



PRE-SERVICE TEACHERS' PERCEPTIONS OF AI ETHICS AND ETHICAL DILEMMAS IN SCIENCE CLASSROOM CONTEXTS

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Introduction

Artificial intelligence is reshaping how teachers teach and how students learn. Yet the speed of adoption has outpaced our understanding of the ethical problems it creates, particularly in classrooms where teachers must make real-time decisions about data, fairness, and student autonomy. International bodies have responded with broad ethical frameworks (UNESCO, 2023; OECD, 2019; European Union, 2024), and researchers have identified recurring principles such as non-maleficence, fairness, transparency, accountability, and privacy protection (Jobin et al., 2019). These principles, however, offer limited guidance when they conflict with each other in practice: prioritizing personalization may compromise equity, and demanding transparency may reduce predictive accuracy (Selbst et al., 2019; Whittlestone et al., 2019). For science education, where teaching depends on data collection, empirical observation, and evidence-based reasoning, these tensions are not abstract; they arise in routine classroom activities.

Research Problem

What remains insufficiently understood is not whether teachers need to understand AI ethics, but how they actually reason through ethical conflicts when they encounter them. Holmes et al. (2021) have emphasized that teachers play a key role in ensuring explainability and accountability in AI-based learning environments, positioning teacher judgment as central to responsible AI use in education. Several lines of research have begun to address this question, though from different angles.

One strand has focused on AI ethics principles and their application in education. Researchers have proposed comprehensive frameworks (Floridi et al., 2018), argued that ethical effects in education are cyclical rather than linear (Dieterle et al., 2024), and mapped the landscape through systematic reviews (Wiese et al., 2025). Yet a gap persists between these principle-level frameworks and what teachers actually face in classrooms.

A second strand has examined teachers' perceptions and readiness. Among in-service teachers, Alshorman (2024) has reported that science teachers recognize the pedagogical benefits of AI but that their readiness to integrate these tools is closely associated with concerns about ethical imple-

Abstract. *Pre-service teachers are increasingly responsible for guiding students through AI-related ethical challenges in science classrooms, yet little is known about how they perceive these challenges. In this study, 165 pre-service teachers completed a 19-item perception scale spanning five AI ethics domains and an engagement measure, and responded to eight open-ended dilemma scenarios set in science classrooms. Participants showed strong agreement on non-maleficence ($M = 4.57$) and privacy protection ($M = 4.51$) but lower and more varied responses on accountability ($M = 3.73$) and fairness ($M = 3.94$). Female participants scored significantly higher than male participants in overall perception, while no differences were found by major field or AI coursework experience. Scenario responses revealed that ethical concerns shifted depending on teaching context: learning integrity dominated in student assignment scenarios, verification responsibility in teacher use scenarios, and privacy-public interest tension in social application scenarios. Across scenarios, proposed solutions remained largely at the level of general prescriptions, such as ethics education and prior consent procedures, with few implementation-ready alternatives. These results point to the need for scenario-embedded AI ethics education within science teacher preparation programs.*

Keywords: *AI ethics, ethical dilemma, pre-service teachers, science education, teacher preparation*

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mentation. Viberg et al. (2025), in a six-country comparative study, have found that higher levels of AI understanding and self-efficacy were associated with greater trust and acceptance, and that awareness of ethical issues was closely linked to professional competence. Lee (2025) has analyzed AI ethics perceptions and scenario-based dilemma awareness among 53 in-service teachers majoring in AI convergence education, finding high awareness in non-maleficence and privacy protection but relatively lower and more varied perceptions in fairness and accountability.

Research on pre-service teachers has grown rapidly but has focused primarily on competencies and attitudes rather than ethical judgment. Han (2025) has assessed AI competencies among 79 pre-service teachers and reported moderate levels of ethical awareness. Gamlem et al. (2026), in a study of 209 Norwegian pre-service teachers, have found that the majority had experience using generative AI but expressed concerns about ethical considerations, privacy infringement, and bias. Ng et al. (2021) have identified understanding, application, and ethics as key components of AI literacy but noted a lack of research analyzing ethical judgment in specific educational contexts. Erdogan et al. (2026), in a study of 219 pre-service science and mathematics teachers, have found that high levels of AI literacy in technical dimensions did not translate into ethical reasoning capacity.

What connects these studies is a shared finding: knowing ethical principles does not automatically produce the ability to apply them in context. This distinction between principle awareness and situated judgment is central to the present study.

Research Focus

The gap this study addresses is not simply that pre-service teachers have been understudied. It is that existing research has measured ethical awareness primarily through general attitude scales or competency inventories, without placing participants in situations that require them to weigh competing values. A pre-service teacher may agree that privacy is important, but the harder question is what they would do when an AI system that improves learning outcomes also collects sensitive student data. Scenario-based approaches can reveal this kind of reasoning in ways that Likert scales alone cannot.

Science classrooms are a particularly productive setting for this investigation. Science teaching routinely involves activities where AI ethics tensions become concrete: students collect and analyze data, use digital tools for inquiry, evaluate evidence, and produce empirical reports. When a student submits AI-generated photographs instead of conducting direct observation, or when an AI assessment system produces gender-biased results in a laboratory report, the ethical dilemma is inseparable from the pedagogical context. These are not hypothetical problems. They are situations that science teachers will increasingly face. Despite this relevance, few studies have examined how pre-service teachers perceive AI ethics specifically within science teaching contexts. The present study addresses this gap by combining a perception scale with scenario-based dilemma items set in science classrooms.

