



# Investigating Higher Education Students' Understanding and Engagement with the Ethical Implications of Artificial Intelligence within STEAM Education

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**Abstract.** STEAM education is an interdisciplinary approach to learning that integrates Science, Technology, Engineering, the Arts, and Mathematics to foster critical thinking and innovation. In this research, the traditional components of STEAM are redefined, with 'E' representing Ethics and 'A' representing Artificial Intelligence. This study investigates the understanding and engagement of university students towards this expanded STEAM framework, focusing on institutions in Malaysia and Indonesia. A quantitative research design was employed, utilizing purposive sampling to select participants from STEAM programs. Data was collected through a structured questionnaire to capture insights into students' understanding and engagement with the ethical implications of artificial intelligence within their educational contexts. The findings highlight significant trends and differences in how students from the two countries perceive the integration of ethics and artificial intelligence into their curriculum. While students generally recognize the importance of these elements, there are varying levels of awareness and preparedness to tackle ethical issues related to AI. The implications of this research suggest that educational institutions need to emphasize ethical training in AI to prepare students for the complexities of the modern technological landscape. The study recommends incorporating comprehensive modules on ethics and artificial intelligence across all STEAM programs, enhancing interdisciplinary collaboration, and promoting active learning strategies to better equip students with the skills and knowledge required to navigate the ethical challenges of rapid technological advancements. These recommendations aim to foster a more holistic and responsible approach to STEAM education, ultimately contributing to the development of socially conscious and ethically informed future professionals.

**Keywords:** STEAM, STEM, Ethics, Artificial Intelligence, Education

## 1 Introduction

In recent years, the integration of Artificial Intelligence (AI) within STEAM (Science, Technology, Engineering, Arts, and Mathematics) education has significantly transformed teaching methodologies and learning experiences. AI technologies offer innovative tools that enhance personalized learning, streamline administrative processes, and foster creative problem-solving skills among students. However, as AI becomes increasingly embedded in educational practices, it brings to the forefront critical ethical considerations that must be addressed to ensure responsible and equitable implementation. The rapid advancement of AI necessitates a comprehensive understanding of its ethical implications, especially within the context of STEAM education, where future innovators and leaders are being cultivated.

The ethical landscape of AI in education encompasses a range of issues, including data privacy, transparency, and accountability. These concerns are paramount as they directly impact the fairness and inclusivity of educational technologies. Understanding these ethical dimensions is crucial for higher education students, who are not only consumers of AI-driven educational tools but also potential developers and policymakers in the field. By engaging with the ethical implications of AI, students can critically evaluate the societal impacts of these technologies and contribute to the development of responsible AI solutions.

This study aims to investigate higher education students' understanding and engagement with the ethical implications of AI within STEAM education. Through a carefully designed questionnaire, we seek to capture students' perspectives on various ethical issues associated with AI and their readiness to address these challenges. Previous research highlights the importance of incorporating ethical discussions into STEAM curricula to prepare students for the complexities of AI technology (Huang, 2024; Hsu et al., 2021; Henze et al., 2022). This study builds on this foundation by examining how well students grasp ethical concepts and how actively they engage in ethical inquiry and reflection.

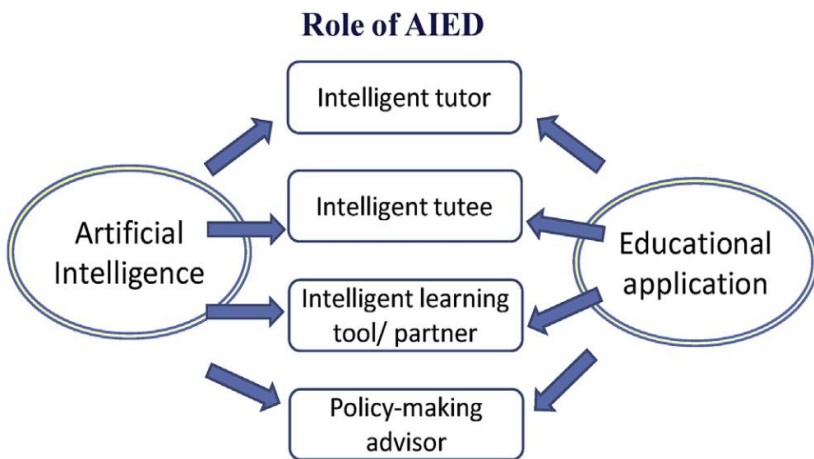
Our research will focus on higher education institutions in Malaysia and Indonesia, providing a diverse cultural context for understanding the ethical engagement of students. By analyzing the data collected, we aim to identify gaps in knowledge and engagement, thereby informing educators and policymakers on effective strategies to enhance ethical education in AI. Ultimately, this study aspires to contribute to the development of ethically conscious professionals who are equipped to lead in a technology-driven world, ensuring that AI advancements benefit society as a whole.

