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Sociology Teachers' Comprehension of Ecological Literacy in Sociology Learning in Senior High Schools in Indonesia: A Critical Pedagogic Study

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Abstract: Climate change and the rapid acceleration of environmental degradation have underscored the necessity of educational strategies that foster ecological awareness and critical engagement among students. Sociology, a social science discipline that investigates the relationship between society and environmental concerns, offers a strategic framework for integrating ecological literacy. The objective of this investigation is to investigate the perceived comprehension of ecological literacy among Sociology teachers and to investigate the integration of ecological literacy into the teaching of Sociology in senior high schools from the perspective of critical pedagogy. The design of this investigation was mixed-methods. A survey was administered to Sociology instructors to collect quantitative data regarding their perceived comprehension of ecological literacy and its integration into classroom practices. Qualitative data were collected through participative observations, in-depth interviews, focus group discussions, and document analysis of instructional materials and lesson plans. The data were analyzed using descriptive statistics and an interactive qualitative analysis model that included data reduction, data visualization, and conclusion drawing. The veracity of the findings was improved through the triangulation of data sources. The results suggest that the majority of teachers reported a high level of perceived comprehension of ecological literacy and acknowledged its significance in addressing environmental and climate-related challenges. Teachers frequently urged students to critically examine environmental issues, social inequalities, and human-environment interactions. Nevertheless, the analysis of documents and classroom observations demonstrated a discrepancy between the pedagogical implementation and curriculum planning. Despite the inclusion of ecological issues in lesson plans, classroom practices frequently prioritized conceptual comprehension over transformative action. The main challenges that emerged were the insufficient institutional support, limited instructional resources, and restrictions on critical classroom dialogue. The research demonstrates that critical pedagogy offers a valuable framework for integrating ecological literacy into Sociology education by promoting environmental responsibility and critical consciousness. The results are a valuable addition to the ongoing discourse regarding ecological education, curriculum development, and teacher professional development. Future research should investigate instructional strategies that enhance the implementation of ecological literacy and assess their long-term influence on students' ecological awareness and transformative action.

Keywords: ecological literacy, critical pedagogy, sociology learning.

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INTRODUCTION

Some of the most urgent global challenges of the twenty-first century include the depletion of natural resources, environmental degradation, biodiversity loss, and climate change (Amer et al., 2024; Nguyen et al., 2023; Badr & El-Shazly, 2024; Fletcher et al., 2024; Kattel, 2022; Kumari, 2025). The Intergovernmental Panel on

Climate Change (IPCC) has reported that human-induced environmental degradation is accelerating, resulting in substantial social, economic, and ecological repercussions worldwide (IPCC, 2021). Additionally, these environmental crises exacerbate social inequalities, which disproportionately affect vulnerable communities and threaten ecosystem sustainability (Badr & El-Shazly, 2024; Kattel, 2022). As a result, resolving environmental challenges requires not only technological and policy solutions but also transformative educational strategies that foster ecological awareness, critical thinking, and responsible citizenship among the younger generation.

Education is widely acknowledged as a key tool for attaining sustainable development and fostering environmental accountability. This acknowledgment is manifested in the United Nations Sustainable Development Goals (SDGs), specifically Goal 4 (Quality Education), Goal 13 (Climate Action), and Goal 15 (Life on Land), which underscore the importance of education in cultivating the knowledge, values, and skills essential for sustainable futures (Akinsemolu & Onyeaka, 2025; Glaviè, 2020; Shulla et al., 2020; Velempini, 2025). In this context, schools serve as essential spaces for developing ecological literacy and supporting students' capacity to respond to environmental and climate-related challenges. Strengthening ecological literacy is therefore aligned with global sustainability agendas such as the SDGs, particularly Goal 13 on climate action. (Gichuru & Thuranira, 2025; Nirupama et al., 2025; Salinas et al., 2022). Ecological literacy has been a major focus in many countries worldwide in response to today's more urgent environmental crisis (Fletcher et al., 2024; Koyama & Watanabe, 2023; Yeh et al., 2022).

Ecological literacy is widely seen as crucial for equipping youth to live sustainably and address contemporary environmental challenges. Research across educational levels links ecological literacy to pro-environmental attitudes and behaviors, yet reveals fragmented implementation that often emphasizes only scientific aspects. Research on middle school and teenage populations indicates that environmental knowledge, attitudes, and emotions are correlated with pro-environmental behaviors or intentions; nevertheless, emotions and awareness may serve as more potent predictors than information alone (Napitupulu et al., 2025; Sigit et al., 2023; Balážová et al., 2024; Cincera et al., 2023; Huoponen, 2024; Muñoz-García et al., 2022). Environmental literacy initiatives (e.g., rainforest-climate change program, resource circulation curriculum, eco-content in language textbooks) enhanced pro-environmental intentions and daily behaviors, including trash sorting, cleanliness, and health-conscious, ecologically relevant activities (Ninsiana et al., 2024; Bissinger & Bogner, 2018; J. Liu & Green, 2024).

Sociology provides a pertinent framework for cultivating ecological literacy by analyzing the intricate interplay between society and the environment. Sociology challenges students to rigorously examine social structures, power dynamics, inequality, and collective action, all of which are intricately linked to environmental concerns (Davidson, 2022; Garcia & Tschakert, 2022; Islam, 2024). Modern environmental challenges, such as climate change, environmental injustice, and resource exploitation, are not only ecological issues but also social concerns shaped by human behavior, economic systems, and political choices (Clark, 2024; Guerrero & Sjöström, 2025). Thus, including ecological literacy in sociology education might enhance students' comprehensive awareness of environmental issues and their wider societal ramifications.

Senior High School (SMA), as a formal educational institution, plays a strategic role in developing human resources with knowledge,

attitudes, and adequate skills to become individuals who are concerned with and responsible for the environment. The students at the Senior High School level exhibit characteristics of individuals who have entered the critical and abstract-thinking development phase (Abdullah, 2021; Triastuti & Laksono, 2021; Abrigo & Chua, 2024; Huoponen, 2024). As part of this attempt, ecological literacy should have been integrated into the school learning process, particularly at the senior high school level (Suwandi et al., 2019; Nurhakim & Kusnoto, 2020; Klein et al., 2021; Xiong et al., 2025). Through either intracurricular or extracurricular learning, schools can contribute to growing and developing the students' attitude and critical knowledge comprehensively related to environmental issues, and likewise growing their personal sense of responsibility to be concerned and to take real action for the sustainable ecological safety (Sigit et al., 2023; Pouresmaieli et al., 2024; Cole et al., 2024).

In Indonesia, the *Merdeka* Curriculum is a national curriculum that gives teachers discretion to determine essential learning materials based on individual schools' needs and local contexts (Kemendikbudristek, 2022). In this context, learning Sociology plays a strategic role in fostering ecological literacy among students, given that this subject is closely related to the dynamic relationship among human beings, the social environment, and nature. In this subject, students study how the dynamics of social change affect the exploitation and conservation of the natural environment, and how community empowerment strategies help maintain ecosystem conservation. By analyzing this social factor, students can develop a more in-depth understanding of the causes of environmental problems and provide contextually appropriate solutions. Sociology also emphasizes the importance of social justice and equality in environmental issues and highlights how different groups are disproportionately affected by environmental degradation.