Research Aim and Research Questions

Accordingly, this study aims to analyze pre-service teachers' perceptions of AI ethics and their reasoning about ethical dilemmas in science classroom contexts. The specific research questions are:

1. What levels and characteristics does pre-service teachers' AI ethics perception exhibit across ethical domains, and do these differ by gender, prior AI coursework experience, or major field?
2. What ethical issues and solutions do pre-service teachers identify in AI ethics dilemma scenarios situated in science classroom contexts?

Research Methodology

General Background

This study adopted a cross-sectional survey design with both closed-ended and open-ended items. The research was conducted in September 2025 with pre-service teachers enrolled in teacher education programs in South Korea. The study drew on Jobin et al.'s (2019) five-principle framework of AI ethics (fairness, transparency, non-maleficence, privacy, and accountability) as an organizing structure for the perception scale, while the scenario component was grounded in the recognition that ethical judgment is shaped by the situational context in which it occurs (Brown et al., 1989). Quantitative data from a Likert-scale survey were analyzed using descriptive statistics and independent-samples t-tests to identify perception patterns and group differences across ethical



domains. Qualitative data from scenario-based open-ended responses were analyzed through thematic analysis and content analysis to examine how pre-service teachers perceive ethical issues and propose solutions within specific teaching contexts.

Participants

Participants were drawn through convenience sampling from three teacher education institutions in South Korea: two national universities of education, which prepare elementary school teachers, and one college of education within a national university, which prepares secondary school teachers. All participants were undergraduate students aged 19 or older enrolled in teacher certification programs. Sampling was conducted through course instructors who distributed the online survey link; participation was voluntary and not linked to course credit or evaluation. A total of 165 pre-service teachers completed the survey. By gender, 104 (63.03%) were female and 61 (36.97%) were male. Participants were distributed across 14 major fields and an ‘other’ category, with the largest representations in elementary education (25, 15.15%), science education (22, 13.33%), and early childhood education (18, 10.91%). Regarding prior experience with AI-related coursework, 92 participants (55.76%) had taken at least one AI-related course, while 73 (44.24%) had not. The general characteristics of the participants are presented in Table 1.

Table 1
Characteristics of Participants (N = 165)

	Characteristics	N	Ratio (%)
Gender	Male	61	36.97
	Female	104	63.03
Major	Elementary Education	25	15.15
	Science Education	22	13.33
	Early Childhood Education	18	10.91
	Physical Education	14	8.48
	Social Studies Education	13	7.88
	Korean Language Education	11	6.67
	English Education	9	5.45
	Mathematics Education	9	5.45
	Music Education	7	4.24
	Ethics Education	5	3.03
	Education	5	3.03
	Computer Education	3	1.82
	Art Education	3	1.82
	Technology & Home Economics Education	2	1.21
	Others	19	11.52
Experience	Experienced	92	55.76
	No experience	73	44.24

Instrument and Procedures

The survey instrument was constructed by adapting the AI ethics awareness scale developed by Jang et al. (2022) and the AI ethics dilemma perception items from Hong and Oh (2024), to fit the research purpose and the characteristics of pre-service teachers as the target population. Two experts in AI education reviewed the instrument for ambiguity, double meaning, and redundancy. The instrument consisted of two sections: an AI ethics perception scale and a scenario-based AI ethics dilemma scale.



The AI ethics perception section comprised 19 items: 17 items across five ethical domains: fairness (3 items), transparency (4 items), non-maleficence (4 items), privacy and data protection (3 items), and accountability (3 items), along with 2 items measuring engagement with AI ethics. All 19 scale items were rated on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree), except item F-1, which assessed personal interest in AI ethics (1 = not at all interested, 5 = very interested). Four items (B-3, C-2, D-3, E-2) were reverse-worded to mitigate acquiescence bias and were reverse-scored during analysis. Cronbach's α for the 19 items was .753, indicating acceptable internal consistency. Because each domain comprises only 2–4 items addressing distinct aspects of the same ethical principle, domain-level reliability was also examined; these values are reported in Supplementary Information (SI 2). Given the small number of items per domain, domain-level means are interpreted as exploratory descriptive indicators rather than reliable subscale scores. Additional items assessed experience with AI ethics issues (yes/no), perceived priority areas for AI ethics education (multiple response), awareness of student data security in digital systems (4-point scale), and open-ended opinions. The full item wordings for the perception scale and the scenario prompts are provided in Supplementary Information (SI 1).

The AI ethics dilemma section consisted of eight hypothetical scenarios adapted from the ethical dilemma items developed by Hong and Oh (2024). The scenarios were deliberately situated in science classroom contexts to examine how ethical dilemmas manifest within science-specific teaching activities, including data collection, empirical observation, laboratory assessment, and evidence-based inquiry. The topic and associated ethical domain of each scenario are presented in Table 2. Each scenario was followed by two open-ended questions in a uniform format: the first asked respondents to describe the ethical issues to be considered in the given situation, and the second asked them to propose solutions. Two AI education experts confirmed the appropriateness of the scenarios based on criteria of relevance, representativeness, and realism.

