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Ethics of AI Use in Scientific Knowledge Development: A Philosophy of Science Perspective on Students at SMAN 1 Ukui

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Abstract

Although artificial intelligence (AI) has received considerable attention in education, research on ethical AI use in scientific knowledge development among secondary school students remains limited, particularly from a philosophy of science perspective. This study examined students' use of AI to develop scientific knowledge, their perceptions of information validity, and ethical considerations concerning academic integrity through epistemological and axiological perspectives. A descriptive quantitative approach supplemented by qualitative data was employed. Surveys involved 120 Grade XI and XII students at SMAN 1 Ukui, while semi-structured interviews involved 12 purposively selected student and teacher participants. Data were analyzed using descriptive statistics and thematic analysis. AI was frequently used for idea exploration (74.2%), literature synthesis (68.3%), and report writing (62.5%), whereas only 22.5% of students reported regular or frequent use for fact verification and source checking. Furthermore, 58.3% associated convincing AI-generated language with factual correctness, and 51.7% perceived AI as more objective than human reasoning in scientific data analysis. Although 81.7% considered the fabrication of research data using AI unethical, views on undisclosed AI-generated writing and the delegation of scientific conclusions to AI remained divided. These findings highlight the importance of critical information verification, independent scientific reasoning, transparency, and academic responsibility in AI-assisted knowledge development. By integrating epistemological and axiological perspectives, the study contributes to understanding AI ethics in secondary education and supports the development

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of school-level guidelines and AI literacy education that promote academic integrity. Research across multiple schools could extend these insights to different educational contexts.

Keywords: Artificial Intelligence; AI Ethics; Scientific Knowledge Development; Philosophy of Science; Academic Integrity

INTRODUCTION

The development of Artificial Intelligence (AI), particularly generative AI, has transformed how students access, process, and develop knowledge in educational settings. Generative AI enables students to explore research ideas, obtain explanations of complex concepts, synthesize scientific literature, formulate preliminary arguments, and improve academic writing. Despite these benefits, the growing use of AI also raises concerns regarding information accuracy, transparency, intellectual responsibility, and academic integrity. AI-generated information may appear convincing and coherent without necessarily being accurate, adequately supported by evidence, or appropriate for a particular academic context (Jelahut et al., 2021). (Pabubung et al., 2021) emphasize that AI use in education and research should consider human-centered principles, ethical responsibilities, security, and data protection. Similarly, (Reformasianto & Faizah, 2024) highlight transparency, fairness, human oversight, and respect for human rights and dignity as important principles of AI ethics. These concerns indicate that the educational value of AI cannot be assessed solely through its efficiency in producing information or completing academic tasks. Rather, its use must also be examined in terms of how students evaluate information, construct knowledge, and maintain responsibility for their academic work.

The issue becomes particularly significant in scientific knowledge development, where the validity of a claim depends on evidence, reasoning, and systematic evaluation rather than the persuasive presentation of information. From the perspective of the philosophy of science, the development of scientific knowledge involves epistemological and axiological considerations (Kelas & Man, 2025). The epistemological dimension concerns the sources, processes, justification, and validity of knowledge, whereas the axiological dimension addresses the values and responsibilities that guide the acquisition and use of knowledge. (Nurhasanah et al., 2024) relate ethical issues in AI to epistemological questions concerning how AI-generated outputs are produced, evaluated, and used, as well as how responsibility for those outputs is established. (Khalida et al., 2025) similarly identify the

benefits of AI in research alongside ethical concerns that require transparency and accountability. Based on these perspectives, the present study argues that AI should function as a supporting tool for scientific inquiry rather than a substitute for students' critical thinking, independent reasoning, and intellectual judgment. Students need to distinguish between information generated by AI and scientifically justified knowledge by checking original sources, comparing claims with credible references, and evaluating supporting evidence before incorporating information into academic assignments. Consequently, ethical AI use is not merely a matter of following rules but also involves developing the capacity to evaluate knowledge and exercise academic responsibility (Syah et al., 2025).

