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Eco-Digital Pedagogy: Current Situation and Its Solution to Enhance Pre-Service Teachers' Pedagogical Competence

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Abstract: Eco-Digital Pedagogy: Current Situation and Its Solution to Enhance Pre-Service Teachers' Pedagogical Competence. Objective: This study aims to: 1) explore the existing model implemented in the classroom related to pedagogical learning, the use of technology, and environment-based learning; and 2) propose eco-digital pedagogy to improve the competence of 21st-century pre-service (trainee) teachers. **Methods:** This study was qualitative with didactical research design, focusing on the analysis of the implementation of pedagogical courses at the Geography Education Study Program at Universitas Negeri Semarang (UNNES). The subjects of this research were selected using a purposive technique and consist of twelve students who had completed pedagogical courses. Primary data, collected from interviews, were then complemented with secondary data from previous research, books, and online articles related to implementing eco-pedagogy and digital pedagogy. **Findings:** The results indicate that pedagogical skills learning, technology utilization, and environment-based learning have been applied, but the intensity, variety of methods, and comprehension are relatively low. Lecturers often underutilize technology as an educational tool and do not fully comprehend the ecological principles underpinning sustainable development. Technology adaptation is limited to the use of LMS, while eco-related materials are minor and not practicable. This condition requires improvement, one of which is through eco-digital pedagogy, a combination based on digitalization and awareness of ecology. It can be implemented through several steps: 1) designing a suitable curriculum, 2) providing adequate facilities, 3) increasing hands-on practice with real and relevant situations, 4) enriching pedagogical learning methods, and 5) utilizing platforms or digital media as a teaching space and a campaign for promoting environmental awareness. **Conclusion:** Digital and eco-related learnings are found to be minimally implemented, thus the learning outputs are not optimal. Eco-digital pedagogy can be applied to enhance the learning quality of pedagogical courses.

Keywords: eco-digital pedagogy, geography trainee teacher, 21st century.

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■ INTRODUCTION

In the 21st century, the world is increasingly interconnected, facing unprecedented problems and situations that most humans have never anticipated (Maker, 2021). The 21st century has brought advanced technologies, leading to more intense globalization. Currently, we are on the cusp of the Fourth Industrial Revolution, and various sectors of life are now surrounded by highly sophisticated technology (Hariyanto, 2019;

Sidi, 2013). The profound changes brought about by the Fourth Industrial Revolution have compelled all aspects of life to adapt to technology, including the education sector. The Fourth Industrial Revolution has introduced new challenges for the teaching-learning process (Molla, Yayeh, & Bisaw, 2022). Schools, colleges, and other educational institutions are now required to develop curricula that align with the skills, character, and competencies of the present century.

The Partnership for 21st Century Learning (Ohio Department of Education, 2016) has developed a framework for 21st-century skills that learners should master, including: (1) key subjects, (2) innovation and learning skills, (3) information, media and technology skills, and (4) life and career skills. In the 21st century, geography skills play a fundamental role, encompassing the learning and understanding of environmental, social, cultural, economic, and political issues in the era of globalization (Reinfried & Hertig, 2012). Geography is a complex discipline, and with its multidisciplinary approach, it encourages a unique learning process. Learning geography is a creative process that can inspire curiosity about the world, particularly regarding nature (Markuszewska, Tanskanen, & Subiros, 2018).

The urgency of geography has escalated exponentially in the 21st century due to the high environmental problems and the need for sustainable development. Geography is inseparable from the principle of sustainability because it includes three critical aspects: a comprehensive understanding of geographic space, the ability to analyze geographic space, and respect and a sense of responsibility toward geographic space (Palacios et al., 2017). Geography, as a system science, connects nature with the environment and various policies, serving as a crucial starting point for integrating multiple disciplines in development, underscoring the urgency of geography in sustainable development (Peng et al., 2020; Qiu, 2017). Geography also holds a strategic and central position in education for sustainable development (Grindsted, 2013; Grindsted, 2014; Haubrich, Reinfried, & Schleicher, 2007; Yli-Panula, Jeronen, & Lemmetty, 2020). Guo et al. (2018) also pointed out that geography offers a suitable context to explore students' experiences of sustainable development.

In line with its urgency, 21st-century geography learning must guide students to approach and solve problems from a geographic and spatial perspective. Innovative learning is essential to empower students to be active, critical, and communicative in addressing issues aligned with 21st-century geography learning objectives (Silviariza, Sumarmi, & Handoyo, 2020). Akbulut (2004) further emphasized the urgent need for an environment that supports creative thinking processes and creates a student-centered learning environment through active learning in geography education. Markuszewska, Tanskanen, & Subiros (2018) added that in this 21st-century era, geography learning should no longer be traditional and textbook-based.

Alim & Altas (2005) stressed that the success of high school geography education depends significantly on the application of effective geography learning methods, the efficient use of various materials and media, and technology in the classroom. However, some previous studies have shown that geography learning still faces various problems and challenges, such as many teachers continuing to use a lecture-centered approach in geography education (Artvinli, 2010). Geography learning also frequently relies on a teacher-centered approach that renders the learning experience passive (Elton, 2011). These issues are compounded by the low ability of geography teachers to implement innovative learning effectively (Paradis & Dexter, 2007).

In this context, teachers are expected to update their competencies to meet 21st-century

challenges and modify their teaching strategies to empower 21st-century students (Caena & Redecker, 2019). Teachers play a pivotal role in driving change in schools. While no curriculum possesses magical powers, the magic in education resides in teachers and students (DeMitchell & Fossey, 1997). Therefore, given that today's students, belonging to Generation Z, require teachers who can adeptly harness modern technology, the core curriculum should underscore the importance of using technology in geography education, including GIS technology. In keeping with the prevalence of technology in daily life, technology must also be integrated into students' education and development (Piotrowska et al., 2019; Utami, Zain, & Sumarmi, 2018).

To develop competent teachers for the 21st century, teacher education and training programs must incorporate 21st-century skills into the curriculum. Education should focus on technological, pedagogical, and disciplinary elements through new approaches and methodologies to foster 21st-century skills in students (Gonzalez-Perez & Ramirez-Montoya, 2022). The findings from Alotaibi's study (2022) highlight that forming proactive teachers in the 21st century can be achieved through the professional development of pre-service teachers, which includes pedagogical approaches, technology-based 21st-century learning, and the enhancement of experience, competence, and proficiency in 21st-century skills.