Teachers play a central role as agents of change in education. They play an important role in developing students' comprehension, including knowledge, attitudes, and behavior regarding environmental concern (Norazlan & Said, 2023; Tomás et al., 2022; Durmus & Kinaci, 2021). Teachers can implement critical pedagogic approaches that encourage students to think critically about social change, question assumptions about its environmental impact, and actively participate in the learning process (Giroux, 2018; Freire, 2021; McLaren & Bosio, 2022). This learning approach is an effective way to integrate ecological literacy into Sociology learning. Environmental challenges, including climate change, ecological degradation, and environmental injustice, are not only ecological concerns but are fundamentally entrenched in social, political, and economic frameworks. Thus, ecological literacy must be seen not just as environmental knowledge but also as the capacity to critically evaluate the interplay between civilization and the environment. Sociology offers a pertinent framework for cultivating ecological literacy by enabling students to analyze environmental challenges through the lenses of social inequality, power dynamics, and societal transformation. This viewpoint closely aligns with critical pedagogy, which prioritizes cultivating critical awareness through reflection and transformative action (Freire, 1970). Critical pedagogy, by prompting students to interrogate the structural origins of environmental issues and investigate avenues for social and ecological justice, provides a suitable theoretical framework for comprehending how teachers incorporate ecological literacy into Sociology education. Consequently, critical pedagogy serves as a conceptual nexus connecting ecological literacy with sociology education, both of which aspire to cultivate critical, socially responsible, and ecologically aware individuals.

Nevertheless, teachers' comprehension and ability to integrate ecological literacy into

sociology instruction remain major challenges. In particular, there is an urgent need to assess how Sociology teachers understand the concept of ecological literacy and how fully they can implement it in their teaching. The challenges teachers face include not only limited resources and training but also constraints in adopting a critical pedagogic approach, which requires a paradigm shift in teaching methods (Roohani & Haghparast, 2020; Wu et al., 2020; Durmus & Kinaci, 2021). Teachers' comprehension of and willingness to integrate ecological literacy into Sociology teaching remain major challenges. Notwithstanding the expanding corpus of work on ecological literacy and sustainable education, three significant gaps persist. Primarily, research has focused on students' ecological literacy, while instructors' perceived comprehension and pedagogical interpretations have been comparatively neglected. Secondly, prior studies have mostly focused on ecological literacy in the realms of scientific and environmental education, with less consideration for its incorporation into Sociology education. Third, little research has examined ecological literacy in relation to Indonesia's *Merdeka* Curriculum, which offers novel options for contextualized and student-centered education. This research examines how Sociology instructors interpret ecological literacy and incorporate it into classroom activities, using a critical pedagogy framework to address existing gaps. This emphasis provides a contextually relevant addition to the literature by linking ecological literacy, sociology education, critical pedagogy, and curriculum reform within the Indonesian educational framework.

This research aims to examine Sociology instructors' perceptions of ecological literacy and its application in Sociology education via a critical pedagogy lens, with the overarching goal of enhancing ecological literacy instruction for students. The research aims to elucidate how Sociology professors define ecological literacy, include ecological viewpoints into their teaching methodologies, and use critical pedagogical concepts to enhance students' environmental awareness and critical consciousness. The results are anticipated to provide valuable guidance for teachers and policymakers in formulating curriculum, teacher professional development initiatives, and educational policies that effectively address current environmental concerns. This study tackles the following research question based on identified gaps in the literature: (1) How do Sociology instructors assess their comprehension of ecological literacy? How can teachers incorporate ecological literacy into sociology instruction? To what degree are critical pedagogical concepts manifested in the use of ecological literacy within Sociology classrooms? What problems do teachers have in integrating ecological literacy into Sociology education?

METHOD

Participant

This research involved 75 Sociology teachers from various Senior High Schools in Indonesia, selected through purposive sampling. Participants for the qualitative phase were chosen using purposive sampling. Following the survey phase, five teachers were deliberately selected for comprehensive interviews. The selection criteria included variability in survey results, teaching experience, school attributes, and readiness to engage. This technique aimed to incorporate multiple viewpoints and provide information-dense scenarios that more comprehensively elucidate the quantitative results. This approach was deemed suitable because the research aimed to investigate Sociology teachers' perceived understanding and experiences of incorporating ecological literacy into classroom practices within the framework of the *Merdeka* Curriculum. In alignment with the phenomenological methodology used in this research, purposive sampling facilitated the

selection of individuals with substantial experience and relevant knowledge of the phenomena under examination (Creswell & Clark, 2017).

This method was chosen to guarantee that teachers from diverse social origins and professional experiences could provide comprehensive insights into their understanding of ecological literacy within the framework of Sociology instruction. Participant selection was based on specific criteria: a minimum of 3 years of teaching experience, an educational background relevant to Sociology education, active involvement in implementing the *Merdeka* Curriculum at their institution, and willingness to participate in interviews, observations, and focus group discussions. The sample included 75 Sociology teachers, with 72% identifying as female and 28% as male, aged between 20 and 60 years. The objective of participant selection was not to achieve statistical representativeness but to obtain comprehensive, contextually relevant insights into teachers' perspectives and pedagogical methods regarding ecological literacy. The data on the characteristics of research respondents are presented in Table 1.

Table 1. Characteristics of respondents

Characteristics	Category	n	(%)
Sex	Male	21	28%
	Female	54	72 %
Age	20 – 29 years	8	10.7 %
	30 – 39 years	52	69.3%
	40 – 49 years	6	8 %
	50 – 59 years	9	12 %
	>60 years	0	0 %
Length of Teaching Time	0-5 years	12	5.3 %
	6-10 years	29	38.7 %
	11-15 years	21	28 %
	16-20 years	4	5.3 %
	>20 years	9	12 %
Academic Education	S1 (Bachelor)	51	68 %
	S1 Bachelor of Education Profession	15	20 %
	S2 (Postgraduate)	9	12 %
Training of Ecological Literacy	Once before	7	9.3 %
	Never before	68	90.7 %

Source: Author's Processed Data (2025)

From Table 1, it can be seen that the composition of research participants varies in terms of both demographics and professional teaching experience. The majority of participants are female (72%); the rest are male (28%). The majority have a bachelor's degree (68%). Majority participants are 30-50 years old, with a fairly even distribution. The participants' teaching experience also varies, with the majority having 6-10 years of teaching experience (38.7%). However, only 7 (seven) teachers (9.3%) have ever attended education or training on ecological literacy either inside or outside the school.