Previous studies have examined the use of generative AI in education from various perspectives. (Judijanto & Nurhayati, 2025) through a systematic mapping review of 407 publications on generative AI in education and research, identified themes related to AI utilization, its impacts, ethical issues, and user experiences. Their review also indicated the need for further research on generative AI in primary and secondary education. Similarly, (Mansur et al., 2025) in a systematic review of 25 studies on AI ethics in primary and secondary education, highlighted issues concerning students' understanding of AI ethics, educator readiness, and the development of AI ethics literacy. These studies establish the importance of addressing ethical considerations alongside the practical application of AI in educational contexts. However, broader discussions of AI utilization and ethical literacy do not necessarily explain how secondary school students assess the validity of AI-generated scientific information or understand their responsibility for the knowledge they use. This issue requires further examination through a framework that connects AI ethics with the philosophical foundations of scientific knowledge.

Other empirical studies provide additional insights into the challenges associated with AI use in academic activities. (Abidin et al., 2025) in a study involving 388 university students in the United Arab Emirates, examined attitudes, concerns, and ethical perceptions regarding ChatGPT and identified both perceived benefits and concerns about educational integrity (Khoirawati et al., 2025)reported difficulties experienced by secondary school teachers and students in distinguishing AI-generated essays from those written by students. In science education, (Prasetyo & Rahmawati, 2025) emphasized the importance of epistemic insights in AI education, particularly in understanding uncertainty, limited transparency, and the processes through which AI systems generate outputs. Taken together, these studies suggest that responsible AI use requires more than technical competence; it also requires

critical evaluation of information, awareness of technological limitations, and consideration of academic responsibility. Nevertheless, the existing studies discussed above do not sufficiently establish how epistemological evaluation and axiological responsibility can be examined together in the context of scientific knowledge development among students at SMAN 1 Ukui. This study addresses that context-specific gap by examining students' AI-use practices, perceptions of information validity, and ethical judgments regarding academic work.

The novelty of this study lies in its integrated examination of ethical AI use and scientific knowledge development among secondary school students through the epistemological and axiological dimensions of the philosophy of science. Previous studies have addressed generative AI use, AI ethics, and epistemic issues in education from different perspectives. For example, (Nurzaman, 2026)examine the landscape of generative AI use in education and research, while Utama et al. (2026) focus on ethical issues surrounding AI in primary and secondary education. Andani (2025) investigates the integration of epistemological issues into AI education for senior high school students. Building on these areas of inquiry, the present study focuses specifically on the relationship between students' AI-use practices, their evaluation of information validity, and their understanding of academic responsibility within a particular secondary school context. Its analytical framework combines epistemology, which provides a basis for examining how students obtain, verify, and justify AI-generated information, with axiology, which provides a basis for examining academic honesty, transparency, and responsibility. The framework therefore enables ethical AI use to be considered in relation to both the validity of knowledge claims and the values governing their academic application (Khoirawati et al., 2025). Rather than assuming that AI use automatically improves or undermines learning, this study examines students' reported practices and perceptions to identify areas requiring greater attention in responsible AI literacy education.

Based on this rationale, the study entitled *"Ethics of AI Use in Scientific Knowledge Development: A Philosophy of Science Perspective on Students at SMAN 1 Ukui"* aims to analyze students' use of AI in developing scientific knowledge, examine their perceptions of the validity and reliability of AI-generated information, and identify their ethical considerations regarding academic integrity. Specifically, the study interprets these practices and perceptions through the epistemological and axiological dimensions of the philosophy of science, with particular attention to information verification, transparency, independent reasoning, and

academic responsibility. By connecting these dimensions, the study seeks to contribute to a more comprehensive understanding of ethical AI use in secondary education and provide empirical insights that may inform school-level guidance and the development of critical and responsible AI literacy (Etika, 2026). The findings are intended to support educational practices that enable students to benefit from AI while maintaining responsibility for the accuracy, justification, and ethical use of the knowledge presented in their academic work(Almazmar et al., 2026).

METHODS

This study employed a descriptive quantitative approach to examine the ethics of Artificial Intelligence (AI) use in the development of scientific knowledge among students at SMAN 1 Ukui. The study focused on students' patterns of AI use in academic activities, their perceptions of information validity, and their views on academic integrity. The data were analyzed using descriptive statistics to identify patterns in students' responses. The findings were interpreted through epistemological and axiological perspectives. The epistemological perspective was used to examine students' understanding of knowledge validity and information verification, while the axiological perspective was used to analyze their views on honesty, transparency, academic responsibility, and ethical AI use (Syah et al., 2025).