Improving pedagogical skills in teacher professional development is essential, given that several studies have shown relatively low levels of teachers' pedagogical skills (Rosali, 2019). Furthermore, a study conducted by Izzati (2016) also assessed the teaching abilities of Geography Education students, revealing that the students' abilities were moderate, with a score of 56.97. Research by Hartono (2015) also indicated that many educational students still lack adequate teaching competence, as evidenced by a score of 6.42, indicating they are less prepared in this regard. Top of Form

To address the aforementioned challenges in 21st-century geography learning, digital pedagogy can be considered one of the strategic alternatives to produce competent teachers and foster innovative geography learning. Digital pedagogy learning is an initiative aimed at enhancing teachers' knowledge and competence through a learning process that centers on problem-solving and the development of higher-order thinking skills, all while making effective use of information technology (Milton & Vozzo, 2013).

Digital pedagogy has become an essential element in education today. The findings from research conducted by Haugsbakken, Nykvist, & Lysne (2019) indicate that, despite the widespread adoption of digital or online learning, many teachers tend to prioritize technological aspects while sometimes neglecting the significance of pedagogical aspects. However, changes in the learning process should ideally be accompanied by a shift in the pedagogical paradigm. In other words, the role of technology in learning should be integrated to transform teaching from traditional and conventional student-centered and collaborative approach (Prakash, 2014).

In addition to digitalization in the 21st century, along with geography's role in sustainable development, pedagogical learning must aim to inspire students to comprehend sustainable development, which includes fostering an awareness and love for the environment through an ecopedagogical perspective. Students should understand these concepts and possess the capacity to address environmental issues (Razak et al., 2017). Education for sustainable development can be effectively achieved through eco-education-based approaches, as supported

by research conducted by Sumarmi, Aliman, & Mutia (2021).

Eco-pedagogy teaches students to understand and appreciate nature as well as the impact of human activities on the environment, thereby fostering greater responsibility in maintaining environmental sustainability (Wardhani et al., 2022). By instilling the values of eco-pedagogy, geography education can contribute to sustainable development by preparing a generation that is aware of the importance of preserving the balance between natural and social systems (Sulaswari et al., 2023). In the context of classroom teaching, teachers who participate in eco-pedagogy training show improvements in environmental education concepts and higher-order thinking skills, which positively affect the dynamics of learning (Asli et al., 2024).

The potential of digital technology combined with eco-pedagogy in learning is substantial; however, many have yet to implement it optimally, including the Geography Education Study Program at Universitas Negeri Semarang (UNNES). Environmental issues are often treated merely as supplementary material rather than as a main thematic framework integrated across various courses. These issues are also presented abstractly, without contextualization, and there is no emphasis on accessing concrete information and data about environmental issues through digital technology. The digital technology currently used is still basic, limited to Learning Management Systems (LMS) for sharing materials and assignments or visual media through PowerPoint slides. Additionally, the fragmentation of courses results in environmental issue-based learning with technology not being systematically integrated.

This situation is clearly not ideal, considering the increasing severity of environmental degradation. Up-to-date environmental issues must be raised to be more adaptive to global challenges, and this requires digital technology as

a tool. Environmental problems must be viewed concretely and data-based to obtain a more factual and scientific picture. Addressing environmental issues can be done using advanced data and tools such as Geographic Information Systems (GIS) and the Internet of Things (IoT). Therefore, an active and participatory pedagogical approach within a digital framework based on environmental awareness is urgently needed. We expect digital and eco-pedagogy to contribute to enhancing geography students' awareness-as they will later become teachers themselves.

This study addresses two main questions: 1) What is the current condition of the implementation of pedagogical learning, technology utilization, and environment-based learning among prospective geography teachers at UNNES? and 2) How can an eco-digital pedagogy model be proposed as a solution to improve the pedagogical competence of 21st-century prospective geography teachers?

■ METHOD
Research Methodology

This study was qualitative with didactical research design, focusing on the analysis of the implementation of pedagogical courses at the Geography Education Study Program at Universitas Negeri Semarang (UNNES). It subsequently proposes the importance of the eco-digital pedagogy model to enhance the competence of 21st-century geography teachers. The curriculum documents of the department revealed that several pedagogical courses were designed to prepare Geography Education students as pre-service teachers. These courses include (1) Geography Curriculum Review, (2) Geography Learning Planning, (3) Geography Learning Strategy, (4) Digital Geography Teaching Material Development, (5) Geography Learning Resources and Media, (6) Geography Learning Evaluation, (7) Classroom Action Research, and (8) Microteaching.

Research Subjects

The subjects of this research were selected using a purposive technique and consist of twelve students in the Geography Education Study Program at UNNES who had completed pedagogical courses to provide comprehensive and accurate information. Subjects were selected from 8th and 10th-semester students, and the number of subjects was determined based on reaching data saturation, where further interviews did not yield significantly new insights, and the subsequent respondents' answers only confirmed the main themes previously identified. Therefore, the interviews were deemed sufficient to collect valid data and could proceed to the data analysis process. After conducting interviews, ten participants were selected, each identified by a P code.

Instruments

The instrument utilized in this study is an interview guideline. All interviews were conducted structurally, so they needed a set of questions. The guideline leads the researchers on the determined aspects and checklists them during the interview. Several essential aspects investigated here are 1) pedagogical skill development, 2) the use of digital technology in teaching and learning, and 3) environmental-based learning in their teaching practices. In this study, the data validity was tested through source triangulation by comparing all information from interviewees (subjects).

Some examples of key interview questions related to the development of pedagogical skills include: (1) What pedagogical courses are offered to prospective geography teachers?; (2) How are the current pedagogical lectures conducted? Are they effective? Are students given opportunities to actively and participatively develop their pedagogical competencies?; (3) What teaching methods are used by the lecturers?

Some examples of key interview questions related to the use of digital technology in teaching include: (1) What types of digital technology are used in the learning process, and has their use been optimized?; (2) How proficient are the lecturers in using digital technology?; (3) Have digital technologies such as GIS, remote sensing, audiovisual tools, and artificial intelligence been effectively integrated into teaching?

Meanwhile, interview questions related to eco-pedagogy include: (1) How do lecturers incorporate environmental content into geography instruction?; (2) What environmental issues are utilized in the learning process? Are they contextual and data-driven?; (3) Are environmental issues discussed with a focus on knowledge formation or character development?