Research Design and Procedures

This study employed a mixed-methods design using a sequential quantitative-qualitative

methodology (John W. Cresswell, 2014) to gain a comprehensive understanding of the ecological literacy observed among instructors in sociology education within a critical pedagogy framework. The quantitative phase was a survey conducted with 75 Sociology teachers from senior high schools. Qualitative data were then gathered via in-depth interviews, focus group discussions, classroom observations, and document analysis to elucidate and contextualize the quantitative results.

The questionnaire used in this research does not assess instructors' objective cognitive comprehension; instead, it gauges their self-perceived grasp of ecological literacy. This methodology aligns with prior research that uses Likert-scale instruments to evaluate perceptions, beliefs, and self-assessments rather than direct knowledge measures (e.g., self-report constructs in educational research). Consequently, the results should be construed as indicative of the instructors' subjective assessment of their own comprehension. At the quantitative stage, a survey of teachers' comprehension of ecological literacy in Sociology learning, using a critical ecological pedagogy approach, was conducted among teachers teaching the Sociology subject across many regions in Indonesia.

Quantitative data were gathered through a structured questionnaire modified from prior research on ecological literacy, environmental education, and sustainability-oriented pedagogy, tailored to the context of Sociology education and the application of the *Merdeka* Curriculum in Indonesian senior high schools. The tool was created to assess teachers' self-assessed comprehension of ecological literacy rather than their actual cognitive knowledge. The questionnaire evaluated four dimensions: perceived comprehension of ecological literacy concepts, incorporation of ecological literacy into Sociology education, application of critical pedagogical principles, and perceived obstacles to implementing ecological literacy. Responses were quantified on a five-point Likert scale, with 1 indicating strong disagreement and 5 indicating strong agreement. Examples were, "I urge students to critically evaluate the ecological consequences of human actions" and "I incorporate environmental topics into Sociology educational resources." To guarantee instrument quality, content validity was confirmed by expert evaluation by professionals in Sociology education and environmental education. The instrument's internal consistency was evaluated using Cronbach's alpha, yielding 0.864, indicating high reliability. These techniques guaranteed that the tool was suitable for assessing teachers' perspectives and pedagogical practices about ecological literacy in Sociology education.

The survey results were then quantitatively processed to determine the teachers' ecological literacy scores. The result of quantitative analysis is then used as the basis for exploring qualitative data in depth. The qualitative data were explored using data collection techniques, including Focus Group Discussion (FGD), observation, document study, and in-depth interviews with several elected teachers, to identify specific characteristics in accordance with the research criteria, as seen in the quantitative data and FGD. FGD and in-depth interview activities were conducted offline to enable the author to explore the data in depth and objectively. Thematic model analysis is used as the framework for qualitative data analysis, focusing on teachers' understanding of ecological literacy in Sociology learning using a critical pedagogic approach.

To enrich and validate the interview findings, a Focus Group Discussion (FGD) involving 13 Sociology teachers was conducted. Participants were purposively selected to represent diverse teaching experiences, school contexts, and levels of engagement with ecological literacy practices. The discussion explored teachers' perceptions of ecological literacy, implementation challenges,

and opportunities to integrate ecological literacy into Sociology learning. The focus group discussion lasted roughly 90 minutes and used a semi-structured discussion guide. The discourse focused on teachers' comprehension of ecological literacy, their experiences in incorporating environmental themes into Sociology education, the application of critical pedagogical methodologies, and the perceived institutional obstacles. The researchers facilitated the session, which was audio-recorded with the participants' agreement for later study.

Qualitative data collected from interviews, observations, focus group discussions, and document analysis were examined using theme analysis in accordance with the six-phase framework established by Creswell & Clark (2017). Following the survey phase, five teachers were purposively selected for in-depth interviews to deepen qualitative understanding of the quantitative results. The selection was determined by the variance in survey scores about teachers' assessed comprehension of ecological literacy and its application in Sociology education. The interview participants exhibited diverse response profiles, including instructors with high, moderate, and poor survey scores. This method aimed to capture a range of viewpoints and experiences related to ecological literacy practices, thereby facilitating a more thorough analysis of the survey findings. The selection method included teaching experience, school background, and desire to engage to ensure that participants could provide information-rich perspectives pertinent to the study aims. The semi-structured protocol for the interviews included inquiries into teachers' understanding of ecological literacy, the integration of environmental issues into Sociology instruction, the implementation of critical pedagogy, and the obstacles they encountered in classroom practice. The interview guide allowed participants to elucidate on their experiences while maintaining consistency across all interviews.

The researchers first familiarized themselves with the data by thoroughly reviewing interview transcripts, observation notes, and documentary evidence to gain a full understanding of participants' experiences. Initially, codes were developed by identifying significant data units related to teachers' perspectives, experiences, and methodologies regarding ecological literacy in Sociology education. The codes were methodically categorized into overarching themes and larger classifications. The resulting themes were evaluated and developed by assessing their coherence and consistency across various data sources. Fifth, each topic was clearly articulated and designated to encapsulate its substantive significance and relevance to the study's aims. The themes were ultimately analyzed and presented by correlating the empirical data with the theoretical framework of critical pedagogy, namely the notions of critical awareness, dialogue, social justice, and transformational learning. Data triangulation was performed using interviews, observations, focus group discussions, and lesson plan materials to enhance the trustworthiness of the analysis.

Instruments

The research instrument used in this study is valid and reliable, despite some modifications made by the author in accordance with the research context (Black, 1994; Sigit et al., 2023). Quantitative data were collected using a closed-ended questionnaire to assess teachers' perceived comprehension of ecological literacy and its application in Sociology education from a critical-pedagogy perspective. The questionnaire comprised 25 items categorized into five dimensions: (1) knowledge of environmental issues, (2) awareness of the effects of human activities on the environment, (3) capacity to incorporate ecological literacy into the curriculum, (4) application of critical pedagogical principles, and (5) obstacles in the implementation of

ecological literacy in education. Table 2 shows that each variable was operationalized using a set of self-report statements designed to capture teachers' perceptions of their knowledge, awareness, and instructional methods regarding ecological literacy. Examples of representative items included assertions such as "I possess substantial knowledge regarding climate change and its effects" and "I motivate students to critically evaluate the environmental consequences of human actions." The questionnaire items were intentionally designed as self-report measures to evaluate instructors' perceived comprehension rather than to objectively assess ecological literacy skills. This difference is crucial, as the research seeks to investigate how teachers conceptualize, interpret, and apply ecological literacy in their professional practice, rather than assess their factual knowledge through standardized testing.

Table 2 illustrates that the instrument integrates ecological literacy constructs with critical pedagogical principles by assessing teachers' perceived environmental knowledge and awareness, as well as their perceived capacity to promote critical reflection, dialogue, and socio-environmental engagement in Sociology education. The questionnaire was modified from prior research on ecological literacy, environmental education, and sustainability-focused pedagogy, and then tailored for Sociology education in the context of the *Merdeka* Curriculum implementation. To ensure instrument quality, content validity was confirmed through expert evaluation by professionals in Sociology education and environmental education, who assessed the relevance, clarity, and contextual suitability of each item. Their input was incorporated into the final iteration of the device before data collection commenced. The reliability was assessed using Cronbach's alpha, which yielded 0.864 for the 25 items, indicating high internal consistency and adequate reliability. Nonetheless, sophisticated construct validation methods, such as Exploratory Factor Analysis (EFA) or Confirmatory Factor Analysis (CFA), were not performed owing to the very restricted sample size. Consequently, while the instrument demonstrated satisfactory content validity and reliability, it is advisable for future research with larger samples to conduct more extensive psychometric validation to enhance the evaluation of ecological literacy notions.