Table 2
Descriptions of Scenario-based AI Ethics Dilemma Items

No.	Topic	Ethical Domain	Description
1	AI Facial Recognition Attendance	Privacy	Students create an AI attendance system that collects and stores facial data
2	Gender-biased AI Assessment	Fairness	AI evaluation system produces gender-biased results in lab report assessment
3	AI-generated Photo Submission	Academic Integrity	Student submits AI-generated rock photos instead of taking real photographs
4	AI-fabricated Protest Footage	Non-maleficence	Student creates fake protest footage using AI for an environmental documentary
5	AI-written Essay Submission	Plagiarism/Copyright	Student submits an AI-restructured essay on endangered wildlife protection
6	AI Hallucination in Teaching Materials	Fact-checking/Accountability	Teacher identifies and filters out AI-generated non-existent cases for a climate change lesson
7	AI Personalized Learning Program	Privacy/Autonomy	Teacher implements an AI program that continuously monitors student performance
8	AI-analyzed Environmental Data for Public Good	Public Interest/Data Ethics	Student uses AI to analyze school air quality data, revealing poor conditions in staff rest areas

Data were collected over approximately four weeks, from September 1 to September 30, 2025, using an online survey platform. Prior to responding, participants were informed of the research purpose, anonymity of data processing, prohibition of use beyond research purposes, and freedom to withdraw participation; only those who consented proceeded to the survey. The estimated response time was approximately 20–30 minutes. Under the Korean Bioethics and Safety Act (Enforcement Rule, Article 13), research using anonymous survey data that does not collect personal identifiers qualifies for exemption from Institutional Review Board review. Accordingly, formal IRB approval was not required. Nonetheless, standard ethical procedures were followed as described above. No personally identifiable information was collected through the survey platform, and all data were stored on a



password-protected device accessible only to the researcher. A total of 165 valid responses were used in the final analysis. All survey responses were collected in Korean and translated into English by the author for reporting purposes. To preserve the meaning of participants' responses, the translation was reviewed by a bilingual colleague with expertise in education research. Coding was conducted on the original Korean responses, and representative quotations were translated after the coding process was finalized.

Data Analysis

Data analysis employed both quantitative and qualitative approaches. For the quantitative analysis of the AI ethics perception scale, descriptive statistics, including mean, standard deviation, mode, and frequency, were computed using IBM SPSS Statistics 29.0 to identify response tendencies across ethical domains. Reverse-worded items were reverse-coded prior to analysis to ensure directional consistency, and internal consistency was verified using Cronbach's α . To examine whether perceptions differed by participant characteristics, independent-samples t-tests were conducted by gender, prior AI coursework experience, and major field (science education vs. other majors). Given the exploratory nature of the study, no correction for multiple comparisons was applied; the group comparisons are therefore interpreted as exploratory, and effect sizes are reported for the gender differences to convey practical magnitude rather than relying on statistical significance alone. For the multiple-response item regarding perceived priority areas for AI ethics education, frequencies and percentages were calculated.

Qualitative analysis was conducted on the open-ended responses to the eight dilemma scenarios. Each scenario included two questions on ethical issues and solutions, yielding a total of 2,640 responses from 165 participants. Each response could be assigned multiple codes when more than one ethical issue was identified; accordingly, the reported frequencies represent the number of responses containing each code rather than the number of unique respondents. The analysis proceeded in two stages. First, inductive coding was performed following the thematic analysis procedure outlined by Braun and Clarke (2006). Responses were read repeatedly to generate initial codes and extract meaningful units, which were then categorized to derive and finalize themes. To ensure reliability, a randomly selected 30% of responses from each scenario (approximately 792 responses) were independently coded by the author and a second coder. Because each response could receive multiple codes, agreement was assessed at the level of individual code assignments, that is, whether each code was present or absent for a given response. Cohen's kappa calculated on this subset was $\kappa = .768$, indicating substantial agreement (Landis & Koch, 1977). The remaining responses were coded by the author using the agreed-upon coding scheme. Discrepancies were resolved through discussion to reach consensus, and the results were reviewed by experts in AI education and science education to verify the analytical validity. Second, content analysis was applied based on the finalized coding scheme to calculate the frequency of each code, thereby quantitatively identifying patterns in pre-service teachers' perceptions (Elo & Kyngäs, 2008).

Research Results

AI Ethics Perception Analysis

Pre-service teachers' AI ethics perceptions were analyzed by domain and item. The results for all 19 items are presented in Table 3, with reverse-scored items (B-3, C-2, D-3, E-2) adjusted for directional consistency. The overall respondent-level mean was 4.17 ($SD = 0.32$). Domain means were ranked as follows: non-maleficence (C) 4.57, privacy and data protection (D) 4.51, engagement (F) 4.09, transparency (B) 4.05, fairness (A) 3.94, and accountability (E) 3.73. Pre-service teachers showed the highest agreement on protection-oriented ethical principles such as AI safety and personal data protection, while domains requiring complex value judgment, such as fairness and accountability, showed relatively lower means with greater response variance.

The non-maleficence domain ($M = 4.57$) exhibited the highest mean and the smallest within-domain variance. All items were at or above $M = 4.44$, reflecting a strong consensus that AI should be used for beneficial purposes and that preventive ethics education is necessary. The privacy and data protection domain ($M = 4.51$) showed similarly high agreement, with item D-2 recording the highest mean across all 19 items ($M = 4.75$, $SD = 0.50$). Support for institutional regulation (D-1, $M = 4.50$) was also strong. However, the reverse item on allowing unrestricted corporate use of personal data (D-3, reverse-scored $M = 4.28$, $SD = 0.97$) showed relatively larger variance, suggesting some divergence regarding the balance between rights protection and data utilization.

Table 3*Descriptive Statistics of Pre-service Teachers' AI Ethics Perceptions by Domain and Item (N = 165)*

Domain	No	<i>M</i>	<i>SD</i>	Mode	Domain <i>M</i>
Fairness (A)	A-1	3.90	1.06	4	3.94
	A-2	3.29	1.05	3	
	A-3	4.62	0.57	5	
Transparency (B)	B-1	4.39	0.75	5	4.05
	B-2	3.10	1.11	2	
	B-3(R)	4.32	0.76	5	
	B-4	4.38	0.71	5	
Non-maleficence (C)	C-1	4.66	0.54	5	4.57
	C-2(R)	4.44	0.86	5	
	C-3	4.59	0.56	5	
	C-4	4.59	0.55	5	
Privacy & Data Protection (D)	D-1	4.50	0.70	5	4.51
	D-2	4.75	0.50	5	
	D-3(R)	4.28	0.97	5	
Accountability (E)	E-1	3.08	0.96	3	3.73
	E-2(R)	3.59	0.95	4	
	E-3	4.53	0.59	5	
Engagement (F)	F-1	3.72	0.82	4	4.09
	F-2	4.47	0.63	5	

The transparency domain ($M = 4.05$) showed high agreement on the necessity of AI explainability (B-1, $M = 4.39$) and limited trust in unexplainable systems (B-4, $M = 4.38$). However, item B-2, which asked whether accuracy should be prioritized over explainability, showed the lowest mean within the domain ($M = 3.10$, $SD = 1.11$), indicating divergent views on the trade-off between performance and transparency.