Data Collection and Analysis

This research utilized both primary and secondary data sources. Primary data was collected through interviews. The interview data were then complemented with secondary data from previous research, books, and online articles related to implementing eco-pedagogy and digital pedagogy. Following data collection, the analysis was conducted using interactive analysis techniques based on the model by Miles and Huberman (1992). The interactive analysis process consisted of three main components: data reduction, data presentation, and drawing conclusions or verification. Data reduction was carried out by organizing and reviewing the interview transcripts to identify an overall picture of the interviews. Subsequently, initial coding was conducted to mark relevant excerpts of sentences or paragraphs, followed by categorizing similar codes. Several key points identified and grouped included: (1) insufficient pedagogical skills, (2) insufficient opportunities to practice, (3) suboptimal use of digital technology, (4) lack of innovative technology in the classroom (outdated technologies), and (5) lack of contextual learning. Afterward, the researcher presented the results of the coding and categorization in a simple table and then drew conclusions.

Ethical Clearance

The researchers have gained permission from Universitas Negeri Semarang (UNNES) to collect data, process data, and publish the results of the study. The permission was proposed through an official letter to the campus. Researchers have also collected permission from subjects/interviewees to carry out the interviews and publish them.

■ RESULT AND DISCUSSION

Examining the Current Situation in the Classroom

According to the Law of the Republic of Indonesia Number 14 of 2005 on Teachers and Lecturers, professional teachers must possess four main competencies to achieve educational and learning goals, namely professional, pedagogical, personality, and social. Professional competence for prospective geography teachers is accomplished through various scientific subjects in geography, such as physical, human, and technical geographies. Learning them typically takes place through classroom lectures, often supplemented with laboratory work and real-world field activities. These courses are designed to equip pre-service teachers with a solid foundation in geography, which they can later impart to their students.

The formation of pedagogical competence for pre-service teachers is achieved through pedagogical courses conducted in a classroom. These pedagogical courses aim to empower pre-service teachers with learning management, which includes understanding educational principles, student needs, curriculum development, learning design, implementing effective and dialogical teaching methods, utilizing educational technology, assessing learning outcomes, and helping students realize their various potentials. The UNNES Geography Education Study Program offers a range of pedagogical courses, including: (1) Geography Curriculum Review, (2) Geography Learning Planning, (3) Geography

Learning Strategies, (4) Digital Geography Teaching Material Development, (5) Geography Learning Resources and Media, (6) Geography Learning Evaluation, (7) Classroom Action Research, and (8) Microteaching.

Interviews conducted with students revealed that, of the eight pedagogical courses they are required to take, they often feel the courses are insufficient to give future pedagogical skills. They need more pedagogical courses to provide higher opportunities. Typically, these pedagogical courses are introduced in the third semester, with one to two courses offered on average. Furthermore, not all lecturers place a strong emphasis in developing pedagogical skills. Pedagogy is primarily just focused on the implementation of microteaching courses, which only carry 2 credits.

In addition to course credits, the effectiveness of pedagogical courses must be inclined. Students feel that the pedagogical lectures, as they stand, are often more theoretical instead of practical at the same time. Lecturers do not always provide opportunities for students to apply the theory. This misalignment suggests a desire for a more practice-oriented approach.

"The development of students' pedagogical skills is currently insufficient as the opportunity is limited to microteaching courses, resulting in relatively slow progress. As a future educator, I strongly prefer a hands-on, practice-based learning approach over theoretical instruction." (P1)

"The lecturer delivers the material and provides practical examples. However, the pedagogical skills offered are still non-optimal, leaving students, including myself, with a deficit in this area. It would be great to integrate activities aimed at enhancing pedagogical skills into the learning process." (P2)

Both statements emphasize the importance of prioritizing direct practice over theory in the development of pedagogical skills. As prospective teachers, students who are provided

with more opportunities for hands-on practice tend to develop different abilities compared to those who mainly consume theoretical content. Prospective teachers who become accustomed to direct practice are often better equipped to master their field, adapt to various situations, and understand the social context necessary for effective and adaptive teaching. Conversely, students who rely primarily on theoretical knowledge may find themselves less prepared and confident.

"The lecture system in geography education falls short in terms of facilitating pedagogical skills. Most lecturers have yet to incorporate the concept of geographical skills into their standard courses, which should be a fundamental competency for all prospective teachers." (P3)

The interviews with the students emphasized the crucial need for pedagogical skills to prepare them as well-prepared teachers. They stressed the importance of intensifying the learning system, shifting the focus from theoretical knowledge alone to the practical ability to effectively manage student learning activities.

The interviewees were clear in their desire to integrate pedagogical skills as a fundamental aspect in all courses. They believe that this approach is essential to ensure that the teaching and learning process between lecturers and students is not solely centered on understanding geography content but also emphasizes the development of skills for effectively managing student activities. They identified a current imbalance within the classroom learning process, where there is an excessive focus on understanding subject matter content while pedagogical skills receive insufficient attention. They highlighted that practical activities aimed at enhancing pedagogical skills can be incorporated into various courses beyond microteaching with teaching practice. For instance, they suggested that teaching practice could also be integrated into learning strategy courses. In other pedagogical courses, students can engage in practical activities through project-based learning. This approach would require students to create a variety of products in alignment with their course requirements, such as developing digital learning media or crafting teaching tools.

Pedagogical competence remains a significant challenge for prospective geography teachers and must be continuously developed. Several other studies have also indicated that pedagogical skills are often a weakness among pre-service teachers compared to other teaching competencies. For instance, a study by Ammoneit et al. (2022) revealed that prospective geography teachers felt most confident in their content knowledge as well as their social and personal competencies, but least confident in their pedagogical knowledge. However, other research has shown that prospective geography teachers are capable of connecting pedagogical theory with practice, particularly in terms of pedagogical content knowledge (PCK) (Reitano & Harte, 2016).

The issue of a gap between theoretical learning and practical teaching is also highlighted in other studies. The lack of seamless integration between theory and practice is particularly prominent, resulting in the relatively weak adaptability of prospective geography teachers in real educational settings (Wan & Cai, 2020). Wan & Cai (2020) also pointed out several similar obstacles, including limited practical opportunities, the absence of effective guidance in teaching practicums, and the overly theoretical nature of some current practicum content, which makes it difficult to reflect actual teaching situations in primary and secondary school geography classrooms. Other identified challenges include a lack of innovative awareness in instructional design among some pre-service geography teachers, making it difficult for them to develop lesson plans aligned with subject development trends and student needs. Furthermore, a lack of awareness regarding student diversity also presents a challenge. In real classroom settings,

pre-service teachers may encounter students with varying needs and learning styles, and their limited awareness of modern technologies hinders the development of professional teaching skills among prospective geography teachers.