The questionnaire was evaluated by specialists in Sociology education and environmental education to determine item relevance, conceptual clarity, and conformity with the research goals. Expert feedback was included in later editions of the instrument. Despite the absence of formal quantitative content validity criteria such as the Content Validity Ratio (CVR), the expert review process enhanced the clarity and comprehensiveness of the questionnaire items.

The five aspects outlined in Table 2 were drawn from recognized theoretical frameworks on ecological literacy, environmental education, and critical pedagogy. To reduce conceptual overlap across aspects, the instrument underwent a content validation procedure with specialists in Sociology education and environmental education. The experts evaluated each item for conceptual relevance, clarity, and alignment with its intended dimension, and their input guided additional improvements to the questionnaire. Despite the absence of formal construct validation processes such as EFA or CFA due to the restricted sample size, the expert review process served as a crucial tool to ensure conceptual coherence and minimize overlap across dimensions.

The questionnaire items were designed to assess instructors' self-assessed comprehension and instructional methods regarding ecological literacy, rather than to objectively gauge ecological literacy proficiency. Consequently, the test records participants' subjective assessments

Table 2. Question instrument about teachers' comprehension of ecological literacy

Dimension	Question
Knowledge on Living Environment	▪ I have good knowledge on climate change issue ▪ I understand the impact of air pollution on human health ▪ I know the importance of biodiversity conservation ▪ I am aware of plastic problems in the sea and on land and their impact on the sustainability of the environmental ecosystem.
Awareness of the Impact of Human Activities on environment	▪ I am aware of human activities exerting a significant impact on environmental change ▪ I understand how power (energy) consumption affects the environment ▪ I understand the consequences of deforestation on climate change ▪ I can integrate environmental issues into sociology teaching material
Ability of Integrating Ecological Literacy into the Curriculum	▪ I often use environmental cases in Sociology teaching in my class ▪ I feel confident in teaching ecological literacy in Sociology learning to students ▪ I use various media (video, article, etc.) to teach ecological literacy to students
Application of Critical Pedagogy	▪ I encourage students to think critically about environmental issues. ▪ I invite the students to analyze social injustice related to environmental issues. ▪ I integrate discussion on public and economic policies into the environmental context ▪ I motivate students to engage in collective action for environmental change.
Challenges in Ecological Literacy Teaching	▪ Limited resources (media, teaching material, etc.) inhibit ecological literacy teaching in Sociology class ▪ Students' poor interest in environmental issues becomes a challenge to me ▪ I think that I am not supported adequately by the school in teaching ecological literacy. ▪ I have difficulty in finding appropriate teaching material to teach ecological literacy
Impact of Ecological Literacy on the Students	▪ I see the students' improved awareness of environmental issues ▪ Students begin to show the positive change of behavior to the environment (e.g., reducing plastic use) ▪ Students engage in environmental activities in the community where they live ▪ Students analyze environmental issues more critically having attended my Sociology class.

of their knowledge, awareness, and instructional experiences.

Due to the self-report nature of the test, the results obtained from the questionnaire should be regarded as indicators of instructors' perceived comprehension and confidence in applying ecological literacy, rather than as direct evidence of actual proficiency. To address this constraint, the survey results were supplemented with interviews, classroom observations, focus group

discussions, and document analysis, enabling a more thorough investigation of teachers' ecological literacy practices.

The questionnaire used a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree). Elevated ratings indicated greater concurrence with each assertion regarding teachers' apparent comprehension of ecological literacy, its incorporation into Sociology education, the use of critical pedagogy, and the obstacles encountered during implementation.

In addition to a closed-ended questionnaire, the author used in-depth interviews, observations, focus group discussions, and document analysis to obtain in-depth data. An in-depth interview was conducted with 5 selected teachers to further explore their understanding of ecological literacy in Sociology learning using a critical pedagogic approach, and to examine the challenges (threats) and opportunities they face in the learning process.

Data Analysis

Quantitative data from the closed-ended questionnaire were analyzed using descriptive statistics to determine teachers' levels of understanding of ecological literacy in Sociology learning through a critical pedagogic approach. The results of the descriptive analysis are presented in a table to facilitate data interpretation. Furthermore, the qualitative data from interviews, FGDs, and observations were analyzed using thematic analysis. The analysis process involved transcribing interview and FGD results, coding the data, identifying key topics, and interpreting the research findings within the context of critical pedagogy. The qualitative data validation was carried out using source triangulation by comparing data obtained from the questionnaire, interview, FGD, observation, and document study, and the data were later verified to ensure data validity.

■ RESULT AND DISCUSSION

Sociology Teachers' Comprehension in Integrating Ecological Literacy into the Learning

Before presenting the survey results, it is essential to recognize that the questionnaire evaluated teachers' self-assessed comprehension of ecological literacy rather than their objectively validated knowledge or proficiency. Consequently, the quantitative findings should be interpreted as indicative of instructors' perspectives on their own comprehension and pedagogical methods, rather than as conclusive evidence of their actual ecological literacy competence. Due to the potential effects of subjective judgment and response bias on self-reported measures, the results are interpreted with caution and supplemented by qualitative data gathered through interviews, classroom observations, focus group discussions, and document analysis. This triangulation method was used to provide a more thorough and nuanced comprehension of how teachers perceive and execute ecological literacy in Sociology education.

This research aims to explore the teachers of Sociology's comprehension of ecological literacy and to identify the support and challenges they encounter in applying ecological literacy using a critical pedagogic approach in Sociology learning at school. Descriptive statistics were used to analyze the quantitative data, including frequencies, percentages, mean scores, and standard deviations. To enhance understanding, mean scores were classified into equal interval ranges as follows: 1.00–1.80 (very low), 1.81–2.60 (low), 2.61–3.40 (moderate), 3.41–4.20 (high), and 4.21–5.00 (very high). This classification was used to characterize teachers' apparent comprehension of ecological literacy and its application in Sociology education. The descriptive study indicated that teachers generally had favorable views of their understanding of

ecological literacy. The majority of respondents exhibited elevated or exceptional levels of perceived comprehension, indicating that ecological literacy is widely seen as a crucial element of Sociology education. Nonetheless, these results must be interpreted with caution, since the questionnaire assessed instructors' self-perceived comprehension rather than objectively validated ecological literacy.