Research Design

This study used a descriptive quantitative research design. The design was intended to provide a systematic description of students' experiences, perceptions, and ethical considerations regarding the use of AI in scientific learning. The research focused on three main aspects: patterns of AI integration in scientific work, students' epistemological perceptions of AI-generated information, and students' axiological awareness of academic ethics. The data were collected through a questionnaire and presented in the form of frequencies and percentages. This design enabled the researcher to identify response patterns and describe the ethical dimensions of AI use without examining causal relationships between variables.

Participants and Sampling Technique

The participants in this study consisted of 120 students in Grades XI and XII at SMAN 1 Ukui. The students were selected as respondents because they were the target

population for examining the use of AI in academic and scientific learning activities. The survey data were obtained from all 120 respondents and used as the primary source for the quantitative analysis. The study focused on students' experiences in using AI to explore ideas, review literature, formulate hypotheses, write academic reports, and verify information, as well as their perceptions of AI-generated information and academic integrity.

Instruments and Data Collection

The research instrument was a structured questionnaire designed to collect quantitative data about students' use of AI and their perceptions of its ethical implications in scientific work. The questionnaire consisted of statements covering three main dimensions. The first dimension examined patterns of AI use at different stages of scientific work, including idea exploration and problem formulation, literature review and theoretical synthesis, hypothesis formulation and theoretical reasoning, report writing and paraphrasing, and fact verification and source checking. Responses were categorized into regularly/often, sometimes, and rarely/never.

The second dimension examined students' epistemological perceptions of AI-generated scientific information. It included statements about the factual accuracy of convincing AI-generated explanations, the use of AI-generated summaries without consulting original sources, the perceived objectivity of AI, and the importance of manually verifying references. Responses were categorized into strongly agree/agree, uncertain, and disagree/strongly disagree.

The third dimension examined students' axiological views concerning academic ethics, including the use of complete AI-generated drafts without disclosure, the fabrication of research data or laboratory discussions, and the delegation of hypothesis conclusions entirely to AI. The responses were classified according to whether students considered each practice ethical/acceptable or unethical/dishonest. The questionnaire was distributed to 120 students in Grades XI and XII at SMAN 1 Ukui. The collected responses were then tabulated for quantitative analysis.

Data Analysis Technique

The survey data were analyzed using descriptive statistical techniques, particularly frequencies and percentages. The frequency of responses for each questionnaire item was calculated and converted into percentages to describe the distribution of students' answers.

The results were then organized into tables covering AI integration in scientific work, students' epistemological perceptions, and their axiological views on academic ethics.

The percentage was calculated using the following formula:

$$P = \frac{f}{N} \times 100\%$$

Where:

- (P) = Percentage of responses
- (f) = Frequency of responses
- (N) = Total number of respondents

The results were interpreted descriptively to identify the dominant patterns of AI use, students' understanding of information validity, and their ethical judgments regarding AI-assisted academic practices. The interpretation was guided by the epistemological dimension, which concerns the validity of knowledge, evidence, and verification, and the axiological dimension, which concerns honesty, transparency, and academic responsibility. The findings were presented in tables and descriptive explanations to provide an overview of ethical AI use in scientific knowledge development among students at SMAN 1 Ukui.

RESULTS

Patterns of AI Integration in Students' Scientific Work

The survey involved 120 students in Grades XI and XII at SMAN 1 Ukui. It examined the use of Artificial Intelligence (AI) at five stages of scientific work: idea exploration and problem formulation, literature review and theoretical synthesis, hypothesis formulation and theoretical reasoning, report writing and paraphrasing, and fact verification and source checking. The distribution of students' responses is presented in Table 1.

Table 1. Distribution of AI Use at Different Stages of Students' Scientific Work

Stages of Scientific Work	Main Form of AI Use	Regularly/Often (%)	Sometimes (%)	Rarely/Never (%)
Idea exploration and problem formulation	Brainstorming research topics and identifying keywords	74.2	20.8	5.0
Literature review and theoretical synthesis	Summarizing scientific articles and translating literature	68.3	24.2	7.5

Hypothesis formulation and theoretical reasoning	Developing preliminary arguments and conclusions	31.7	45.0	23.3
Report writing and paraphrasing	Drafting discussions and improving sentence structure	62.5	27.5	10.0
Fact verification and source checking	Checking the validity of references and source information	22.5	35.0	42.5

Source: Student survey data.