These conditions underscore the urgency of enhancing the pedagogical abilities of prospective geography teachers, particularly concerning their currently low awareness and capability in integrating technology. This is because pedagogical skills and technological integration are two sides of the same coin—they are inseparable. Bashir & Jimmy (2023) stated that technological, pedagogical, and content knowledge significantly influence the readiness of pre-service teachers to integrate technology into classroom practice. Salas-Rueda (2019) also emphasized that teachers' pedagogical competence strengthens the integration of technology into classroom practices. Another researcher, Abebe (2021), further asserted that pedagogical knowledge affects the overall effectiveness of TPACK in prospective teachers.

The use of technology in learning within the UNNES Geography Education Study Program is still not optimal. This is indeed unfortunate, considering that technology in the current era is highly advanced and diverse, with specific tools designed for the field of education. Furthermore, the campus itself is a formal educational institution with the highest status and level, making it a model for other institutions. In reality, the department has yet to maximize its resources and facilities ideally. Lecturers tend to rely solely on Microsoft PowerPoint for their presentation materials, which is a well-known tool used everywhere, even though the campus staff can harness more innovative and effective technologies.

"It can be stated that the utilization of technology is still suboptimal. The presentation of materials is predominantly restricted to Microsoft PowerPoint, with not all lecturers employing this tool, particularly those of an older generation. Consequently, the learning process often appears monotonous, as most lecturers tend

to rely on Sikadu's Learning Management System (LMS) as an online-based learning platform. The lack of innovation is noticeable." (P4)

"The utilization of technology by lecturers is inadequate. Technology-based learning, which incorporates creative and innovative elements, is seldom employed, particularly when training prospective teacher students to create technology-based teaching materials like interactive games. Students typically acquire the skills to create technology-based interactive teaching materials through external training sessions or webinars outside the regular lecture process."

As future teachers, students feel that they have not been provided with qualified, innovative, or futuristic technology. Regrettably, the continued use of outdated technologies not only impacts the lack of interaction between lecturers and students but can also instill a mindset in these student teachers that innovation is unnecessary. They may believe that sticking to familiar old technologies is sufficient. This mindset is undoubtedly perilous because it can cause teacher and student competencies to lag behind their peers.

Hence, students are eager to create and employ more efficient and engaging teaching media, such as geography-themed games. Traditionally, games have been seen as potentially distracting students from their studies. However, it would be fascinating if educators could transform such media into effective learning tools rather than something that diminishes students' interest and learning abilities.

"Improvements in technology utilization in the classroom are necessary to enhance competency attainment. Innovation concerning the use of technology within the classroom remains minimal, primarily applied in a limited number of practice-based courses, especially those related to map-making and geographic information system analysis." (P6)

Based on the interviews, it is evident that most lecturers tend to conduct the learning process using basic technology and often fall into

monotony. This indicates that the role of technology does not dominate in the teaching and learning process, as seen in activities like uploading materials and collecting assignments, which tend to be repetitive and uninteresting.

There are only several additional technologies used in practice-based courses, including cartography, Geographic Information Systems (GIS), and remote sensing. In other courses, the use of technology is not prevalent. The technology employed is often one-way and lacks diversity, making the classroom learning experience eventually become dull.

The findings of this study align closely with several other studies, including those by Tondeur et al. (2012) and Masoumi (2021), which reported that many pre-service teachers felt unprepared to use technology in their future classrooms, indicating a clear gap between training and practical application. Similarly, Guo et al. (2020) identified several significant obstacles faced by pre-service teachers in integrating multimedia technology into environmental education (EE). These barriers included: (1) multimedia technology is perceived as useful for EE, but it is difficult to implement and is even considered neither the best method nor an urgent need for the realization of EE; (2) multimedia technology is highly effective in promoting EE learning, yet the application of GIS remains challenging; (3) pre-service teachers' multimedia literacy skills are in urgent need of improvement, particularly in terms of concrete application in classroom instruction; (4) it is necessary to strengthen competencies in using multimedia technology and GIS within teacher education programs, as well as to reinforce constructivist-based pedagogical training; and (5) teachers' positive attitudes toward the use of multimedia technology in environmental education are still suboptimal due to practical limitations, especially regarding technical skills and the use of GIS.

Several factors contribute to the lack of integration of innovative technology in geography teacher education. One key factor is that some lecturers, particularly senior ones, lack the skills and technological competence required and often struggle to adapt to technological disruption in the era of Industry 4.0. The lack of targeted training for senior lecturers also contributes to their limited technological proficiency. Moreover, courses related to digital technology especially GIS and remote sensing are often taught by lecturers who are not involved in pedagogical coursework, leading to a dichotomy between technological and pedagogical components. This finding is consistent with the study conducted by Aleksieva (2025), which highlights that there is a noticeable gap in policy and coordination between different course types-specifically, information and communication technology in teaching versus subject-specific methodologies-when it comes to equipping future teachers for digital transformation. Although teacher education programs at universities incorporate digital technologies to enhance learning outcomes, they frequently overlook the training of pre-service teachers in preparing students for the demands of the digital era. Yang et al. (2022) also emphasized that while ICT training does have an impact, it does not always translate into effective teaching practices.

The implementation of mastering digital technology in the learning process within the academic environment is an essential aspect that must be addressed. This is closely connected to the endeavor to introduce technological adaptation in the teaching and learning process for geography education students as future educators. The incorporation of digital technology during lectures can enhance students' comprehension and habits, consequently fostering valuable technology proficiency as a foundation for their future teaching and learning endeavors.

For prospective geography teachers, the ability to integrate technology into their teaching is essential and must be effectively supported and facilitated by universities. Unlike many other

professions, digital competence in teaching is complex and operates on two levels. First, teachers must be adept at using technology fluently, serving as role models for their students. Second, their digital skills must be pedagogically oriented, requiring ongoing didactic decisions about how digital tools can expand learning opportunities across different subjects. The preparedness of teachers to utilize digital technology in student learning is therefore crucial (Warsi & Rani, 2024).

The interview results also revealed that the enhancement of character development, particularly in terms of environmental consciousness, still requires attention. While efforts to instill these noble values have been made, they tend to be confined to Conservation Education and Environmental Geography courses. These two courses alone are insufficient, given that character development necessitates a sustained and intensive commitment.

In practice, the development and reinforcement of environmental care character also demand a contextual strategy. Environmental awareness extends beyond mere affection for the natural surroundings; it requires a comprehensive understanding of what should be avoided, prevented, penalized, and optimally implemented to maintain ecological balance. According to students, most lecturers in the study program primarily focus on delivering course content rigidly, rather than encouraging students to comprehend real-world environmental issues or devise solutions to address them. This situation is regrettable, as geography is a discipline closely aligned with the study of nature.