Nonetheless, the results must be interpreted with caution, since the questionnaire assessed instructors' self-assessed comprehension rather than objectively measured ecological literacy competency. The quantitative findings suggest favorable views on ecological literacy, while qualitative data reveal discrepancies between the extent of teachers' conceptual understanding and its classroom application. Numerous teachers demonstrated a robust understanding of environmental issues; however, their explanations frequently centered on general environmental knowledge and did not adequately address broader aspects of ecological literacy, including environmental justice, socio-ecological interdependence, and transformative action. This implies that elevated perceptions of comprehension do not inherently correlate with similarly high levels of actual ecological literacy competency in practice.

Although most teachers have good comprehension, it remains limited to basic knowledge. Only a few teachers could comprehensively explain the crucial aspects of ecological literacy, such as knowledge and understanding of environmental concepts, the ability to think critically about ecological issues, and the skill to take action on environmental issues. When asked about their understanding of ecological literacy, the majority of teachers characterized it as the ability to identify environmental issues and understand the relationship between human actions and environmental sustainability.

"Utilizing the environment for learning by giving emphasis on the utilization of waste existing in the surroundings" (KA, Sociology Teacher)

"Having heard theoretically, but not comprehended it in-depth because there has been no training to sharpen and to improve ecological literacy-related competency" (AM, Sociology Teacher)

"Literacy comprehension of ecological condition or natural habitat surrounding the students" (WP, Sociology Teacher)

While the quantitative results indicate that instructors believe they possess a robust understanding of ecological literacy, the qualitative data reveal significant limits in the depth of that knowledge. The majority of teachers could recognize environmental issues and articulate their immediate effects; however, only a limited few exhibited a profound comprehension of ecological literacy as a socio-political construct associated with power dynamics, inequality, environmental justice, and collective transformation. This gap underscores the constraints of self-assessment tools, which may indicate instructors' confidence in addressing environmental subjects rather than their capacity to critically engage with the overarching principles of ecological literacy. From a critical pedagogy standpoint, the data indicate that ecological literacy among many teachers is mostly limited to environmental knowledge rather than critical consciousness. The qualitative data significantly contribute to uncovering aspects of knowledge that self-reported survey answers alone do not capture, offering a more thorough assessment of teachers' ecological literacy practices.

The interview data show that teachers have a fairly good understanding of ecological literacy. Teachers have had basic knowledge of ecological literacy, but they have not had adequate skills to implement it. The integration of ecological literacy into Sociology education is an important measure

to address urgent environmental issues today. Sociology teachers play a strategic role in transmitting knowledge and attitudes concerning the environment to students. Considering the findings of research, it can be seen the extent to which a teacher can integrate ecological literacy into Sociology learning using a critical pedagogic approach. The table below presents the results of a survey indicating teachers' ability to integrate ecological literacy into the sociology curriculum.

Tabel 3. Distribution of teachers' responses on the integration of ecological literacy into sosiology learning ($n = 75$)

Statement	Percentage of Respondents (%)					Mean Score
	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	
I am capable of integrating environmental issues into Sociology learning materials	1.3	4.0	13.3	42.7	38.7	4.05
I often use environmental case study in Sociology teaching in my class	1.3	5.3	17.3	45.3	30.7	3.89
I feel confident in teaching ecological literacy in Sociology learning to students	2.7	8.0	24.0	41.3	24.0	3.65
I use various media (video, article, etc.) to teach ecological literacy to students	1.3	6.7	18.7	46.7	26.7	3.87
Percentage Scale	0%	25%	50%	75%	100%	

Source: Author's Processed Data (2025)

Note. Percentage values may not total 100.0 due to rounding.

Table 3 illustrates the distribution of instructors' responses regarding the incorporation of ecological literacy into Sociology education. In general, responses were primarily in the "Agree" and "Strongly Agree" categories across all items, suggesting that teachers' ability to integrate ecological issues into classroom instruction is highly regarded. The teachers' capacity to incorporate environmental issues into Sociology learning materials and their utilization of environmental case studies as learning resources generated the highest levels of agreement. Nevertheless, the item on confidence in teaching ecological literacy showed a relatively higher proportion of neutral responses, suggesting that, despite recognizing the significance of ecological literacy, some teachers are unsure how to effectively incorporate it into their classroom practices.

These results corroborate prior research that underscores the growing recognition of environmental themes as a critical element of sustainability-oriented education (Chen et al., 2022; Balážová et al., 2024). However, the prevalence of neutral responses suggests that integrating ecological literacy into teaching practice requires more than mere conceptual awareness. Teachers' pedagogical preparedness, access to pertinent instructional resources, and opportunities for professional development are all critical components of successful implementation. As a result, the findings indicate that the integration of ecological literacy into Sociology education is still being developed rather than fully institutionalized in classroom instruction.

The result of the survey is confirmed with the qualitative data resulting from in-depth interviews and FGD with 13 (thirteen) Sociology teachers, enriching the findings of the research related to the attempt taken by teachers to integrate ecological literacy into Sociology learning using a critical pedagogic approach. In

addressing inquiries about incorporating ecological literacy into Sociology education, teachers emphasized various pedagogical strategies, such as contextual case studies, environmental initiatives, and dialogues on local ecological issues.

"Choosing contextual material and learning in a social environment related to the living environment. For example, in choosing local wisdom material, I invited students to know the tradition or customary rule of the community in maintaining the environment, such as the "Awig-awig" custom in Bali prohibiting the people from cutting off the trees haphazardly, etc. (YS, Sociology Teacher)

"Ecological literacy is included in material related to social harmony, in which it contains harmony with the surrounding environment, which can be related to norms living within the community related to natural conservation (AY, Sociology Teacher)

"Teachers attempt to put ecological literacy into the material of Community Empowerment because the material relates to the environment"(SD, Sociology Teacher)

The results of the research show that the Sociology teachers' comprehension of ecological literacy varies fairly with the critical pedagogic approach. Some teachers demonstrate in-depth understanding, while others have difficulty integrating ecological literacy into their teaching. Although the majority of teachers state that they have integrated ecological literacy into Sociology instruction, only a very few of them can explain the crucial aspects of ecological literacy comprehensively, such as knowledge and understanding of environmental concepts, the ability to think critically about ecological issues, and the skill to take action regarding the environment. This finding is in line with previous research indicating that the quality of teachers in environmental (ecological) literacy is still limited (K. S. Liu et al., 2018; Tomás et al., 2022; Kumari, 2025)

In the teaching-learning process, the majority of teachers have demonstrated self-confidence in integrating ecological literacy into Sociology instruction, with a mean score of 4.05 (high). Using various learning models and media, most teachers have attempted to contextualize surrounding environmental issues with the Sociology learning material. Through a series of learning activities using learning films or videos, group discussions, project-based assignments, and field assignments, students' ecological awareness of living environmental issues needing urgent solutions can be gradually developed. This is in line with previous research findings that problem-based learning can improve students' ecological literacy (Widowati et al., 2021; Anggraini et al., 2022; Partiwi, 2022).