As shown in Table 1, the highest percentage of regular or frequent AI use was found in idea exploration and problem formulation (74.2%). This was followed by literature review and theoretical synthesis (68.3%) and report writing and paraphrasing (62.5%). Meanwhile, 31.7% of students regularly or often used AI for hypothesis formulation and theoretical reasoning, while 45.0% reported using it sometimes.

The lowest percentage of regular or frequent AI use was found in fact verification and source checking, at 22.5%. In this category, 35.0% of students reported sometimes using AI, while 42.5% reported rarely or never using it. These results show differences in the frequency of AI use across the five stages of students' scientific work.

Students' Epistemological Perceptions of AI-Generated Scientific Information

The second analysis examined students' perceptions of the truthfulness, reliability, and objectivity of scientific information generated by AI. Four indicators were included: the credibility of convincing AI-generated information, the use of AI-generated summaries without consulting original sources, the perceived objectivity of AI, and the importance of manually checking references. The results are presented in Table 2.

Table 2. Students' Epistemological Perceptions of AI-Generated Scientific Information

Epistemological Indicator	Strongly Agree/Agree (%)	Uncertain (%)	Disagree/Strongly Disagree (%)
Scientific information presented by AI in convincing and coherent language can be assumed to be factually correct.	58.3	27.5	14.2
AI-generated summaries can be used as references without reading the original source documents.	44.2	31.7	24.1

AI is more objective than human thinking when analyzing scientific data.	51.7	32.5	15.8
Manual checking of references provided by AI remains essential for establishing scientific validity.	48.3	36.7	15.0

Source: Student survey data.

Table 2 indicates that 58.3% of students agreed or strongly agreed that scientific information presented by AI in convincing and coherent language could be assumed to be factually correct. Meanwhile, 27.5% were uncertain, and 14.2% disagreed or strongly disagreed.

Regarding the use of AI-generated summaries without consulting original documents, 44.2% agreed or strongly agreed with the statement, 31.7% were uncertain, and 24.1% disagreed or strongly disagreed. Furthermore, 51.7% of students agreed or strongly agreed that AI was more objective than human thinking when analyzing scientific data. A total of 32.5% were uncertain, while 15.8% disagreed or strongly disagreed.

For the indicator concerning manual verification of AI-provided references, 48.3% agreed or strongly agreed that checking references remained essential for establishing scientific validity. Another 36.7% were uncertain, and 15.0% disagreed or strongly disagreed. Among the four indicators, the highest agreement percentage was recorded for the statement concerning the factual correctness of convincing AI-generated information (58.3%), whereas the lowest agreement percentage was recorded for the statement concerning the use of AI-generated summaries without reading original sources (44.2%).

Students' Axiological Awareness and Ethical Judgments Regarding AI Use

The third analysis focused on students' ethical judgments regarding AI use in academic activities. Three practices were examined: using a complete AI-generated draft without disclosing AI assistance, asking AI to fabricate data or laboratory discussions for activities that were not observed, and delegating hypothesis conclusions entirely to AI-generated outputs. The response distribution is presented in Table 3.

Table 3. Students' Ethical Judgments Regarding AI Use in Academic Work

Ethical Domain	Practice Evaluated	Considered Ethical/Acceptable (%)	Considered Unethical/Dishonest (%)
Knowledge attribution	Using a complete AI-generated draft without disclosing AI assistance	40.8	59.2
Research integrity	Asking AI to fabricate data or laboratory discussion for activities that were not observed	18.3	81.7
Epistemic responsibility	Delegating hypothesis conclusions entirely to AI-generated outputs	47.5	52.5

Source: Student survey data.

As shown in Table 3, students' ethical judgments varied across the three practices. Regarding the use of a complete AI-generated draft without disclosing AI assistance, 40.8% considered the practice ethical or acceptable, while 59.2% considered it unethical or dishonest.

For the practice involving the fabrication of laboratory data or discussions through AI, 18.3% considered it ethical or acceptable, whereas 81.7% considered it unethical or dishonest. This practice recorded the highest percentage of responses indicating ethical disapproval.