"The lecture has successfully conveyed the elements of character development related to environmental conservation. This has been implemented in courses like Conservation Education and Environmental Geography. However, there is still room for improvement, particularly in the integration of contextual-based learning that addresses environmental issues in daily life." (P7)

"Based on a comprehensive study, Geography Education encompasses all aspects of human life, ranging from physical and social entities to the natural environment. However, in the process of teaching, there is a deficiency in efforts to nurture an environmental character. This situation may be attributed to the unfortunate lack of contextual learning opportunities related to environmental issues."

"To date, the concept of environmental care has not been integrated into every course within our department. This value has only been emphasized in the Conservation Education course during the first semester so that environmental sustainability issues are not consistently reinforced." (P9)

Based on the interviews, materials related to environmental awareness must be more relevant to the societal reality. Unfortunately, students often do not find the relevance, contextualization, or emphasis on sustainability in the course materials. Lecturers tend to present the material as is, without incorporating the actual conditions that manifest as issues in the social and natural environment that students will ultimately encounter.

"Compared to courses in other majors, our study program has indeed made adequate efforts to instill the character of environmental care within the entire academic community, especially among students. However, contextual learning that addresses environmental issues still tends to be lacking as many lecturers emphasize subject-centered teaching." (P10)

Based on the interviews, lecturers' instruction focuses solely on subject-specific material, neglecting the application of contextual environmental cases. Only a few lecturers incorporate environmental issues from everyday life as discussion material in their classes, and an even smaller number of them apply environmental conservation principles in their teaching and learning processes. This approach contradicts the essence of geography, where all courses are expected to adopt contextual learning, addressing

environmental issues and exploring practical solutions.

The findings of this study are quite consistent with several previous studies, one of which is by Kurniawan et al. (2024), which revealed that the environmental literacy of Geography Education students at UNNES falls into the moderate category. Similarly, their level of environmental responsibility was also categorized as moderate. Another study by Zafar et al. (2024), conducted at a different institution, also showed that prospective teachers do not always demonstrate a high level of environmental literacy, as the average results still fall within the moderate category. A related study by Hanke & Schmalor (2025) also supports this finding, showing that prospective geography teacher students possessed a relatively good level of knowledge regarding climate change, but there were still notable deficiencies in action-based knowledge and a relatively high level of individual uncertainty.

Another study by Gamira & Firomumwe (2021) found that prospective geography teachers at Lowveld University displayed positive attitudes toward the teaching of Environmental Education (EE) and demonstrated a strong understanding of EE's strategic role in fostering students' environmental literacy. However, the effectiveness of EE implementation in classrooms continues to face significant challenges, particularly regarding the lack of comprehensive pedagogical training and insufficient instructional resources to support experiential learning (Gamira & Firomumwe, 2021). In addition, other studies have emphasized that, in general, the literature review analysis highlights the lack of environmental competences among pre-service teacher students and the gaps in teacher training curricula with respect to EE (Alvarez-Garcia et al., 2015).

These findings serve as an analysis to identify issues related to character development. By doing so, the department can produce geography teachers who are professional and environmentally conscious, in alignment with the subject's core concept of the interaction between all living beings, particularly humans and the environment. This initial data is expected to inform the creation of policies and innovations promoting these values, specifically for prospective teachers in the Geography Education Study Program at UNNES.

This is in line with the statement by Mongar (2022), who noted that limited qualifications and professional development in teaching Environmental Studies (ES) have resulted in a lack of confidence in teaching ES, insufficient pedagogical content knowledge, and unclear objectives related to ES. These findings suggest the need to integrate more knowledge of Education for Sustainable Development (ESD) into teacher education programs to adequately prepare teachers to teach ES when required and to embed ESD principles into other subjects. Moreover, Rosman et al. (2019) and Pavlova (2013) also emphasized that ESD and technology education share many commonalities that can be used to develop innovative teaching and learning concepts. Geography is arguably one of the most suitable subjects for realizing both of these educational priorities (Bengel & Peter, 2021).

Proposing Eco-Digital Pedagogy as a Solution

Based on the interviews, it is evident that pedagogical skills, technology utilization, and environment-based learning have been incorporated into teaching and learning activities in the classroom. Nevertheless, the frequency, methodological diversity, and comprehensiveness of these approaches are somewhat lacking. This is regrettable, given that technology and environmental awareness are crucial elements for students in the Geography Education Study Program, especially as they are systematically prepared to become professional, adaptable, creative, and forward-thinking educators.

One of the strategies to address this challenge involves the promotion of eco-digital pedagogy, which is centered on the responsible use of cutting-edge technology and the

commitment to environmental stewardship for sustainable development. This approach aims to empower them to become competent 21st-century educators, which needs to be restructured to incorporate training in the instruction of essential competencies. Educators in the 21st century must acquire the skill set to deliver technology-supported learning experiences for fostering efficient and sustainable 21st-century learning (Mandal, 2018; Calacar, 2020).

Burbules, Fan, and Repp (2020) have outlined five primary facets of rejuvenation and innovation to confront educational challenges, namely (1) modifications in the vision and objectives of education, (2) shifts in the educational context and ecosystem, (3) alterations in the learning process, (4) transformations in the teaching process, and (5) modifications in educational policies and institutions. Consequently, digital pedagogy is a fundamental strategy in addressing these challenges. This pedagogy is not solely reliant on the teacher's technological proficiency but also emphasizes the teacher's role in harnessing technology to foster critical thinking skills and nurture the affective development of students (Purfitasari, Masrukhi, Prihatin, & Mulyono, 2019).

Digital pedagogy places its emphasis on problem-solving-based learning planning, presenting knowledge as a challenge to be solved rather than as a mere advancement. This approach is effective as it integrates knowledge, pedagogical, and technological elements into the learning process, thereby fostering collaborative and active (Maor, 2013).

Pardinan and Loremia (2020) demonstrate that digital pedagogy significantly contributes to the development of individual competencies in students. Additionally, Ahuja and Yadav (2019) reveal that students' academic performance is enhanced when taught using interactive digital pedagogy compared to traditional classroom settings. Furthermore, Moreno, Calderon, and Arias-Estero (2021) assert that the integration of Technological Pedagogical Content Knowledge (TPCK) and Collaborative Learning (CL) enhances the advancement of digital competencies and academic achievements among prospective teachers.

According to Spiro (2013), digital pedagogy exhibits distinctive characteristics, which include: 1) amalgamating theory and practice, 2) promoting creativity and critical thinking, 3) nurturing creativity, play, and problem-solving, 4) fostering participation, collaboration, and public engagement, and 5) aiming to enhance critical comprehension of the digital environment.