The fairness domain ($M = 3.94$) revealed a notable split. Agreement on the need for diversity and inclusivity in AI data was high (A-3, $M = 4.62$, $SD = 0.57$), but views on distributive justice regarding universal versus targeted provision of AI resources (A-2, $M = 3.29$, $SD = 1.05$) were divided, indicating that the application of fairness principles varies depending on the specific context.

The accountability domain ($M = 3.73$) was the lowest across all domains. While the need for social consensus on responsibility distribution was strongly endorsed (E-3, $M = 4.53$), items on developer responsibility (E-1, $M = 3.08$) and consumer liability (E-2, reverse-scored $M = 3.59$) showed low means and high variance, suggesting that pre-service teachers recognize the complexity of responsibility attribution but have not yet established clear criteria for assigning responsibility to specific agents.

The engagement domain ($M = 4.09$) revealed a gap between normative recognition and personal involvement. Agreement on the need for expanded AI ethics education was high (F-2, $M = 4.47$), but personal interest in AI ethics was comparatively lower (F-1, $M = 3.72$).

In summary, pre-service teachers showed a strong consensus on protection-oriented principles but displayed lower agreement and greater variance on items requiring value negotiation, such as distributive justice, the performance-explainability trade-off, limits of data use, and responsibility attribution.

To examine whether AI ethics perceptions differed by participant characteristics, independent-samples t-tests were conducted by gender, prior AI coursework experience, and major field. The results are presented in Table 4. Female participants scored significantly higher than male participants in overall AI ethics perception ($p = .009$, Cohen's $d = 0.42$), non-maleficence ($p = .001$, $d = 0.53$), and engagement ($p = .017$, $d = 0.39$). The effect sizes ranged from small to medium, indicating that the gender differences, while statistically significant, represent

modest practical differences. In contrast, no significant differences were found across any domain based on prior AI-related coursework experience or major field (science education [$n = 22$] vs. other majors [$n = 143$]; all $ps > .05$).

Table 4

Comparison of AI Ethics Perceptions by Participant Characteristics (N = 165)

By Gender					
Domain	Male <i>M</i> (<i>SD</i>)	Female <i>M</i> (<i>SD</i>)	<i>t</i>	<i>p</i>	<i>d</i>
Fairness	3.97(.58)	3.92(.57)	0.55	.586	0.09
Transparency	3.97(.51)	4.10(.39)	–1.84	.068	0.30
Non-maleficence	4.42(.57)	4.66(.37)	–3.34	.001**	0.53
Privacy & Data Protection	4.40(.61)	4.57(.46)	–1.94	.055	0.33
Accountability	3.69(.44)	3.76(.47)	–0.92	.358	0.15
Engagement	3.94(.67)	4.18(.57)	–2.40	.017*	0.39
Overall	4.09(.36)	4.22(.28)	–2.64	.009**	0.42
By Coursework					
Domain	Exp. <i>M</i> (<i>SD</i>)	No Exp. <i>M</i> (<i>SD</i>)	<i>t</i>	<i>p</i>	
Fairness	3.98(.58)	3.89(.57)	1.00	.325	
Transparency	4.02(.48)	4.09(.38)	–1.02	.291	
Non-maleficence	4.56(.48)	4.59(.45)	–0.41	.632	
Privacy & Data Protection	4.49(.56)	4.53(.49)	–0.48	.556	
Accountability	3.71(.41)	3.76(.51)	–0.70	.506	
Engagement	4.13(.63)	4.04(.59)	0.94	.356	
Overall	4.16(.34)	4.18(.29)	–0.40	.769	
By Major Field					
Domain	Sci. Ed. <i>M</i> (<i>SD</i>)	Others <i>M</i> (<i>SD</i>)	<i>t</i>	<i>p</i>	
Fairness	3.82(.50)	3.95(.58)	–1.00	.305	
Transparency	4.05(.41)	4.05(.44)	0.00	.972	
Non-maleficence	4.59(.41)	4.57(.48)	0.19	.846	
Privacy & Data Protection	4.67(.41)	4.48(.54)	1.58	.127	
Accountability	3.74(.47)	3.73(.46)	0.09	.903	
Engagement	4.00(.49)	4.11(.63)	–0.78	.458	
Overall	4.17(.25)	4.17(.33)	0.00	.974	

Note. Gender: Male $n = 61$, Female $n = 104$. Coursework: Exp. $n = 92$, No Exp. $n = 73$. Major: Sci. Ed. (science education majors) $n = 22$, Others $n = 143$. All t tests had 163 degrees of freedom. Cohen's d is reported for all gender comparisons. * $p < .05$. ** $p < .01$.

Experiences and Educational Needs Regarding AI Ethics

When asked about direct experiences with AI ethics issues, only 26 of 165 respondents (15.76%) reported having such experiences, while 139 (84.24%) reported none. Among the 26 who reported experience (multiple responses), privacy and data protection was the most frequently selected domain, followed by accountability, fairness, and transparency.