## 2 Literature Review

This literature review discusses areas pertaining to the topic of the research. The discussions include the three main variables – ethics, AI and STEAM are defined to set the framework for the connective relationship that they are to have with each other. Then ethics and AI is looked into before looking into ethics of AI in education, especially related to STEAM.

Defining AI is complex, as various authors have highlighted. Simmons and Chappell (1988) described AI as “behavior of a machine which, if a human behaves in the same way, is considered intelligent.” Dobrev (2005) echoed this, stating “AI will be such a program which in an arbitrary world will cope no worse than a human.” More recently, Zuniga, Goyanes, and Durotoye (2023) defined AI as “the tangible real-world capability of non-human machines or artificial entities to perform tasks, solve problems, communicate, interact, and act logically, similar to biological humans.” Over the decades, these definitions suggest that the synergy between humans and machines is essential for maximizing AI’s benefits.

This paper focuses on the ethics of AI in STEAM education. Before exploring this topic, it is essential to understand AI in education (AIED), which has been studied since the early days of AI (O’Shea & Self, 1983). AIED ensures the responsible and fair use of AI technologies in educational settings, including teaching, learning, and management (Hwang, 2020). Similarly, Hwang, Xie, Wah, and Gasevic (2020) define AIED as “the use of AI technologies or application programs in educational settings to facilitate teaching, learning, or decision-making.” Based on this definition, Hwang et al. (2020) presented a framework for the roles of AIED (Figure 1).



**Fig. 1.** Framework for the roles of AIED.

STEAM education is encompassed under AIED, integrating Science, Technology, Engineering, Arts, and Mathematics. In STEAM, AI is used to enhance creativity and critical thinking among students. How and Hung (2019) show that STEAM learners can use AI to predictively simulate different scenarios, improving their problem-solving skills and beyond. Thus, it is essential to encourage students to understand the ethics of AI adoption and its impact on individuals and society, as posited by Remalsira et al. (2023). Their research suggests that hands-on engagement enhances students’ ability to critically evaluate AI technologies and articulate the ethical and societal impacts of AI applications (p. 22).

Understanding the ethics of AI in STEAM, which is a focus of this paper, can prepare students to navigate the complex moral landscape of emerging technologies. Integrating ethical discussions into STEAM curricula helps students identify and address issues like bias, privacy, and accountability in AI systems. Ethical AI seeks to ensure that AI systems are designed and used in ways that are fair, inclusive, and respectful of human values. It requires collaboration across disciplines, involving technologists, ethicists, policymakers, and the public, to create guidelines and frameworks that mitigate risks and promote beneficial outcomes for all. This comprehensive approach ensures the development of future innovators and leaders who are equipped with the knowledge and responsibility to create ethical and inclusive AI solutions.

Another focus of this paper is on engaging with AI ethics in STEAM education, which requires creating interactive and interdisciplinary learning experiences that emphasize ethical considerations in technology development. This can include case studies, debates, and collaborative projects where students address real-world AI challenges. Studies on AI in STEAM, such as those on computational skills (Huang, 2024), the role of active learning and self-efficacy in AI-STEAM courses (Hsu, Abelson, Lao, Chen, 2021), and implementing STEAM with digital creativity tools (Henze, Schantz, Malik, & Bresges, 2022), exemplify the integration of AI and its ethical dimensions. By fostering a culture of ethical inquiry and reflection, educators can help students understand the societal impacts of AI and the importance of responsible innovation. Active engagement ensures that future STEAM professionals are not only technically skilled but also ethically conscious, prepared to lead in a technology-driven world. (575 words)

### 3 Methodology

This study adopted a quantitative research design with a survey method. Creswell (2017) explains that survey research offers a quantitative or numerical overview of a population's trends, opinions, or perspectives by sampling a portion of that population. Thus, this survey included questionnaires aimed at objectively and accurately capturing teachers' views, feedback, and tendencies regarding the use of English in teaching Science.