Teachers, in this case, students in the UNNES Geography Education Study Program, should possess strong ecopedagogical skills. Ecopedagogy is a movement within the academic realm that aims to instill in students a comprehensive understanding, heightened awareness, and life skills harmonious with environmental conservation endeavors (Misiaszek, 2019). In operational terms, Surata (2010) defines ecopedagogy as a learning approach rooted in love, active participation, and creativity.

Ecopedagogy generally encompasses three primary areas. The first is technical (functional) ecoliteracy, which serves to impart an understanding of fundamental scientific, ecological, and biological concepts, as well as the positive and negative impacts of human activities on ecological systems. The second is cultural ecoliteracy, which fosters insight, awareness, and comprehension of diverse cultural perspectives regarding the relationship between humans and the environment, ultimately contributing to the sustainability of life. The third is critical ecoliteracy, which strives to incorporate educational topics in ecological politics, technological advancements, and communication, all achieved through critical and constructive dialogue (Yasida, 2020).

Ecopedagogy places a strong emphasis on ecological awareness, particularly in relation to environmental conservation. Learning based on

ecopedagogy is instrumental in cultivating critical awareness and nurturing students' characters, fostering their understanding of their intrinsic connection with nature. This understanding equips them with the ability to apply these characteristics in their daily lives. It positions students as independent, autonomous learners, empowering them to unlock their full learning potential through experiences gained outside the classroom. Students are also encouraged to be aware that each of their actions has an impact not only on themselves but also on the surrounding environment (Payne, 2018).

As a critical approach, ecopedagogy enables the education of individuals on environmental and social issues (Tsegay, 2016). In alignment with this, Gyallay (2004) elaborates that ecopedagogy seeks to cultivate awareness, knowledge, and concern regarding social, political, ecological, and even economic matters within diverse regional settings, spanning from rural villages to urban areas.

Based on the explanation of the two preceding pedagogic values, which are digital and ecological in nature, their combination can be implemented to enhance the competencies of (prospective) 21st-century geography teachers. Several steps that can be taken include the following.

First, the design of an inclusive curriculum that maximizes opportunities for the use of technology and promotes environmentally conscious practices. The curriculum serves as the backbone of any learning program in both formal and informal educational institutions. Therefore, lecturers and educational boards within the institution must be proficient in creating a curriculum that is practical and pertinent. A curriculum that aligns with ecological and digital concepts enhances the prospects of a seamless learning process.

Second, the provision of infrastructure, particularly adequate technology, to enhance the skills of students (prospective teachers). In daily practice, school facilities are a crucial considertin, as without adequate resources, even the most innovative ideas and plans may remain unrealized.

Third, the promotion of hands-on practice in real-world conditions to ensure relevance. Lecturers can engage in more practical exercises to deepen the understanding and critical thinking abilities of Geography Education students. Such exercises familiarize pre-service teachers with real-life issues in the field, preparing them for future challenges.

Fourth, the enrichment of pedagogical learning methods, including peer practice to encourage critical evaluation and reflection. Lecturers can also employ other methods such as focused discussions, particularly those related to ecological issues or climate crisis campaigns on social media. Students may occasionally be required to practice teaching at institutions or schools using the specific methods they are studying.

Fifth, the utilization of digital platforms and media as educational spaces and mediums for promoting environmental awareness and sustainable development campaigns. In the 21st century, digital platforms serve as arenas for discourse, learning, and information exchange. Lecturers must inspire pre-service teachers to become well-versed in technology. In this context, technology is not just a set of tools but a multifaceted resource. Students can be trained to deliver content through digital platforms, create relevant quizzes, and establish spaces for cross-cultural idea exchange to enrich their knowledge. Digital media can also serve as avenues for research and the dissemination of analyses of ecological issues.

By implementing these methods, the principles of eco-digital pedagogy can facilitate the development of highly competent 21st-century trainee teachers. Their proficiency will initiate a chain reaction of systematic quality education: proficient teachers will produce students with strong competence, and this cycle will continue.

■ **CONCLUSION**

In the 21st century, teachers are expected to possess proficient, up-to-date, and relevant pedagogical skills. Regrettably, many Geography Education students still lack the necessary pedagogical competence as aspiring educators. According to interviews, they often underutilize technology as an educational tool and may not fully comprehend the ecological principles underpinning sustainable development. This situation necessitates improvement, which can be approached from an eco-digital pedagogy perspective combining pedagogy grounded in digitalization and ecology. The implementation of this concept can occur through five primary methods: (1) designing an inclusive curriculum, (2) providing adequate facilities, (3), enhancing practical, hands-on experiences in real and pertinent situations, (4) enriching pedagogical learning techniques, and (5) utilizing digital platforms and media as educational spaces and channels for promoting environmental awareness and sustainable development campaigns. These methods can be put into practice by adjusting the classroom environment, even though maximum efforts are required. Its implementation requires fundamental changes to the curriculum, the provision of supporting facilities or infrastructure, and the willingness of lecturers or department administrators to thoroughly understand the concept of eco-digital pedagogy.

This study has several limitations. First, the subjects investigated were drawn from only one university while conditions may vary across other campuses. Second, the data collection method relied solely on interviews with a limited number of interviewees. Further studies are expected to analyze subjects from a broader range of institutional backgrounds with a larger sample size. Data collection methods such as questionnaires and observations could also be employed considering a mixed-method approach.

■ **REFERENCES**

Abebe, F. F. (2021). Pre-service teachers' technological pedagogical content knowledge (tpack) self-efficacy and development in k-6 math. University of Nebraska.

Ahuja, S., & Yadav, D. (2019). Effect of digital pedagogy in ierventions in rural areas. *MIER Journal of Educational Studies Trends and Practices*, 227-240.

Aleksieva, L. (2025). Preparing pre-service teachers for the digital transformation of education: exploring university teacher educators' views and practical strategies. *Education Sciences, 15*(4), 404. https://doi.org/10.3390/educsci15040404

Almazroa, H. & Alotaibi, W. (2023). Teaching 21st century skills: Understanding the depth and width of the challenges to shape proactive teacher education programmes. *Sustainability, 15*(9), 1-25.

Álvarez-García, O., Sureda-Negre, J., & Comas-Forgas, R. (2015). Environmental education in pre-service teacher training: A literature review of existing evidence. *Journal of Teacher Education for Sustainability, 17*(1), 72-85.

Ammoneit, R., Turek, A., & Peter, C. (2022). Pre-service geography teachers' professional competencies in education for sustainable development. *Education Sciences, 12*(1), 42. https://doi.org/10.3390/educsci12010042

Artvinli, E. (2017). What is innovative geography teaching? A perspective from geography teachers. *Journal of Education and Training Studies, 5*(6), 9-23.