The interview results indicate that teachers often have a basic comprehension of ecological literacy and acknowledge its significance in tackling current environmental issues. Nevertheless, the qualitative findings indicate that the incorporation of ecological literacy into Sociology education differs significantly in both depth and pedagogical approach. Numerous teachers reported using methodologies such as case studies, classroom dialogues, and project-based initiatives to present environmental concerns. Although these methods provide students with the opportunity to confront real-world socio-environmental issues, their execution does not always align with the transformational objectives of critical pedagogy.

From a Freirean standpoint, ecological literacy must transcend mere dissemination of environmental information to foster critical awareness (conscientização), empowering pupils to scrutinize the systemic origins of environmental degradation and social inequity. The results demonstrate that the majority of teachers effectively motivated students to recognize

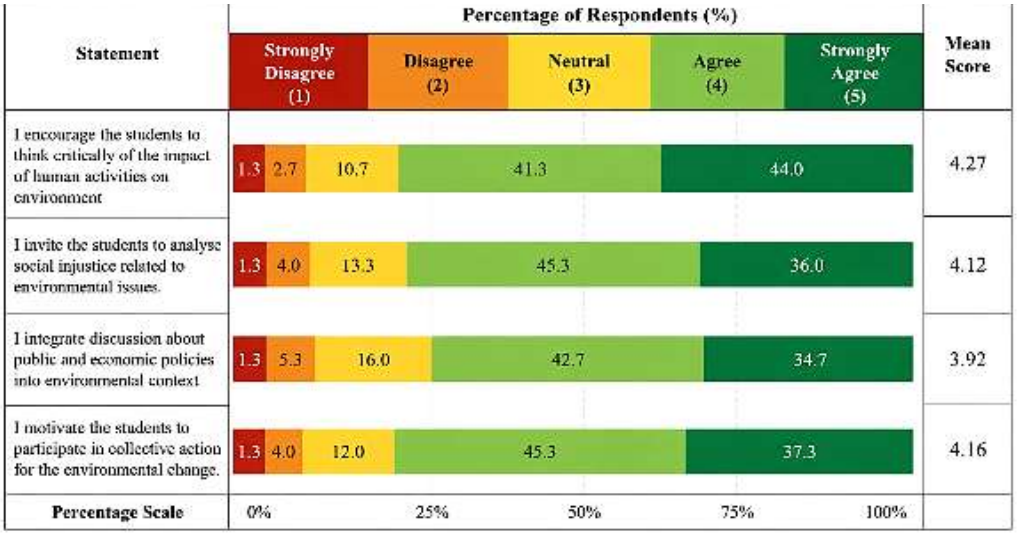
environmental issues and examine their repercussions; however, a smaller number of teachers promoted more profound critical exploration of topics such as environmental justice, power dynamics, inequitable resource allocation, and collective social activism. Consequently, educational activities often prioritize environmental knowledge over the cultivation of transformational socio-ecological comprehension.

Moreover, although project-based learning and case-study methodologies have the capacity to foster dialogic and participative learning, classroom observations indicated that their implementation was often dominated by teacher-centered instruction. This indicates that pupils were often seen as passive consumers of environmental information instead of active co-creators of meaning. Freire (1970) posits that critical pedagogy necessitates authentic discussion, contemplation, and action (praxis) that enable learners to confront prevailing social realities. Consequently, while the tactics used by teachers signify significant progress in incorporating ecological literacy into Sociology education, their transformational potential remains unfulfilled. These results suggest that ecological literacy training occupies a position between environmental awareness and critical ecological consciousness, underscoring the need for enhanced focus on dialogic interaction, student empowerment, and social change in Sociology education.

The Application of Critical Pedagogy in Sociology Learning

The critical pedagogy approach is an effective strategy for integrating ecological literacy into Sociology learning. A critical pedagogic approach emphasizes students' abilities to comprehend, critique, and take real action regarding environmental issues within the community. Based on the survey results, teachers have varying abilities in applying critical pedagogic principles to students' ecological literacy. The table below presents the teachers' ability to apply critical pedagogic principles to Sociology learning.

Tabel 4. Distribution of teachers' responses on the aplication of ecological critical pedagogy to sosiology learning ($n = 75$)



Source: Author's Processed Data (2025)

Note. Percentage values may not total 100.0 due to rounding.

Table 4 displays the distribution of responses regarding the integration of critical pedagogy into the study of Sociology. The results suggest that the majority of teachers chose "Agree" or "Strongly Agree" for all statements, indicating positive perceptions of their efforts to promote critical thinking, social analysis, and collective engagement with environmental issues. The item encouraging students to critically examine the environmental consequences of human activities elicited the strongest agreement. In contrast, discussions connecting environmental issues with public policy and economic structures elicited comparatively lower levels of agreement.

These results indicate that teachers have begun to transition from transmissive methodologies to more dialogical and reflective learning processes from a critical pedagogical perspective. (Freire, 1970, 2021; Misiaszek, 2022) contends that education should empower students to critically analyze social realities and cultivate transformative agency. The results indicate that Critical Pedagogy may still be implemented primarily at the level of individual awareness, rather than deeper examinations of power relations, environmental justice, and socio-political transformation. Although critical reflection is increasingly incorporated into Sociology learning, the comparatively low number of responses related to policy and structural analysis underscores this. This finding is consistent with research indicating that problem-based learning has a positive and significant effect on students' critical thinking ability and ecological literacy (Andriopoulou et al., 2022; Nur et al., 2023).

The quantitative data presented in Table 6 are corroborated by interview and FGD data, indicating that the majority of teachers have attempted to apply critical pedagogic principles to sociology learning by stimulating students' critical thinking about the connection between human activities and environmental sustainability. The teachers also invite students to identify and analyze social injustice related to environmental issues in context by connecting these issues to global concerns, such as injustice in natural resource management, damage to forest ecosystems, industrial pollution, and the impact of climate change on the long-term sustainability of vulnerable community groups. Furthermore, teachers encourage students to take concrete actions to conserve the environment, such as recycling, campaigning for energy conservation on social media, and participating in conservation activities. During the discourse on the application of critical pedagogy, participants were asked about their methods for prompting students to critically analyze environmental concerns and social disparities.

"By inviting the students to discuss ecological issues in the surrounding environment, doing real practice and action in the ecosystem" (WP, Sociology Teacher)

"Children are invited to observe the school environment and shown with a concrete example. Then, they are told to observe the environment where they live" (MR, Sociology Teacher)

Analysis of lesson plans reveals that ecological themes have been carefully included in instructional design. These concerns are not addressed as independent subjects but are instead included within overarching sociological themes, such as social change, globalization, and social inequality. This approach aims to establish ecological literacy as a fundamental aspect of sociological study, highlighting the link between environmental issues and social institutions.

Analysis of documents and classroom observations indicated discrepancies in the use of ecological literacy in Sociology education. Although lesson-planning papers often included ecological literacy aims through environmental themes, case studies, and project-based activities, the implementation of these aspects in

classroom practice varied among instructors. In some instances, environmental concerns were effectively integrated into educational programs, but opportunities for critical thought, dialogic interaction, and transformational action were not consistently realized. The results indicate that ecological literacy was often included in curricular development and topic selection; however, its execution in classroom practice varied in depth and pedagogical approach. The results suggest a partial alignment rather than a total discrepancy between intended and enacted curricula, with teachers exhibiting differing abilities to convert ecological literacy objectives into significant learning experiences that adhere to the principles of critical pedagogy.