A questionnaire was chosen as the instrument for this study due to its effectiveness in collecting information from people through a series of questions. Lindemann (2023) highlights twelve benefits of using a questionnaire, including standardized responses, anonymity and confidentiality, cost-effectiveness, and flexibility. In this study, the flexibility was demonstrated by developing a new questionnaire based on a literature review, focusing on the understanding and utilization of AI ethics in STEAM education.

The questionnaire format was designed to closely align with the research objectives, comprising six sections (Appendix A) with the following choice of scale selection:

1. Research agreement
2. Demographics
3. Understanding of AI ethics in STEAM education
4. Engagement with the ethical implications of AI in STEAM education

### 5. Context and recommendations

These first five sections used multiple-choice questions, while the final section included open-ended questions. The questionnaire was reviewed by three experts to ensure validity and reliability, leading to amendments that better reflected the research objectives before being sent to pilot participants. According to Stewart (2007), a pilot study is crucial as it tests research protocols, data collection instruments, sample recruitment strategies, and other techniques in preparation for a larger study. The pilot study for this research resulted in no further changes to the questionnaire. The expert review and pilot study stages were vital in mitigating common methodological issues.

The finalized questionnaire was distributed via Google Forms, with the link shared through WhatsApp and in person in class. Participants were from higher education institutions in Malaysia (Universiti Teknologi MARA) and Indonesia (University of Mataram and Bumigora University), chosen due to their educational background relevant to the study's focus. This purposive sampling, as described by Etikan (2021), involves selecting individuals who can provide the most relevant information based on the researcher's judgment.

The collected data were automatically analyzed and then processed using the SPSS application for further analysis. Descriptive and inferential statistics were chosen to describe the characteristics and make predictions based on the dataset (Hillier, 2021).

## 4 Findings and Discussions

The findings section of this survey research via the use of a questionnaire delves into the participants' understanding and engagement with the ethics of AI in STEAM education. It examines their awareness of key ethical issues.

### 4.1 Demographic

This section constitutes the results of the study based on the research questions presented. The Demographic information of the respondents in Table 1 shows the distribution of samples by Age, Gender, University, as well as Field of Study. There were a total of 59 respondents who participated in the study. Of the total sample, 39 of the respondents were between the ages of 21 to 23 years old (66%), followed by 10 (17%) of the respondents who were between the ages of 18 to 20. Meanwhile, there were nine (15%) of them who were between the ages of 24 to 26, and only one respondent who was over 27 years old. Regarding the distribution of the gender, there were 28 (48%) male students, while 31 (52%) were female students. Furthermore, 38 of the respondents were from UiTM (64%), followed by 19 (32%) from University of Mataram, and only two (3%) from Bumigora University. Regarding the samples' field of study, 34 (58%) of them were from the Science Department, followed by 22 (37%) from the Arts. While two (3%) of the participants were from the Engineering field, and only one (2%) of them were from the Technology Department.

**Table 1.** The Demographic Profile of the Respondents

	Item	Frequency	Percentage (of 100%)
AGE	18-20	10	17
	21-23	39	66
	24-26	9	15
	27 and above	1	2
	<b>Total</b>	<b>59</b>	
GENDER	Male	28	48
	Female	31	52
	<b>Total</b>	<b>59</b>	
UNIVERSITY	UiTM	38	64
	University of Mataram	19	32
	Bumigora University	2	3
	<b>Total</b>	<b>59</b>	
FIELD OF STUDY	Science	34	58
	Technology	1	2
	Engineering	2	3
	Arts	22	37
	Mathematics	0	0
	<b>Total</b>	<b>59</b>	

### 4.1 Understanding Ethic of AI in STEAM

This section is to present the findings of higher education students’ understanding on ethics of AI in STEAM education. Two types of analysis were carried out. First is to look into the Mean and standard deviation (SD) while the second is via two way ANOVA to ???.

Table 2 depicts that the highest mean score of 4.16 (SD = .798) is obtained from the item **A1. “How familiar are you with the concept of Artificial Intelligence (AI)?”**. It is followed by **A2. “How familiar are you with the ethical implications of AI in STEAM education?”** with a mean score of 3.47 (SD = .953). In contrast, the lowest mean scores are shown by the items **A3. “How often are ethical implications of AI in STEAM education discussed in your courses?”** with mean scores of 3.12 (SD = .948) and 3.34 (SD = .801) respectively. The overall mean score of 3.53 indicates that the students generally exhibit a lack of understanding regarding the ethical implications of AI within their STEAM classes.