The results for perceived priority areas for AI ethics education (multiple responses, $N = 165$) are presented in Table 5.

Table 5*Perceived Priority Areas for AI Ethics Education (N = 165, Multiple Responses)*

Domain	Frequency	%
Privacy & Data Protection	140	84.85
Accountability	135	81.82
Transparency	70	42.42
Fairness	66	40.00
Public Interest	62	37.58

Privacy and data protection (140 responses, 84.85%) and accountability (135 responses, 81.82%) showed the highest frequencies, followed by transparency (70, 42.42%), fairness (66, 40.00%), and public interest (62, 37.58%). These results indicate that pre-service teachers regard privacy protection and accountability as the areas most in need of attention in AI ethics education, while the substantial proportions for fairness, transparency, and public interest suggest the need for an integrated approach rather than one focused on specific domains.

No participant disagreed with the need for expanded AI ethics education (item F-2; no responses at 1–2 points), indicating near-universal endorsement. Regarding awareness of student data security in digital systems, responses of “worried” or higher accounted for 69.09% (114 respondents), confirming considerable concern about student data management among pre-service teachers.

AI Ethics Dilemma Scenario Analysis

Open-ended responses to eight hypothetical scenarios situated in science classroom contexts were analyzed through thematic analysis and content analysis. The main codes, frequencies, categories, and final themes for each scenario are presented in Table 6.

Table 6*Thematic Analysis of Ethical Dilemmas in Science Class Scenarios (N = 165)*

No.	Main Codes (Frequency)	Category	Final Theme
1.AI Facial Recognition Attendance (Privacy)	Privacy infringement/data leakage (127), Data security vulnerability (86), Lack of consent (29), Unclear responsibility (12), Surveillance concern (10)	Privacy infringement, Data management	Biometric data collection via AI entails critical issues of privacy protection and data security
2.Gender-biased AI Assessment (Fairness)	Gender bias/discrimination (108), Fairness violation (78), Data/algorithm bias (44), Uncritical acceptance of AI (33), Teacher responsibility (17)	Algorithmic bias, Assessment fairness	AI assessment bias requires teachers' critical review and professional judgment
3.AI-generated Photo Submission (Academic Integrity)	Bypassing learning process (81), Academic integrity violation (60), Factual accuracy of AI output (41), Plagiarism/copyright (32), Assessment fairness (22)	Academic integrity, Loss of inquiry experience	Substituting AI-generated content for direct observation undermines the educational value of scientific inquiry
4.AI-fabricated Protest Footage (Non-maleficence)	Fabricated information (76), Distortion of facts (72), Defamation/harm to groups (65), Social impact/responsibility (54), Lack of AI ethics awareness (18)	Fabricated content, Social harm	AI-generated false content poses risks of factual distortion, defamation, and social damage
5.AI-written Essay Submission (Plagiarism/Copyright)	Plagiarism/copyright (76), Loss of learning opportunity (40), Ghostwriting/academic dishonesty (32), Missing citation (31), Lack of creativity (29)	Plagiarism, Weakened self-directed learning	AI ghostwriting undermines academic honesty, self-directed learning, and creative thinking
6.AI Hallucination in Teaching Materials (Fact-checking/Accountability)	Risk of misinformation (77), Fact-checking responsibility (68), Teacher accountability (50), Reduced reliability (42), AI hallucination awareness (27)	Information reliability, Teacher verification	Teachers bear ultimate responsibility as final verifiers of AI-generated information

No.	Main Codes (Frequency)	Category	Final Theme
7.AI Personalized Learning Program (Privacy/Autonomy)	Privacy infringement (109), Monitoring burden (38), Data leakage risk (34), Biased feedback (15), Labeling/stratification (9), Autonomy violation (6)	Privacy, Learner autonomy	Tension between personalization benefits and learner privacy/autonomy protection
8.AI-analyzed Environmental Data for Public Good (Public Interest/Data Ethics)	Data use ethics (104), Public interest/social contribution (97), Consideration for vulnerable groups (50), Responsible problem-raising (21), Privacy risk (14)	Public interest, Data ethics	AI-driven data use for public good entails both social contribution and ethical responsibilities

Scenario 1: AI Facial Recognition Attendance System. Pre-service teachers most frequently identified privacy infringement and data leakage risk (127), followed by data security vulnerability (86) and lack of consent procedures (29). One respondent noted: “Privacy issues such as students’ portrait rights must be considered, and legal and ethical responsibility must be clearly established in case of data leakage.” Proposed solutions centered on establishing prior consent procedures (74), strengthening data security (61), and limiting the scope of data collection (58).

Scenario 2: Gender-Biased AI Assessment. This scenario placed the fairness problem within a science-specific task, the assessment of laboratory reports, where data collection skill is the object of evaluation. Gender bias and discrimination (108) and fairness violation (78) were the most frequently cited issues, along with data and algorithm bias (44). Responses framed the problem in different ways. Some identified it as a technical flaw: “The AI system producing more errors for female students’ data could lead to gender discrimination caused by a biased algorithm” (P15). Others emphasized teacher responsibility: “Using AI results without critical review means abandoning one’s professional responsibility as a teacher and relying entirely on technology” (P1). Still others connected it to assessment fairness: “If female students receive unfair evaluations due to AI errors, it constitutes a violation of equity in education, regardless of their actual abilities” (P4). The most frequently proposed solution was teachers’ critical review and final judgment (89), followed by algorithm improvement (57) and cross-verification (56). Among the proposed solutions, several respondents offered concrete strategies: “The teacher should cross-verify results by manually re-evaluating a sample of reports and comparing them with the AI output to determine whether bias exists” (P1).