Asli, S., Abu-Alhiga, R., Teti, T., Algmal, S., Hofstein, A., Shehadeh-Nasser, A., & Hugerat, M. (2024). How participation in a teachers' eco-pedagogy workshop affects the promotion of teachers' environmental education and organizational concepts. *European Journal of Educational Research*, 13(1). https://doi.org/10.12973/eu-jer.13.1.341

Bashýr, K., & Jýmmy, L. (2023). Pre-service teachers' technological, pedagogical and content capability and digital pedagogy

readiness. *Journal of Teacher Education and Educators, 12*(3), 303-326.

Bengel, P. T., & Peter, C. (2021). Modern technology in geography education attitudes of pre-service teachers of geography on modern technology. *Education Sciences, 11*(11), 708. https://doi.org/10.3390/educsci11110708

Burbules, N. C., Fan, G., & Repp, P. (2020). Five trends of education and technology in a sustainable future. *Geography and Sustainability*, *1*(2), 93-97.

Caena, F. & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (DigcompeDu). *European Journal of Education,* 54(3), 356-369.

Calacar, G. B. (2020). Teaching the 2st Century Skills: Teachers' Competence, Practices and Challenges. *Journal of World Englishes and Educational Practices*, *2*(2), 81-91.

Daniel, G., & Thomas, F. (2021). Attitudes of pre-service geography teachers towards teaching environmental education at the lowveld university. *I-manager S Journal on School Educational Technology, 16*(3), 9. https://doi.org/10.26634/jsch.16.4.17950

DeMitchell, T., & Fossey, R. (1997). The limits of law-based school reform: Vain hopes and false promises. Lancaster, PA: Technomic Publishing Co., Inc.

Elton, L. (2001). Research and teaching: conditions for a positive link. *Teaching in Higher Education,* 6(1), 43-56.

Gonzalez-Perez, L. I. & Ramirez-Montoya, M. S. (2022). Components of education 4.0 in 21st century skills frameworks: Systematic review. *Sustainability,* 14, 1493.

Grinsted, T. S. (2013). From the human-environment theme towards sustainability – Danish Geography and Education for sustainable development. *European Journal of Geography,* 4(3), 6-20.

Grinsted, T. S. (2014). The matter of geography in education for sustainable development: The case of Danish University Geography. In Transformative approaches to sustainable development at universities, 13–24.

Guo, F., et al. (2018). Sustainable development in geography education for middle school in China. *Sustainability,* 10, 1-27.

Guo, F., Meadows, M. E., Duan, Y., & Gao, C. (2020). Geography pre-service teachers' perspectives on multimedia technology and environmental education. *Sustainability, 12*(17), 6903. https://doi.org/10.3390/su12176903

Gyallay, P. (2004). Environment: PAP-ETAP reference guide book, chapter 13. (http//www.un.org.kh/fae/pdfs/section4/chapterxxx3/33.pdf)

Hanke, M., & Schmalor, H. (2024). (Un-)certain knowledge of pre-service geography teachers about climate change. *Journal of Geoscience Education*, 1–13. https://doi.org/10.1080/10899995.2024.2409605

Hariyanto, R. (2019). *Tranformasi pendidikan abad 21 melalui rumah belajar*. http://pena.belajar.kemdikbud.go.id/2019/07/tranformasi-pendidikan-abad-21-melalui-rumah-belajar/

Haubrich, H., Reinfried, S., & Schleicher, Y. (2007). Geographical education for sustainable development. *Proceedings of the Lucerne-Symposium,* 42, 243-250. Switzerland, July 29-31 2007.

Haugsbakken, H., Nykvist, S., & Lysne, D. A. (2019). The need to focus on digital pedagogy for online learning. European. *Journal of Education*, *2*(3), 25–31.

Izzati, R., Yani, A., & Mulyadi, A. (2016). *Pengaruh program pengalaman lapangan (ppl) terhadap peningkatan kompetensi pedagogik calon guru*

geografi (studi terhadap kompetensi menyelenggarakan pembelajaran yang mendidik mahasiswa PPL geografi). Universitas Pendidikan Indonesia).

Kurniawan, E., Saputra, Z. S., & Akhyar, M. (2024). Environmental literacy and responsibility level of students in the geography education study program in universitas negeri semarang as prospective teachers. *International Journal of Environmental Impacts, 07*(02), 221–232. https://doi.org/10.18280/ijei.070207

Maker, C. J. (2022). From learing to guiding, facilitating, and inspiring: A needed shift for the 21st century. *Education Sciences, 12*(18) 1-15.

Mandal, S. (2018). The competencies of the modern teacher. *International Journal of Research in Engineering, Science and Management, 1*(10), 351–360.

Maor, D. (2013). Does the use of the TPACK model enhance digital pedagogies: We don't understand the present so how can we imagine the future? *Proceeding of 30th Ascilite Conference*, 531–540.

Markuszewska, I., Tanskanen, N., & Subiros, J. V. (2018). New ways to learn geography – challenges of the 21st century. *Quaestiones Geographicae, 37*(1), 37-45.

Masoumi, D. (2021). Situating ICT in early childhood teacher education. *Education and Information Technologies, 26*(3), 3009–3026.

Milton, M., & Vozzo, L. (2013). Digital literacy and digital pedagogies for teaching literacy: Pre-service teachers' experience on teaching rounds. *Journal of Literacy and Technology, 14*(1), 72–97.

Misiaszek, G. W. (2019). Ecopedagogy: teaching critical literacies of 'development', 'sustainability', and 'sustainable development.' *Teaching in Higher Education, 0*(0), 1–18.

Molla, A., Yayeh, M., & Bisaw, A. (2023). The current status of faculty members' pedagogical competence in developing 21st century skills at selected universities in Ethiopia. *Cogent Education, 10*(2), 1-15.

Mongar, K. (2022). Teachers' preparedness to teach environmental science in Bhutan. *Eurasia Journal of Mathematics Science and Technology Education, 18*(10), em2166. https://doi.org/10.29333/ejmste/12454

Moreno, L., Calderon, A., & Arias-Estero, J. L. (2021). Digital pedagogy and cooperative learning: Effect on the technological pedagogical content knowledge and academic achievement of pre-service teachers. *Revista de Psicodidactica, 26*, 53–61

Ohio Department of Education. (2016). Partnership for 21st century skills [review of partnership for 21st century skil*ls*]. In *Marietta College*. https://www.marietta.edu/sites/default/files/documents/21st_century_skills_standards_book_2.pdf

Palacios, F. A., Oberle, A., Quezada, X. C., & Ullestad, M. (2017). Geographic education for sustainability: Developing a Bi-national geographical thinking curriculum. Dalam *The Power of Geographical Thinking, International Perspectives on Geographical Thinking*, 103-119.