**Table 2.** The Students' Understanding of AI in STEAM

	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>
How familiar are you with the concept of Artificial Intelligence (AI)?	59	4.19	.798
How familiar are you with the ethical implications of AI in STEAM education?	59	3.47	.953
How often are ethical implications of AI in STEAM education is discussed in your courses?	59	3.12	.948
To what extent do you understand the ethical challenges posed by AI in STEAM education?	59	3.34	.801
<b>TOTAL</b>	<b>59</b>	<b>3.53</b>	<b>0.875</b>

Section 3 of the questionnaire looks into the participants' understanding on ethics of AI in STEAM Education. The two-way ANOVA with UiTM, UM and UBG resulted in the following findings on Familiarity (1.2), Frequency (1.2) and Thoughts (1.3) related to understanding on ethics of AI in STEAM education.

**Table 3.** [Two-Way ANOVA] – Universities (UiTM, UM, UBG) to Understanding (A2 Familiarity)

<b>Between-Subjects Factors</b>						
<b>Universities</b>			<b>Value Label</b>	<b>N</b>		
Universiti Teknologi MARA, Malaysia	Universities	1	Universiti Teknologi MARA, Malaysia	38		
Universitas Mataram, Indonesia	Universities	2	Universitas Mataram, Indonesia	19		
Bumigura University, Indonesia	Universities	3	Bumigura University, Indonesia	2		

<b>Test of Between-Subjects Effects</b>						
<b>Universities</b>	<b>Source</b>	<b>Type III Sum of All Squares</b>	<b>df</b>	<b>Mean Squares</b>	<b>F</b>	<b>Sig.</b>
Universiti Teknologi MARA, Malaysia	Corrected Model	.000 <sup>a</sup>	0			
	Intercepts	493.921	1	493.921	588.021	.000
	Universities	.000	0			
	Error	31.079	37	.840		
	Total	525.000	38			
	Corrected Total	18.526	37			
Universitas Mataram, Indonesia	Corrected Model	.000 <sup>b</sup>	0			
	Intercepts	189.474	1	189.474	184.091	.000
	Universities	.000	0			
	Error	18.526	18	1.029		
	Total	208.000	19			
	Corrected Total	18.526	18			
Bumigura University, Indonesia	Corrected Model	.000 <sup>c</sup>	0			
	Intercepts	32.000	1	32.000		
	Universities	.000	0			
	Error	.000	1	.000		
	Total	32.000	2			
	Corrected Total	.000	1			

a R Squared = .000 (Adjusted R Squared = .000)

b R Squared = .000 (Adjusted R Squared = .000)



<sup>c</sup> R Squared = . (Adjusted R Squared = .)

The Two-Way ANOVA results (Table 3) on Familiarity with AI Ethics in STEAM Education shows that all three universities have a high significant familiarity with AI ethics ( $p = .000$ ), indicating a baseline awareness across these institutions. There is no variation due to "Universities" as a factor, as all sums of squares are zero.

**Table 4.** [Two-Way ANOVA] – Universities (UiTM, UM, UBG) to Understanding (A3 Frequency)

<b>Test of Between-Subjects Effects</b>						
Universities	Source	Type III Sum of All Squares	df	Mean Squares	F	Sig.
Universiti Teknologi MARA, Malaysia	Corrected Model	.000 <sup>a</sup>	0			
	Intercepts	411.184	1	411.184	510.260	.000
	Universities	.000	0			
	Error	29.816	37	.806		
	Total	441.000	38			
	Corrected To- tal	29.816	37			
Universitas Mata- ram, Indonesia	Corrected Model	.000 <sup>b</sup>	0			
	Intercepts	142.316	1	142.316	187.200	.000
	Universities	.000	0			
	Error	18.526	18	.760		
	Total	208.000	19			
	Corrected To- tal	18.526	18			
Bumigura Univer- sity, Indonesia	Corrected Model	.000 <sup>c</sup>	0			
	Intercepts	24.500	1	24.500	5.444	.258
	Universities	.000	0			
	Error	4.5000	1	4.500		
	Total	29.000	2			
	Corrected To- tal	4.500	1			

<sup>a</sup> R Squared = .000 (Adjusted R Squared = .000)

The Two-Way ANOVA results (Table 4) on the frequency of AI Ethics discussions in STEAM Education indicate that UiTM, and UM, have highly significant intercepts ( $p = .000$ ), suggesting frequent discussions on AI ethics in STEAM education. UBG

Indonesia does not show a significant intercept ( $p = .258$ ), indicating infrequent discussions. The minimal significance difference among the universities suggests slight variations in discussion frequency.