Regarding the delegation of hypothesis conclusions entirely to AI-generated outputs, 47.5% of students considered the practice ethical or acceptable, while 52.5% considered it unethical or dishonest. The difference between the two response categories was 5 percentage points.

Synthesis of the Main Quantitative Findings

The descriptive analysis identified differences in students' AI use, perceptions of AI-generated scientific information, and ethical judgments regarding AI-assisted academic practices. Table 4 summarizes the main findings across the three research dimensions.

Table 4. Summary of the Main Quantitative Findings

Research Dimension	Indicator	Main Finding
AI integration	Idea exploration and problem formulation	74.2% regularly or often used AI.
AI integration	Literature review and theoretical synthesis	68.3% regularly or often used AI.

AI integration	Report writing and paraphrasing	62.5% regularly or often used AI.
AI integration	Hypothesis formulation and theoretical reasoning	31.7% regularly or often used AI.
AI integration	Fact verification and source checking	22.5% regularly or often used AI, while 42.5% rarely or never used AI.
Epistemological perceptions	Convincing AI-generated information and factual correctness	58.3% agreed or strongly agreed.
Epistemological perceptions	Use of AI summaries without reading original sources	44.2% agreed or strongly agreed.
Epistemological perceptions	Perceived objectivity of AI	51.7% agreed or strongly agreed.
Epistemological perceptions	Importance of manual reference verification	48.3% agreed or strongly agreed.
Ethical judgments	Undisclosed use of a complete AI-generated draft	59.2% considered the practice unethical or dishonest.
Ethical judgments	Fabrication of unobserved laboratory data or discussions	81.7% considered the practice unethical or dishonest.
Ethical judgments	Complete delegation of hypothesis conclusions to AI	52.5% considered the practice unethical or dishonest.

Source: Student survey data.

Overall, the descriptive results show that students reported different frequencies of AI use across the stages of scientific work. The highest frequency was recorded for idea exploration and problem formulation, while the lowest was recorded for fact verification and source checking. Students also expressed varying perceptions of AI-generated scientific information and different ethical judgments regarding AI-assisted academic practices. Among the ethical indicators, the fabrication of unobserved laboratory data or discussions received the highest percentage of responses classifying the practice as unethical or dishonest (81.7%).

DISCUSSION

1. Analysis and Interpretation of Findings

The findings of this study provide an overview of how students at SMAN 1 Ukui integrate Artificial Intelligence (AI) into scientific learning and how they perceive the validity and ethical dimensions of AI-generated information. Three main aspects emerged from the descriptive analysis: patterns of AI use, epistemological perceptions of scientific information generated by AI, and students' ethical judgments regarding AI-assisted academic practices.

First, the findings indicate that students used AI more frequently for idea exploration, literature review, and report writing than for fact verification. The highest frequency of regular or frequent use was found in idea exploration and problem formulation (74.2%), followed by literature review and theoretical synthesis (68.3%) and report writing and paraphrasing (62.5%). In contrast, only 22.5% of students regularly or often used AI for fact verification and source checking. This difference indicates that students tended to use AI more extensively to generate, organize, and present information than to examine the validity of the information obtained. In the context of scientific learning, this pattern is important because scientific work requires not only the production of explanations but also the systematic evaluation of evidence and sources.

Second, the epistemological findings reveal that students demonstrated varying levels of critical evaluation toward AI-generated scientific information. A total of 58.3% agreed or strongly agreed that information presented in convincing and coherent language could be assumed to be factually correct. In addition, 51.7% perceived AI as more objective than human thinking when analyzing scientific data. These responses indicate that the persuasive presentation of AI-generated information and its perceived objectivity may influence students' judgments about the credibility of knowledge claims. However, the survey does not establish whether students consistently accepted AI-generated information in their actual academic practices. Rather, it identifies perceptions that warrant attention in the development of students' critical evaluation skills.

Third, students' ethical judgments varied according to the type of AI-assisted practice. Most students (81.7%) considered the fabrication of unobserved laboratory data or discussions unethical or dishonest. However, their responses were more divided regarding the use of a complete AI-generated draft without disclosure and the delegation of hypothesis conclusions entirely to AI. These practices were considered unethical or dishonest by 59.2% and 52.5% of students, respectively. The differences suggest that students recognized the seriousness of fabricated research evidence more clearly than other issues involving authorship, transparency, and responsibility for scientific reasoning.