Scenario 3: AI-Generated Photo Submission. What distinguished this scenario from other academic integrity cases was the emphasis on the loss of direct experience. While academic integrity violation was frequently noted (60), the most prominent concern was that the student had bypassed the learning process entirely (81), substituting AI-generated images for firsthand observation. Respondents emphasized that “the core of the assignment is developing inquiry skills through direct observation; generating photos with AI violates learning ethics.” Another respondent articulated the science-specific dimension: “The purpose of this assignment lies in the experience of actually visiting the school surroundings, observing rocks firsthand, and photographing and classifying them” (P23). A third linked it explicitly to assessment fairness: “Compared to other students who actually took photos and analyzed them, this student sought the same outcome without effort, which raises questions about fairness in evaluation” (P12). Among proposed solutions, ethics education and guidance (121) was the most frequent, followed by designing tasks requiring direct experience (50). However, few respondents proposed specific implementation measures such as revising the assignment rubric to require process documentation or integrating observation logs as mandatory components. One notable exception was a respondent who suggested: “The teacher should include source documentation and evidence of actual performance as mandatory conditions in the assignment requirements” (P15). The high frequency with which pre-service teachers identified the loss of inquiry experience as a core issue indicates their recognition that in science education, the process of empirical observation holds educational value distinct from the product itself.

Scenario 4: AI-Fabricated Protest Footage. Fabrication of false information (76), distortion of facts (72), and defamation of specific groups (65) were the major issues identified. Respondents raised distinct concerns about the social impact of AI-generated content. Some focused on the harm to specific groups: “Creating fabricated violent protest footage could instill negative images of environmental organizations and constitute defamation” (P16). Others emphasized the nature of the medium itself: “A documentary conveys social messages based on facts; including fabricated content seriously undermines the credibility of the work” (P4). A third perspective addressed the user’s responsibility: “AI is useful as a creative tool, but when it generates false content indistinguishable from reality, the ethical responsibility lies with the user” (P1). AI ethics and media literacy education (101) was the most frequently proposed solution, followed by fact-checking guidance (69). One respondent proposed a concrete

measure: “AI-generated content must be clearly labeled as fabricated, and source verification and fact-checking should be included as mandatory evaluation criteria” (P15).

Scenario 5: AI-Written Essay Submission. Plagiarism and copyright infringement (76) was the most frequent concern, followed by loss of learning opportunity (40), ghostwriting/academic dishonesty (32), and missing citation (31). A representative response stated: “Using AI itself is not wrong, but submitting the output as one’s own without disclosure violates academic honesty.” Respondents framed the problem from different angles. Some focused on the loss of learning itself: “The purpose of an essay assignment is for students to organize their own thoughts and explain them logically; having AI restructure internet sources and submitting it as one’s own undermines the authenticity of the learning activity” (P12). Others emphasized the misuse of technology: “This essay assignment was intended for students to engage in self-directed inquiry, yet the student relied on AI without any independent exploration” (P6). A third perspective highlighted the broader implications for assessment: “Submitting work produced by AI without disclosure is equivalent to plagiarism and could distort the evaluation criteria for student assignments” (P1). Proposed solutions included ethics education and guidance (97) and source citation education (55). One respondent proposed a concrete strategy: “Rather than simply submitting a final product, the teacher should connect the essay to presentation or discussion activities, making it difficult for students to rely solely on AI-generated content” (P25).

Scenario 6: AI Hallucination in Teaching Materials. This scenario was distinctive in that it was recognized not only as a problem but also as a positive example of teacher practice. The teacher’s decision to verify AI-generated content before using it in class was noted approvingly, even as respondents identified the risk of misinformation (77) and the burden of fact-checking responsibility (68) as primary concerns. One respondent highlighted the consequences for student learning: “If teachers fail to verify AI-generated content and include it in worksheets, students may encounter false information and accept it as fact, leading to incorrect learning” (P25). Another respondent emphasized the teacher’s critical stance: “The teacher recognized that AI-provided information is not always reliable and did not accept it uncritically, clearly understanding that AI is a tool, not the decision-maker” (P6). Beyond this positive recognition, respondents emphasized that confirming the accuracy of AI-generated information constitutes a core component of teacher professionalism. In science teaching, where factual accuracy directly affects the validity of students’ scientific understanding, this verification responsibility carries particular weight.

Scenario 7: AI Personalized Learning Program. Privacy infringement (109) was identified with the highest frequency, followed by monitoring burden (38) and data leakage risk (34). Respondents recognized the dilemma from multiple angles. One focused on psychological impact: “Continuous monitoring of academic activities raises concerns about student privacy infringement and psychological burden” (P2). Another addressed data governance: “The teacher must clearly inform students and parents about the purpose, scope, and duration of data collection, and obtain consent” (P4). A third raised the issue of surveillance: “Continuously monitoring all aspects of students’ learning activities through AI could be perceived as surveillance of their daily lives” (P73). Solutions were more diversely distributed than in other scenarios: informing students and parents (75), securing prior consent (70), supplementing with teacher feedback (64), data protection (42), and minimizing data collection (34). This diversity suggests that the scenario was perceived as a complex dilemma where educational benefits and ethical risks coexist.