**Table 5.** [Two-Way ANOVA] – Universities (UiTM, UM, UBG) to Understanding (A4 Thought)

Test of Between-Subjects Effects						
Universities	Source	Type III Sum of All Squares	df	Mean Squares	F	Sig.
Universiti Teknologi MARA, Malaysia	Corrected Model	.000 <sup>a</sup>	0			
	Intercepts	451.605	1	451.605	657.987	.000
	Universities	.000	0			
	Error	25.395	37	.686		
	Total	477.000	38			
	Corrected To- tal	25.395	37			
Universitas Mata- ram, Indonesia	Corrected Model	.000 <sup>b</sup>	0			
	Intercepts	193.211	1	193.211	336.871	.000
	Universities	.000	0			
	Error		18	.544		
	Total		19			
	Corrected To- tal		18			
Bumigura Univer- sity, Indonesia	Corrected Model	.000 <sup>b</sup>	0			
	Intercepts	24.500	1	24.500	49.000	.000
	Universities	.000	0			
	Error	.500	1	.500		
	Total	25.000	2			
	Corrected To- tal	.500	1			

a R Squared = .000 (Adjusted R Squared = .000)

b R Squared = .000 (Adjusted R Squared = .000)

The Two-Way ANOVA results (Table 5) Understanding of AI’s Ethical Challenges in STEAM Education show significant effects for UiTM and UM ( $p < .001$ ), but not for UBG Indonesia ( $p = .090$ ). UiTM and UM have a significant baseline effect on the dependent variable, while UBG Indonesia does not. The findings do not explain any variance in the dependent variable for these universities.

## 4.2 Engagement on Ethic of AI in STEAM

This part of the paper presents the findings for higher education students' engagement on the ethics of AI in STEAM.

Table 6 shows that the highest mean score is obtained from item B1. How important do you think it is to include ethics in AI in STEAM education? With a mean score of 4.19 (SD=.819). It is followed by item B2. **“How prepared do you feel to address ethical issues related to AI in your future career?”** with a mean score of 3.44 (SD=.772). On the contrary, the lowest mean scores are 1.78 (SD=.418) and 2.93 (SD=1.048) for item B3. **“Have you participated in any workshops or seminars focused on the ethical implications of AI in STEAM education?”** and B4. **“How often do you engage in discussions about the ethical implications of AI in STEAM education with friends or lecturers?”**. Furthermore, the total mean score of 3.08 indicates that most of the students were not really engaged with the ethical implications of AI within their STEAM classes.

**Table 6.** The Students' Engagement of AI in STEAM

	N	Mean	Std. Deviation
Have you participated in any workshops or seminars focused on the ethical implications of AI in STEAM education?	59	1.78	.418
How important do you think it is to include ethics in AI in STEAM education?	59	4.19	.819
How often do you engage in discussions about the ethical implications of AI in STEAM education with friends or lecturers?	59	2.93	1.048
How prepared do you feel to address ethical issues related to AI in your future career?	59	3.44	.772
<b>TOTAL</b>	<b>59</b>	<b>3.08</b>	<b>0.764</b>

Scale 1-5

A Pearson product-moment correlation was run to determine the relationship between age and students' understanding of AI in STEAM education. Table 7 indicates that there is no relationship between students' age and their understanding of AI in STEAM as the r coefficient value is greater than 0.05 or 5% ( $r = .549, p > .05$ ).

**Table 7.** Correlation Analysis between Age and Students' Understanding of AI in STEAM

	Age	Understanding
Age	Pearson Correlation	1
	Sig. (2-tailed)	.549
	N	59

		Age	Understanding
Understanding	Pearson Correlation	-.080**	1
	Sig. (2-tailed)	.549	
	N	59	59

\*\*Correlation is significant at the 0.01 level (2-tailed).

Table 8 indicates that there is no relationship between students’ engagement of AI in STEAM and their gender as the r coefficient value is higher than 0.05 or 5% ( $r = .426, p > .05$ ).