Paradis, T. W. & Dexter, L. R. (2007). Learner-Centered teaching and assessment in an undergraduate field analysis course. *Journal of Geography, 106*(4), 171-180.

Pardinan, E. G., & Loremia, R. A. (2020). Digital pedagogy analysis on technology trend relevant to education 4.0. *International Journal of Scientific & Tchnologicy Research, 9*(8), 390–399.

Pavlova, M. teaching and learning for sustainable development: ESD research in technology education. *Int. J. Technol. Des. Educ.* 2013, 23, 733–748.

Payne, P. G. (2018). The framing of ecopedagogy as/in scapes: Methodology of the issue. *Journal of Environmental Education, 49*(2), 71–87.

Peng, J., et al. (2020). Linking spatial differentiation with sustainability management: Academic contributions and research directions of physical geography in China. *Progress in Physical Geography,* 44(1), 14-30.

Piotrowska, I. Cichon, M., Abramowicz, D., & Sypniewski, J. (2019). Challenges in geography education – A review of research problems. *Quaestiones Geographicae,* 38(1), 71-84.

Prakash, B. K. (2014). Digital pedagogy and its arrival in teacher education. Gulbarga University.

Purfitasari, S., Masrukhi., Prihatin, T., & Mulyono, S, E. (2019). *Digital pedagogy sebagai pendekatan pembelajaran di era industri 4.0. Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS 2 (1), 806-811.*

Qiu, J. (2017). The role of geography in sustainable development. *National Science Review,* 4, 140-143.

Razak, N. H. B. A., Iksan, Z. H., & Zakaria, S. Z. S. (2017). (2017). Students' reflection on green school. *Journal of Techno-Social, 9*(1), 44–52.

Reinfried, S. & Hertig, P. (2012). Geographical education: How human-environment-society processe work. http://www.eolss. net /sample-chapters/c01/e6-06b-46.pdf).

Reitano, P., & Harte, W. (2016). Geography pre-service teachers' pedagogical content knowledge. *Pedagogies an International Journal, 11*(4), 279–291. https://doi.org/ 10.1080/1554480x.2016.1195740

Rosali, E. S., Singkawijaya, E. B., Hadi, M. I., & Noviyanti, R. W. (2019). *Analisis kesiapan mahasiswa pendidikan geografi dalam menghadapi program pengenalan lapangan persekolahan. In Prosiding Seminar Nasional Pendidikan Geografi UPI.*

Rosman, N. R.., Khaizer, M. & Zahari, Z. The integration of education for sustainable development in design and technology subject: through teacher's perspective. *Asian J. Assess. Teach. Learn.* 2019, 9, 29–36

Salas-Rueda, R.-A. (2019). TPACK: Technological, pedagogical and content model necessary to improve the educational process on mathematics through a web application? *International Electronic Journal of Mathematics Education, 1*(1), 1–13. https://doi.org/ 10.29333/iejme/5887

Sidi, I. P. S., & Setiadi, B. N. (2013). *Manusia Indonesia abad 21 yang berkualitas tinggi ditinjau dari sudut pandang psikologi.* https://himpsi.or.id/blog/ makalah-3/post/manusia-indonesia-abad-21-yang-berkualitas-tinggi-ditinjau-dari-sudut-pandang-psikologi-19

Silviariza, W. Y., Sumarmi, & Handoyo, B. (2020). Improving critical thinking skills of geography students with spatial-problem based learning (SPBL). *International Journal of Instruction,* 14(3), 133-152.

Spiro, J. D. (2013). "Effective Principals in Action." *SAGE Journals*, *94*(8), 27–31.

Sulaswari, M., Fatah, A., Fatmawati, N., & Falaq, Y. (2023). Exploring ecopedagogy through local wisdom-based social studies learning for junior high school students in kudus. *In International Conference On Social Science Education Proceeding* (Vol. 1, pp. 197-202).https://doi.org/ 10.20527/0h3cp360

Sumarmi, Aliman, M., & Mutia, T. (2021). The

effect of digital eco-learning in student worksheet flipbook to environmental project literacy and pedagogic competency. *Journal of Technology and Science Education, 11*(2), 357–370.

Surata, K. (2010). *Pembelajaran lintas budaya: penggunaan subak sebagai model "ecopedagogy." Jurnal Kajian Bali, 3*(2).

Tondeur, J., Van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education, 59*(1), 134–144.

Tsegay, S. M. (2016). Analysis of globalization, the planet and education. *International Journal Of Environmental & Science Education, 11*(18).

Utami, W. S., Zain, I. M., & Sumarmi. (2018). Geography literacy can develop geography skills for high school students: it is true ? *IOP Conf. Series: Materials Science and Engineering 296 (2018) 012032,* 1-6.

Wan, Z., & Cai, T. (2023). Strategies for cultivating teaching skills of geography preservice teachers in the context of the new era. *Frontiers in Educational Research, 6*(31). https://doi.org/10.25236/fer.2023.063111

Wardhani, P. I., Palupi, H. S., Widyatmoko, W., Musiyam, M., Nur Hafida, S. H., & Pratiwi, E. S. (2022). Implementation of environmental ethics in ecopedagogy-based geography learning by teachers on environmental sustainability. *In Proceedings of the 7th Progressive and Fun Education International Conference (PROFUNEDU 2022)* (pp. 42-49). Atlantis Press. https://doi.org/10.2991/978-2-494069-71-8_6

Warsi, L. Q., & Rani, Y. (2024). Analysis of teachers' readiness in using digital technology for students' learning: problems and potential solutions. *Human Nature Journal of Social Sciences, 5*(2), 292-305. DOI: 10.71016/hnjss/t32ny040

Yang, L., Martínez-Abad, F., & García-Holgado, A. (2022). Exploring factors influencing pre-service and in-service teachers perception of digital competencies in the Chinese region of Anhui. *Education and Information Technologies, 27*(9), 12469–12494.

Yli-Panula, E., Jeronen, E., & Lemmetty, P. (2020). Teaching and learning methods in geography promoting sustainability. *Educ. Sci*, 10, 5.

Zafar, N. A., Mannan, N. T., & Hussain, S. (2024). Knowledge, attitude and behavioral components of environmental literacy: perceptions of prospective teachers for quality education in Lahore. *Journal of Education and Educational Development, 11*(1), 95–118. https://doi.org/10.22555/joeed.v11i1.962