Scenario 8: AI-Analyzed Environmental Data for Public Good. This scenario stood apart from the others in the range of evaluative stances it elicited. Rather than focusing primarily on risk identification, participants simultaneously recognized both the ethical responsibilities of data use (104) and the positive social contribution of the student’s action (97). Consideration for vulnerable groups (50) was also noted, alongside concern about privacy risks of exposing specific groups’ working conditions (14). What distinguished this scenario was the range of ethical framing. Many respondents evaluated it as a positive case of AI use. One stated: “This is a good example of using AI for the public interest, where AI functions as an ethical tool for evidence-based decision-making rather than relying on subjective impressions” (P1). Another described it in terms of solidarity: “AI objectively revealed the poor conditions in the rest areas of cleaning staff and cafeteria workers, contributing to a sense of community solidarity” (P16). At the same time, respondents who focused on the ethical risks noted the tension between public benefit and individual privacy. As one participant put it: “It is about balancing the realization of social responsibility through data analysis with the protection of personal and sensitive information” (P135). A more cautious respondent warned: “While this is a positive case in terms of public interest, from the perspective of fairness, the fact that air purifiers were not placed in classrooms could also become a point of contention” (P14).

Across the eight scenarios, ethical concerns varied by teaching context: learning integrity dominated in student assignment scenarios (Scenarios 3, 5), verification responsibility in teacher use scenarios (Scenarios 2, 6), and privacy-public interest tension in social application scenarios (Scenarios 7, 8), with data protection appearing

as a cross-cutting concern (Scenarios 1, 7). Scenario 4, by contrast, centered on misinformation and social harm and did not map neatly onto this context-based typology. Proposed solutions, however, showed less variation. The most frequently cited responses (ethics education and guidance, teachers' professional judgment, and prior consent procedures) remained at a general prescriptive level, while implementation-ready alternatives were rare.

Discussion

The central finding of this study is that pre-service teachers' ethical perception is not uniformly developed across domains. Protection-oriented principles, specifically non-maleficence and privacy, received strong and consistent endorsement, while domains that demand active value judgment, fairness and accountability, showed lower agreement and greater variance. This pattern is not simply a matter of degree. It reflects a qualitative difference in what each domain asks of the respondent. Agreeing that "AI should not cause harm" requires recognizing a widely shared norm. Deciding who bears responsibility when an AI system produces a biased assessment requires weighing competing claims under uncertainty. The challenge of ensuring fairness in AI-based assessment has also been documented in higher education contexts, where AI grading systems have been found to raise concerns about validity and equity (Zacharis & Papadakis, 2025). The low domain-level reliability for fairness and accountability, reported in Supplementary Information (SI 2), further supports this interpretation: items within these domains tap into genuinely different aspects of the construct. Participants responded less consistently to the items associated with fairness and accountability, which appear to reflect multiple dimensions of ethical judgment rather than a single coherent construct. This suggests that these are not single attitudes to be "raised" through education but require case-by-case reasoning.

A similar pattern has been observed in other populations. Lee (2025), using the same perception scale with 53 in-service teachers specializing in AI convergence education, also found high scores in non-maleficence and privacy but lower and more variable scores in fairness and accountability. While the two studies cannot be directly compared because the samples, contexts, and scenario compositions differ, the recurrence of this pattern across both pre-service and in-service teachers is worth noting. It raises the tentative possibility that the difficulty of fairness and accountability reasoning may be inherent to these constructs rather than a function of teaching experience. This observation warrants further investigation through direct comparison designs.

Female participants scored significantly higher than male participants in overall AI ethics perception, and particularly in non-maleficence and engagement. The effect sizes were small to medium (Cohen's $d = 0.39$ – 0.53), suggesting that while the differences are meaningful, they should not be overstated. The marginally non-significant result for privacy ($p = .055$, $d = 0.33$) suggests a possible trend that warrants further investigation with larger samples. The absence of significant differences by AI coursework experience is also noteworthy. One might expect that students who have taken AI-related courses would show heightened AI ethics perception, but the data do not support this assumption. Because the content, duration, and quality of participants' AI coursework were not measured, this study cannot determine why; one possibility is that current AI coursework focuses on technical competencies rather than ethical reasoning, a question that future research could examine more directly. Erdogan et al. (2026) observed a comparable disconnect, reporting that high AI literacy did not automatically translate into ethical reflection.

The scenario-based analysis revealed that pre-service teachers do not apply a fixed set of ethical principles uniformly across situations. Instead, the salience of specific ethical issues shifted depending on the teaching context. In student assignment scenarios (Scenarios 3, 5), learning integrity and the educational value of the inquiry process were foregrounded. When the focus shifted to teacher use of AI (Scenarios 2, 6), however, participants prioritized verification responsibility and professional judgment. The social application scenarios (Scenarios 7, 8) elicited a different pattern altogether, centering on the tension between privacy protection and public interest. This context-dependent activation of ethical priorities resonates with situated cognition perspectives, in which judgment is understood as shaped by the circumstances in which it occurs (Brown et al., 1989). Rather than possessing a single "level" of ethical perception, pre-service teachers appear to activate different ethical priorities depending on the situation they encounter. What this study contributes is descriptive evidence suggesting that pre-service teachers' ethical concerns are not uniformly applied but shift depending on the teaching context in which the dilemma is situated. While previous studies have documented uneven levels of ethical awareness across domains (Lee, 2025; Han, 2025), few have examined how specific teaching contexts may foreground different ethical priorities within the same group of participants.

Two findings carry implications that are specific to science education rather than to ethics education in general. In Scenario 3, the most frequently identified issue was not plagiarism or dishonesty in the abstract, but the bypassing of direct observation, a concern rooted in what science education values as a discipline. Respondents recognized that generating rock photographs with AI is problematic not merely because it is dishonest, but because it removes the learning that comes from firsthand empirical engagement. In Scenario 6, the emphasis on teacher verification of AI-generated content reflected an understanding that in science teaching, factual inaccuracy does not merely constitute poor teaching; it risks distorting students' scientific understanding. These findings suggest that pre-service teachers possess an intuitive grasp of science-specific pedagogical values, even when they lack the vocabulary or frameworks to articulate them formally.