This discrepancy indicates that although ecological literacy has been formally recognized in curriculum design, its implementation in classroom practice is inconsistent and incomplete. Ecological concerns are included in the planning, although they are not consistently manifested in the actual teaching and learning activities.

Nevertheless, most teachers admit that the integration of ecological literacy into sociology instruction remains limited and not yet optimal. In implementing ecological literacy through a critical pedagogic approach in Sociology learning, teachers face several challenges, both internal and external. Internal challenges include teachers' limited understanding of ecological literacy and poor pedagogical ability to integrate it into their teaching. Meanwhile, external challenges relate to limited facilities and infrastructure, support from school policy, and engagement with students' parents. Data on challenges faced by teachers in implementing ecological literacy are presented below.

Tabel 5. Distribution of teachers' responses on the challenges they encounter in implementing ecological literacy in sosiology learning ($n = 75$)

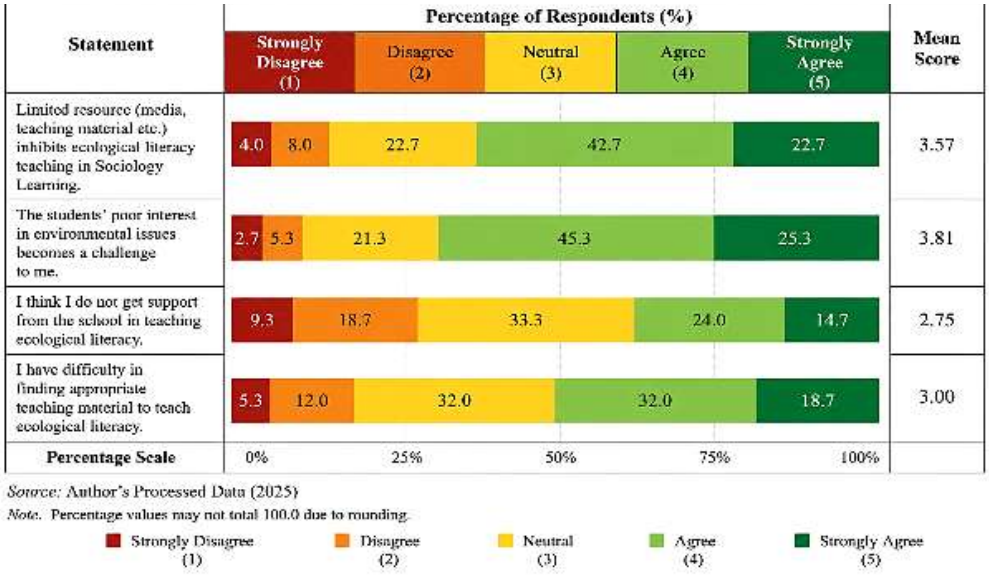


Table 5 shows that limited resources and students' low interest in environmental issues pose significant challenges for teachers. They think that students' lower interest makes the teachers' appeal to bring this issue into the learning less effective. This finding is consistent with previous research indicating that most students possess conceptual knowledge of the environment, yet this is not accompanied by environmental attitudes and behaviors (Häggström & Schmidt, 2020; Lestari et al., 2023). The solution implemented by the teachers includes collaborating with

environmental organizations, developing creative teaching materials, and utilizing digital technology to make learning more engaging. Some teachers emphasize the importance of school and policymakers' support to prioritize ecological literacy in the curriculum and learning. Participants were asked to consider the difficulties encountered in implementing ecological literacy in classroom practice.

"Not all teachers have applied the contextual learning connecting sociology material to ecological literacy. Teachers still tend to teach based on the content of the textbook" (YS, Sociology Teacher)

"The constraint the teachers encounter is mainly the students tending to be less interested in conserving the environment" (SD, Sociology Teacher)

"The difficulty in presenting the field condition in the learning class. Moreover, the observation made by the students is limited, can neither be guided nor done at any time" (MR, Sociology Teacher)

Table 5 also presents several important findings regarding the challenges teachers face, including limited resources (e.g., facilities and infrastructure), limited support from school policy, and inadequate training and professional mentoring. The results underscore many obstacles teachers encounter in integrating ecological literacy into Sociology education. Table 7 indicates that the predominant problems mentioned were students' little interest in environmental concerns (M = 3.81) and limitations with teaching resources and instructional materials (M = 3.57). Conversely, views of school support were indicated at a modest level (M = 2.75), suggesting that institutional support may not be seen as a significant obstacle by all teachers. The results suggest that initiatives to bolster ecological literacy in Sociology education should prioritize increasing students' engagement with environmental concerns and improving access to relevant teaching resources and learning materials. This assistance may help teachers translate their ecological literacy into more effective teaching practices.

This finding is in line with previous research indicating that the school's environmental conditions, school policy support, and parents' engagement are the main barriers to the development of students' knowledge and skills in a loving environment (Häggström & Schmidt, 2020; Prasetyo Riyadi et al., 2018). In addition, this finding confirms the importance of the school's support through providing professional training and mentoring for the teachers to improve their capacity to integrate ecological literacy into Sociology learning.

On the other hand, this study also identifies several opportunities that teachers can use to improve students' ecological literacy. The use of social media technology can be an effective means of improving the students' interest in environmental issues. Teachers can use social media to share engaging learning content relevant to students' lives. In addition, teachers can use social media as an effective means of assigning the students to produce creative content about the environmental care campaign. This finding is in line with previous research emphasizing that the use of technology media in learning can improve the students' enthusiasm and active participation (Widowati et al., 2021; Anggraini et al., 2022; Andriopoulou et al., 2022). In addition, engaging students in various practical environmental care projects is a strategic opportunity for teachers to improve students' ecological literacy. Teachers, as facilitators, can invite students to collaborate on designing a real-world action project focused on the environment by leveraging the community's local wisdom. The teachers can incorporate this program into a practical assignment on the material of Local Wisdom-based Community Empowerment in the

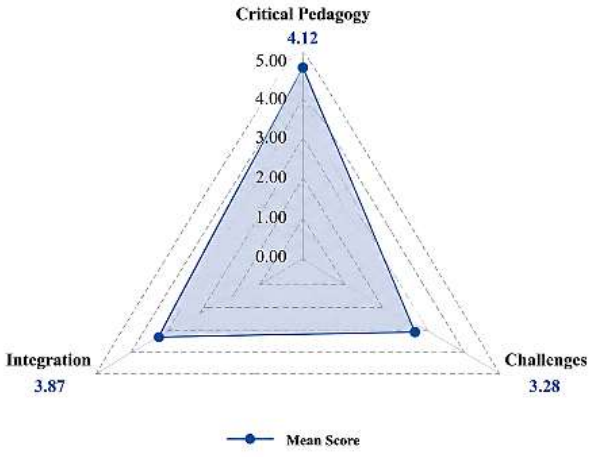
Sociology learning. Furthermore, through a project that reinforces the profile of Pancasila students, teachers can collaborate with the community concerned with the environment outside the school to design the environmental care program more comprehensively.

