digital Literacy (X) and Environmental Knowledge (Y)

Base on [Figure 1](#), the multicollinearity test aims to determine whether there is an intersection between the independent variables. In regression analysis, it is required that there is no relationship between the independent variables. Multicollinearity does not occur, that the tolerance value for each digital literacy variable ($1.0 > 0.1$), and the value VIF for each variable $1.0 > 0.1$, based on these results, thus the data from the variables does not occur multicollinearity.

Hypothesis Test

In this research, there are 3 hypotheses which are tested using SPSS IBM Statistics 22 computer assistance. Hypothesis testing uses simple regression, the data used in this research is digital literacy (X) and environmental knowledge (Y). After the data obtained from the field has been processed and has gone through various required tests, the next stage in testing the causality model is to carry out regression. Based on the causality model that was formed theoretically, a path analysis diagram was obtained and then the coefficient values for each path were calculated. The first step presents the correlation coefficients between variables, the influence of digital literacy on environmental knowledge has a correlation coefficient of 0.632, as seen in the calculation results using SPSS, with a significance of $0.00 < 0.05$, which means significant. Based on the table above, it can be seen that the correlation coefficient for the influence of the digital literacy variable on Environmental Knowledge is 0.632. From these calculations it was found that the correlation between digital literacy and environmental knowledge was significant $\alpha = 0.05$. The results of calculating the linearity of the regression of the relationship between the digital literacy variable and environmental knowledge obtained a regression equation $\hat{Y} = 9.239 + 0.135X$. This equation shows a positive relationship between digital literacy and environmental knowledge. Statistical hypothesis $H_0 : \beta = 0$, and $H_1 : \beta \neq 0$, with rejection H_0 parameter if $F_{count} > F_{table}$. Based on the table above $F_{count} = 31.973$ with the values $sig = 0.00$ and thus the values $sig < 0.05$ and $F_{count} > F_{table}$, then H_0 it is rejected, meaning H_1 it is accepted. This means that it is proven that there is a significant influence of digital literacy variables on environmental knowledge. There is a positive influence of digital literacy on environmental knowledge.

Discussion

The development of the industrial era 4.0 makes it easier for students to meet their knowledge needs, students do not need to bring books, because ebooks are available, they only need the ability to search and process information on Google, Wikipedia, and so on. The lecturer's role is to direct, guide and provide tools that students can use from valid and trusted sources. The process of change towards digital transformation of higher education is a complex process ([Anggoro et al., 2023](#); [Giang et al., 2021](#)). Learning in the digital era is increasingly flexible, students can manage their learning independently. This research aims to find and empirically analyze the influence of digital literacy on environmental knowledge for mathematics education students who take part in environmental knowledge learning. Ideal learning of the industrial era 4.0 was oriented to students' ability to solve problems, think critically, collaborate, communicate, be creative, and be innovative by using digital technology as a work tool. Educators need to prepare an attractive presentation of learning material with an attractive design ([Hermanto & Srimulyani, 2021](#); [Shopova, 2014](#)). Teachers' characteristics such as educational level, age, gender, educational experience and digital literacy for educational purposes can influence the adoption of an innovation in teaching ([Adeoye, 2023](#); [Vieira et al., 2019](#)). The industrial era 4.0 has an impact

on digital transformation, bringing convenience to students by digitizing electronic-based learning, more flexibility, independent learning to train skills solution problems, collaboration, creativity, critical thinking, and skills communication. This encourages innovation in learning, especially learning environmental knowledge.

The results of hypothesis testing show that there is a positive influence of digital literacy on environmental knowledge. The coefficient of determination is 0.40 with a percentage of 40.0% indicating that the large contribution of digital literacy to environmental knowledge, the remaining 60.0% is due to the influence of other factors. In the era of digital learning, environmental knowledge as learning achievement can be influenced by digital literacy, as research results state that there is a total influence of digital literacy on learning achievement (Pagani et al., 2016; Soeprijanto et al., 2022). The findings reveal highly significant positive associations between internet access/use and environmental knowledge (Cheng, 2023). The results of other research state that the application of digital literacy also has a positive and significant effect on students' science learning outcomes (Akhyar et al., 2021; Brata et al., 2022; Puniatmaja et al., 2024). So it can be stated that there has been a significant increase in student learning outcome scores using the hybrid or blended learning model. The implementation of hybrid learning has a significant increase in education settings (Basyoni et al., 2020; Winarni et al., 2022). The results of multiple linear regression tests show that digital literacy and risk internet behavior simultaneously have a significant effect on science learning achievement, with a contribution of 9.4%. And the results of a simple linear regression test show that digital literacy does not have a substantial effect on science learning achievement. Implementing digital literacy in coastal areas has only reached 45% in the learning process (Hajar et al., 2022; Romadhianti et al., 2021). Results from surveys and focus groups were analyzed to identify students' access to and use of digital technology, to better understand how their academic success can be enhanced through the development of digital literacy. This study identified a disconnect between students' perceptions of their digital capabilities and institutional requirements for learning (Ahmed & Roche, 2021; Elphick, 2018). Digital literacy has a positive influence and impact on the learning process, learning achievements and learning outcomes, as well as academic success in implementing hybrid learning. Students with good digital literacy capability have good environmental knowledge. Students perception and adapting their technological literacy has an impact on their digital literacy capabilities.