All scenarios were embedded in science classroom situations, yet they were not equally science-specific. Some raised ethical issues, such as plagiarism and privacy, that are intrinsically cross-disciplinary and apply broadly across educational contexts, and the responses to these issues reflected general ethical reasoning rather than discipline-specific judgment. This is not a limitation of the study design but a distinction that should be acknowledged when interpreting the results. At the same time, even these broadly applicable issues took on science-specific meaning when situated in inquiry-based tasks, where data collection and empirical evidence are central to the learning goal.

In the student misuse scenarios (Scenarios 3, 4, and 5), the most frequently proposed solution was ethics education and guidance, and the leading solutions in the remaining scenarios, such as prior consent procedures and teachers' critical review, likewise remained at a general prescriptive level. While this reflects a genuine recognition that ethical awareness needs to be developed through education, the predominance of these general-level responses also reveals a limitation. Few respondents proposed implementation-level strategies such as revising assessment rubrics, establishing AI usage protocols, or creating verification procedures. The gap between principle recognition and practical application echoes findings from Erdogan et al. (2026) and may reflect the early stage of pre-service teachers' professional knowledge development, in which awareness of ethical principles has not yet been transformed into context-specific pedagogical strategies (Shulman, 1986). The emphasis on source citation and disclosure in Scenario 5 also resonates with recent discussions on the need for institutional standards as AI tools redefine the boundaries of academic integrity (Lund et al., 2025). Notably, the few concrete proposals that did appear, such as requiring process documentation in assignments or cross-verifying AI outputs with manual evaluation, appeared in responses that addressed the specific teaching context in detail, suggesting that situated reasoning and implementation-level thinking may develop together.

The absence of significant differences between science education majors and participants from other fields deserves comment. One might expect that science education students, who are more likely to encounter data-driven inquiry in their training, would show distinctive patterns of ethical reasoning about science classroom scenarios. The data do not support this expectation. This result suggests that the ethical reasoning captured by the scenarios was not contingent on discipline-specific training but rather reflected general pedagogical judgment exercised within science classroom contexts. For JBSE readers, this finding implies that AI ethics education in science teacher preparation need not be restricted to science education majors; it is relevant across the teacher education curriculum. This does not contradict the science-specific patterns noted earlier: it is the science classroom context, rather than disciplinary training itself, that brings particular ethical concerns to the foreground.

Scenario 8 stands apart from the other scenarios in an important respect. Grounded in a science inquiry activity, in which a student measured particulate matter and analyzed the data with AI, it prompted participants to recognize AI's potential for positive social contribution alongside its ethical risks, whereas most scenarios elicited primarily problem-identification responses. The coexistence of high frequencies for both data use ethics (104) and public interest (97) indicates that both ethical caution and recognition of AI's public benefit were prominent in participants' responses, rather than responses defaulting to a purely risk-averse stance. The coexistence of risk awareness and recognition of benefit suggests that AI ethics education should not focus exclusively on risks and prohibitions but should also explore how AI can be used responsibly for public benefit.

Conclusions and Implications

This study set out to examine how pre-service teachers perceive AI ethics and reason through ethical dilemmas situated in science classrooms. Three findings stand out.

First, ethical perception is uneven. Pre-service teachers readily endorse protection-oriented principles but struggle with domains that require weighing competing values. This unevenness is unlikely to be closed by more information alone. It may reflect the inherent difficulty of fairness and accountability reasoning, which appears to



call for judgment rather than knowledge. Female pre-service teachers showed modestly higher perception overall, though the small-to-medium effect sizes indicate this difference should not be overstated.

Second, ethical reasoning is context-dependent. The same group of participants foregrounded different ethical concerns depending on whether the scenario involved student assignments, teacher use of AI, or social applications. This means that teaching AI ethics through abstract principle lists is unlikely to be sufficient. Pre-service teachers need practice reasoning through concrete dilemmas in the kinds of situations they will actually encounter.

Third, science classrooms offer a distinctive lens. When pre-service teachers identified the loss of inquiry experience or the need for teacher verification of AI-generated content as core concerns, they were drawing on values specific to science education: the primacy of direct observation and the non-negotiability of factual accuracy. These responses suggest that AI ethics education can be productively embedded within science methods courses rather than treated as a separate add-on. What is distinctive here is the science classroom context itself, not the disciplinary background of the teacher: the same science situations brought these concerns to the foreground regardless of participants' major.

These findings carry practical implications. Teacher preparation programs should incorporate scenario-based deliberation activities where pre-service teachers practice navigating value conflicts in realistic teaching situations. The gap between normative recognition and personal engagement suggests that such activities should involve direct interaction with AI tools, such as designing lessons with generative AI, evaluating AI-based assessments, and running data-driven inquiry projects, so that ethical issues are encountered firsthand rather than discussed hypothetically. The predominance of general-level solutions points to the need for explicit training in implementation-level responses: drafting AI usage guidelines, revising assessment rubrics, and creating verification protocols.

Several limitations should be noted. The sample was drawn from three institutions through convenience sampling, which constrains generalizability. Self-reported responses to hypothetical scenarios may not reflect how pre-service teachers would act in actual classroom situations. Future research could address these limitations through experimental designs testing the effectiveness of scenario-based AI ethics interventions, longitudinal studies tracking ethical reasoning development across teacher preparation, and direct comparison studies between pre-service and in-service teachers using matched instruments.

In sum, as AI becomes a routine part of science classrooms, the teachers entering those classrooms need more than awareness of ethical principles. They need the capacity to recognize when principles conflict, to reason through those conflicts in context, and to translate their reasoning into concrete pedagogical decisions. Building that capacity is not a peripheral concern in teacher preparation; it is central to preparing teachers for the classrooms they will actually inhabit.

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