This research finding confirms the critical pedagogic theory proposed by Freire. Through his theory, Freire confirms the importance of education as a means of growing critical consciousness and social transformation (Freire, 1970). The finding shows that ecological literacy taught through a critical pedagogic approach in Sociology learning not only improves students' critical understanding of environmental issues but also encourages them to take real action on them. It is in line with Freire's (1970) view that education should liberate individuals from mistreatment by developing critical consciousness. The results of the study show that this approach is effective in improving students' critical reasoning ability related to environmental issues. This is in line with the results of previous research (Gunansyah et al., 2023; Laya, 2020b; Laya, 2020a), which show that fostering a critical educational atmosphere in schools contributes to students' comprehension and awareness of environmental issues around them.

Henry Giroux emphasizes the importance of education in creating political and social consciousness among the students. Giroux states that education should teach students to develop critical reasoning and thinking abilities related to issues of power and injustice within the community (Giroux, 2018). This finding supports Giroux's view by indicating that ecological literacy in Sociology learning, taught from a critical pedagogic perspective, can help students comprehend the power structures that contribute to environmental issues at the local, national, and global levels. Meanwhile, Peter McLaren emphasizes the importance of creating a dialogic space between students and teachers to collectively foster a critical dialogical culture (McLaren & Bosio, 2022). McLaren views education as a collaborative process in which all students are entitled to voice their inspiration. This study's finding shows that the critical dialogical space between teachers and students in the learning process very effectively improves students' comprehension of environmental issues.

Overall, the results of the current study confirm the critical pedagogic theory in many respects. In addition, this study highlights the need for additional support from policymakers, school stakeholders, and teachers, as well as teachers' adaptive strategies to cope with the existing challenges (threats) and opportunities. Larger institutional support, through appropriate efforts to develop resources, will be very important in helping teachers effectively apply critical pedagogy to Sociology learning. This research contributes theoretically to existing literature by providing empirical evidence on the application of critical pedagogy to ecological literacy in Sociology learning. This finding of the study can also be used to identify areas where this approach can be improved and strengthened. The study's use of self-reported questionnaire data, which captures perceived comprehension rather than objective knowledge, is a limitation. It is suggested that future research integrate objective assessment instruments to more comprehensively measure instructors' ecological literacy.

Figure 1 presents a comprehensive comparison of the mean scores across the three principal variables examined in this study: ecological literacy integration, critical pedagogy application, and implementation problems. The radar map indicates that the application of critical pedagogy achieved the greatest mean score (M = 4.12), followed by the incorporation of ecological literacy into Sociology education (M = 3.87). In contrast, implementation difficulties yielded a notably lower mean score (M = 3.28). This trend indicates that teachers often see



Note. The scale ranges from 1 (Very Low) to 5 (Very *High*).

Source: Author's Processed Data (2025)

Figure 1. Comparative mean scores of teachers' perception across three dimentions (n = 75)

themselves as proficient at integrating ecological concepts into Sociology teaching while concurrently using instructional methods that promote critical thinking about environmental issues.

The significance of the critical pedagogy aspect aligns with Freire's (1970) and Misiaszek's (2022) assertions that education must foster critical awareness through conversation, reflection, and active engagement with social realities. Within Sociology education, ecological challenges offer significant opportunities for students to critically analyze the relationships among environmental deterioration, social inequity, and human agency. Similarly, the comparatively elevated score for ecological literacy integration corroborates prior research highlighting that environmental themes are progressively acknowledged as a vital element of sustainability-focused education (Black, 1994; DNN & Capra, 1997). The results demonstrate that Sociology instructors recognize the pedagogical significance of ecological literacy and have endeavored to integrate environmental issues into classroom instruction via debates, case studies, and contextual learning activities.

Nonetheless, the challenge underscores the enduring structural and pedagogical limitations that may hinder the effective implementation of ecological literacy. In line with other studies on Education for Sustainable Development (ESD), teachers reported challenges including inadequate instructional resources, a scarcity of teaching materials, and varying levels of student engagement with environmental topics. Such limits may diminish prospects for cultivating critical discussion and transformational learning experiences that are fundamental to critical pedagogy. The findings indicate that enhancing ecological literacy in Sociology education requires teachers' dedication and pedagogical proficiency, along with ongoing institutional support through curriculum development, professional learning opportunities, and the availability of relevant educational resources. The radar chart collectively indicates that teachers hold favorable views on integrating ecological literacy and critical pedagogical practices; however, the enduring success of sustainability-focused education depends on confronting the contextual challenges that continually shape classroom practice.

■ CONCLUSION

The results of this research have significant implications for educational policy and

professional practice. Teachers usually recognize the significance of ecological literacy in Sociology education; however, its implementation varies in depth, indicating a need for more systematic support to enhance its integration within the *Merdeka* Curriculum. At the professional level, the Sociology Teachers' Working Group (MGMP Sosiologi) might assume a strategic role by fostering collaborative learning communities, creating themed teaching modules, and facilitating classroom-based exchanges of best practices centered on ecological literacy and critical pedagogy. Regular seminars and lesson-study activities may assist teachers in progressing beyond mere environmental knowledge to promoting environmental justice, fostering critical discussion, and encouraging collective socio-ecological action within classroom learning. Curriculum developers should explicitly incorporate ecological literacy into Sociology learning outcomes, teaching resources, and assessment frameworks, ensuring that environmental issues are regarded as essential elements of sociological inquiry and citizenship education rather than supplementary content. Such approaches would enhance Sociology education's capacity to develop ecologically responsible, critically aware, and socially involved people.

Nonetheless, the results must be considered in the context of many constraints. A purposive sample limits the transferability of the results to the broader population of Sociology instructors in Indonesia, and the questionnaire assessed teachers' self-perceived comprehension rather than objectively measuring ecological literacy skills. Despite data triangulation through interviews, observations, focus group discussions, and document analysis, the interpretation of qualitative results remains context-dependent. Subsequent research should incorporate larger, more diverse samples, utilize more stringent psychometric validation methods, and examine the impact of MGMP-based professional development and curricular innovations on the sustained advancement of students' ecological literacy, critical consciousness, and environmental citizenship.

DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the preparation of this manuscript, the author used ChatGPT to assist with manuscript outlining, organization of ideas, and the preparation of data visualization formats for presenting statistical results; Consensus to identify relevant scholarly references; and QuillBot to support English-language editing and grammar checking. All analytical decisions, interpretation of findings, and conclusions were made solely by the author. The author critically reviewed and revised all AI-assisted outputs to ensure accuracy, originality, and adherence to scholarly standards, and assumes full responsibility for the final published content.

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