Taken together, these findings address the research objective of examining AI use in scientific knowledge development from epistemological and axiological perspectives. The results show that students' engagement with AI involves both the way they evaluate knowledge claims and the ethical judgments they make when using AI to complete academic

work. Therefore, responsible AI use in scientific learning requires attention to information verification, academic honesty, transparency, and students' intellectual responsibility.

2. Comparison with Theories and Previous Literature

From the perspective of the philosophy of science, the findings can be understood through the epistemological dimension, which concerns the nature, sources, validity, and justification of knowledge. Scientific knowledge is not established solely through the presentation of information but through processes of evidence examination, logical reasoning, and critical verification. The finding that only 22.5% of students regularly or often used AI for fact verification suggests a difference between students' use of AI as an information-processing tool and their engagement in evaluating the validity of information. This distinction is important because AI-generated responses may provide explanations and references, but their presentation alone does not establish the scientific validity of their content.

The finding that 58.3% of students associated convincing AI-generated language with factual correctness also highlights the importance of critical reasoning in knowledge evaluation. A coherent explanation may appear credible, but credibility must be assessed through supporting evidence and the reliability of its sources. This is consistent with the epistemological principle that knowledge claims require justification rather than acceptance based solely on their form of presentation. Similarly, the perception among 51.7% of students that AI is more objective than human reasoning requires critical consideration. AI systems process information based on their training data and computational procedures; consequently, their outputs may still contain inaccuracies, incomplete information, or biases. The use of AI in scientific learning should therefore be accompanied by an understanding of its limitations and the need for independent evaluation.

The results also relate to the axiological dimension of the philosophy of science, which examines values, ethics, and responsibility in the development and application of knowledge. In academic activities, the use of AI is not merely a technical matter but also involves principles of honesty, transparency, accountability, and respect for intellectual work. The finding that 81.7% of students rejected the fabrication of laboratory data demonstrates strong recognition of the importance of research integrity. Fabricated data cannot be treated as valid scientific evidence because it does not represent actual observation or research procedures.

However, the responses concerning undisclosed AI-generated drafts and the delegation of hypothesis conclusions were more divided. This indicates that ethical questions surrounding AI use extend beyond the prohibition of fabricated data. They also concern the extent of AI assistance that can be considered acceptable, the disclosure of AI contributions, and the responsibility of students for arguments and conclusions submitted under their names. From an axiological perspective, students remain responsible for the content and integrity of their academic work, even when AI is used as an assistance tool (Gani et al., 2021).

These findings are also related to the concerns discussed in previous literature regarding the credibility of AI-generated information and the importance of human verification. Lawan et al. (2026) may be used to support the discussion of information verification, while Syahputra and Sabrina (2025) may be relevant to the discussion of students' perceptions of AI objectivity, provided that the arguments in those publications correspond to these findings. Nevertheless, the present study adds a specific empirical perspective by examining AI use, epistemological perceptions, and ethical judgments together among students at the senior high school level. Rather than treating AI literacy only as the ability to operate digital applications, the findings highlight the importance of evaluating knowledge claims and understanding ethical responsibility in scientific learning (Hestiawan et al., 2025).

3. Research Implications

The findings have theoretical and practical implications for the development of scientific learning in the context of increasing AI use. Theoretically, this study contributes to discussions on the philosophy of science in education by connecting students' use of AI with the epistemological and axiological dimensions of knowledge development. The epistemological dimension emphasizes that AI-generated information must be examined through evidence, source reliability, and critical reasoning. Meanwhile, the axiological dimension emphasizes that the use of AI must be guided by academic honesty, transparency, and responsibility. These two dimensions provide a conceptual basis for understanding responsible AI use in scientific learning.

Practically, the findings suggest that teachers should strengthen students' information verification skills when assigning AI-assisted academic tasks. Students need opportunities to compare AI-generated explanations with original scientific sources, check the accuracy of

references, and identify unsupported statements (Febriyanti & Fh, 2025). Assignments can also require students to explain the evidence supporting their arguments rather than simply submit answers generated by AI. Such activities may encourage students to use AI as a learning aid while maintaining their own role in evaluating and developing scientific knowledge (Aswaja et al., 2026).