Digital awareness and literacy are very important to be matured as the initial foundation for mastering digital technology well. Perceptions of digital literacy can change over time as technology develops. Research results may become outdated as new technologies emerge or changes in digital literacy trends (Astuti et al., 2021; Sudana et al., 2023). Research findings reveal that the problem-solving competency area is considered the most important for student learning performance, followed by information and data literacy, and communication and collaboration (Chaw & Meng Tang, 2020). Digital literacy and collaboration skills provide a perfect or very strong correlation to environmental literacy (Nurjannah et al., 2023; Tang & Chaw, 2016). The research results show that student teachers have a good perception of utilizing digital literacy as a learning resource. Indicators of basic information and communication technology skills are in the high category, indicators of information skills are in the very high category, indicators of media awareness are in the high category, and indicators of computational thinking are in the quite high category (Darmaji et al., 2023; Rusydiyah et al., 2020). Using digital literacy helps students to take advantage of technology in improving science process skills so that in this study they learn how much influence digital literacy has on science skills, including environment knowledge. Digital literacy capability are seen as metacognitive abilities, which are characterized by abilities such as information and data literacy capability, communication, collaboration, problem solving, and science process skills needed in environmental literacy atau environmental knowledge.

Digital literacy encourages students to adapt designs and innovate in learning environmental knowledge. The research results show that environmental knowledge learning carried out using the problem based instruction model can increase students' environmental awareness and ability to solve problems (Khanafiyah & Yulianti, 2013). Digital literacy is the ability to understand and use various forms of information from variety of sources accessed through information and communication technology by having social skill, learning ability, and having critical thinking, creative and inspirational attitudes (Fitroh et al., 2024; Spante et al., 2018). The results of this study are in line with previous research. Implementing e-learning for student learning can affect students' digital literacy capability and will also affect student behavior in the use of digital information (Bintoro & Winarsih, 2022; Dewi, 2022; Prior et al., 2016). The rise of the internet and the emergence of new digital devices require information users for information needs, access information effectively and efficiently, applies information, and use information effectively and efficiently. Environmental knowledge learning is designed in such a way that students still have awareness of the environment, critical thinking, problem solving, and learning presented on a digital basis, continues to provide inspiration and creativity for students supported by the ability to understand and use digital information, so that learning can be effective and efficient.

These specific digital literacy dimensions are determined by the software applications students use and capture similarities among students' performance caused by their familiarity with the assessment tool and context. The design of a digital literacy assessment is discussed based on these findings, with particular emphasis on the

influence of the nature of the digital application and environment used in the assessment on the measured digital literacy achievement scores (Reichert et al., 2023). One method of improving the quality of environmental education in higher education is the use of research learning methods and problem learning methods. The scientific level of the content of the discipline is ensured by providing students with the opportunity for independent study and choosing methods for ecological assessment of the state of ecosystems (Aydoğan, 2022; Fomina, 2020; Sanova et al., 2022). It can be concluded that there is a strong level of correlation and has a simultaneous and partial influence between digital literacy and students' self-directed learning on the use of e-modules in evaluating course learning processes and outcomes.

Usee-module can make it easier for students to learn and can increase independent learning in students. In order to ensure that the provenance of digital data and information is held accountable from scientific design to implementation science, whether they relate to academic or Industry 4.0 paradigms of innovation, there is an increasing need to guide digital transformation toward critically informed digital citizenship. Environmental knowledge learning paradigm in the industrial era 4.0 in higher education by providing digital literacy capability, including data and information literacy, use of technology, communication, critical thinking, including digital security. Opportunities and challenges for learning environmental knowledge in the digital era include providing digital sources of e-books, e-modules and various applications that can help students learn and improve learning outcomes.

4. CONCLUSION

Based on the results of research and discussion, it can be concluded that digital literacy can influence environmental knowledge. Hybrid learning of environmental knowledge requires digital literacy capability. The research results show that digital literacy has a positive influence on environmental knowledge. The higher a student's digital literacy, the higher their environmental knowledge, the rest were other factors that were not examined in the research. The findings state that digital literacy capability contribute 40% to environmental knowledge. Environmental knowledge learning can be improved by strengthening students' digital literacy so they can follow the flow of implementing hybrid learning. The results of this research have implications for strengthening students' digital literacy, as well as digitizing environmental knowledge learning. This can encourage students' digital literacy capability.

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