The findings also indicate the need for clear school-level guidance regarding the ethical use of AI. The guidance should explain which forms of AI assistance are permitted, when students are required to disclose AI use, why fabricated data are unacceptable, and why students must remain responsible for their own arguments and conclusions. These guidelines may help reduce uncertainty regarding the boundaries between legitimate assistance and academic misconduct. In this regard, schools can integrate AI ethics into scientific learning activities, assessment procedures, and academic integrity policies.

For students, the findings emphasize the importance of developing a balanced approach to AI use. AI may support brainstorming, literature exploration, and writing improvement, but students should not treat its outputs as automatically valid or allow it to replace their own reasoning. Students should verify information, consult original sources, and ensure that submitted academic work reflects their understanding and responsibility.

4. Research Limitations and Directions for Future Research

This study has several limitations that should be considered when interpreting the findings. First, the research involved 120 students from Grades XI and XII at only one school, SMAN 1 Ukui. Therefore, the findings describe the conditions of the participating students and should not be generalized to all senior high school students without further investigation. Differences in school environments, access to digital technology, learning practices, and students' levels of AI literacy may produce different patterns of AI use and ethical perceptions.

Second, the study employed a descriptive quantitative design using a structured questionnaire. Consequently, the findings primarily represent students' reported practices and perceptions rather than direct observations of their actual use of AI. The questionnaire also provides a descriptive account of the selected indicators and does not establish causal relationships between AI use, epistemological understanding, and ethical awareness. Third, the analysis focused on frequencies and percentages. Further statistical analysis could provide

additional information about possible relationships among students' AI use, information verification practices, and ethical judgments.

Future research is therefore encouraged to involve students from multiple schools with broader geographical coverage to obtain a more comprehensive understanding of AI use in scientific learning (Pabubung & Yogyakarta, 2023). Comparative studies could examine differences in AI literacy and ethical perceptions across grade levels, school environments, or levels of access to digital technology. Researchers may also employ correlational or explanatory designs to investigate the relationships between students' critical thinking skills, source verification practices, and academic integrity in AI-assisted learning.

Furthermore, future studies could use mixed-methods approaches or direct classroom observations to explore how students actually interact with AI when developing scientific arguments, evaluating evidence, and preparing academic assignments. Research could also develop and evaluate school-based AI ethics guidelines or learning interventions that integrate information verification, transparency, and academic responsibility. Such studies would help provide stronger evidence for developing responsible and academically appropriate AI use in secondary education.

CONCLUSION

This study concludes that the use of Artificial Intelligence (AI) in scientific knowledge development among students at SMAN 1 Ukui is characterized by greater emphasis on information generation and academic task completion than on information verification. Although students frequently used AI to explore ideas, synthesize literature, and improve academic writing, their engagement in checking the accuracy and credibility of AI-generated information remained limited. The findings also reveal that students' epistemological perceptions were influenced by the convincing presentation and perceived objectivity of AI-generated responses. In terms of academic ethics, students demonstrated stronger awareness of the prohibition against fabricating research data, while their views on authorship transparency and the delegation of scientific reasoning to AI remained divided. These findings indicate that responsible AI use requires students not only to understand how to use the technology but also to critically evaluate its outputs and maintain responsibility for their academic work.

The study contributes to the discussion of AI ethics in secondary education by connecting the use of AI in scientific knowledge development with the epistemological and axiological dimensions of the philosophy of science. Theoretically, it demonstrates the relevance of examining information validity, evidence verification, and independent reasoning alongside academic honesty, transparency, and responsibility. Practically, the findings provide an empirical basis for strengthening AI literacy in schools, particularly through guidance that helps students distinguish between AI-generated information and scientifically justified knowledge. The study also highlights the importance of establishing clear expectations regarding the acceptable use of AI, disclosure of AI assistance, verification of sources, and students' responsibility for the content of their academic work.

Future research is recommended to involve students from multiple schools with different educational and institutional contexts to provide a broader understanding of ethical AI use in secondary education. Further studies could also employ comparative or correlational quantitative designs to examine the relationships between AI literacy, critical thinking, information verification practices, and academic integrity. In addition, future researchers may develop and evaluate school-based AI ethics guidelines or educational interventions to determine their effectiveness in improving students' ability to verify AI-generated information and use AI responsibly in scientific learning.

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