**Table 8.** Correlation Analysis between Gender and Students’ Engagement of AI in STEAM

		Age	Understanding
Engagement	Pearson Correlation	1	-.106**
	Sig. (2-tailed)		.426
	N	59	59
Gender	Pearson Correlation	-.106**	1
	Sig. (2-tailed)	.426	
	N	59	59

\*\*Correlation is significant at the 0.01 level (2-tailed).

### 4.3 Context on Ethics of AI in STEAM Education

Section 5 of the questionnaire looks into the participants’ context and recommendations on ethics of AI in STEAM Education based on Two-Way ANOVA analysis.

**Table 9.** [Two-Way ANOVA] – Field of Study (Science to include Science, Tech, Engineering, Math) (Arts to include all other fields) with C1

Between-Subjects Factors			
	Field of Study	Value Label	N
Science	Field of Study 1	Science	38
Arts	Field of Study 2	Arts	21

#### Test of Between-Subjects Effects

Dependent Variable: C1 Do you think your current curriculum adequately addresses the ethical implications?

Universities	Source	Type III Sum of All Squares	df	Mean Squares	F	Sig.
Science	Corrected Model	.000 <sup>a</sup>	0			
	Intercepts	479.605	1	479.605	758.521	.000
	Universities	.000	0			
	Error	23.395	37	.632		

<b>Test of Between-Subjects Effects</b>						
<b>Dependent Variable: C1 Do you think your current curriculum adequately addresses the ethical implications?</b>						
<b>Universities</b>	<b>Source</b>	<b>Type III Sum of All Squares</b>	<b>df</b>	<b>Mean Squares</b>	<b>F</b>	<b>Sig.</b>
	Total	503.000	38			
	Corrected Total	23.395	37			
	Corrected Model	.000 <sup>b</sup>	0			
	Intercepts	213.762	1	213.762	183.975	.000
Arts	Universities	.000	0			
	Error	23.238	20	1.162		
	Total	237.000	21			
	Corrected Total	23.238	20			

a R Squared = .000 (Adjusted R Squared = .000)

b R Squared = .000 (Adjusted R Squared = .000)

The Two-Way ANOVA results (Table 9 Curriculum Adequacy on AI Ethics in Science vs. Arts) show that students in both the Science and Arts fields significantly perceive their curriculum as adequately addressing the ethical implications of AI ( $p < .001$ ). The F values for the intercept are 758.521 for Science and 183.975 for Arts, indicating a strong effect on students' perceptions.

**Table 10.** Two-Way ANOVA] – Field of Study (Science to include Science, Tech, Engineering, Math) (Arts to include all other fields) with C2

<b>Between-Subjects Factors</b>			
<b>Field of Study</b>	<b>Value Label</b>	<b>N</b>	
Science	Field of Study 1	38	
Arts	Field of Study 2	21	

<b>Test of Between-Subjects Effects</b>						
<b>Dependent Variable: C2 Do you believe that incorporating ethics in STEAM educations will positively ...</b>						
<b>Universities</b>	<b>Source</b>	<b>Type III Sum of All Squares</b>	<b>df</b>	<b>Mean Squares</b>	<b>F</b>	<b>Sig.</b>
	Corrected Model	.000 <sup>a</sup>	0			
Science	Intercepts		1	592.105	686.881	.000
	Universities	.000	0			
	Error	31.895	37	.862		

Test of Between-Subjects Effects						
Dependent Variable: C2 Do you believe that incorporating ethics in STEAM educations will positively ...						
Universities	Source	Type III Sum of All Squares	df	Mean Squares	F	Sig.
	Total	624.000	38			
	Corrected Total	31.895	37			
	Corrected Model	.000 <sup>a</sup>	0			
	Intercepts	275.048	1	275.048	290.251	.000
Arts	Universities	.000	0			
	Error	18.952	20	.948		
	Total	294.000	21			
	Corrected Total	18.952	20			

a R Squared = .000 (Adjusted R Squared = .000)

The Two-Way ANOVA results (Table 10: Impact of Incorporating AI Ethics in STEAM Education) indicate that students in both the Science and Arts fields believe that incorporating AI ethics in STEAM education will positively impact them ( $p < .001$ ). This is supported by high F values for the intercept: 686.881 for Science and 290.251 for Arts, showing a strong effect on their beliefs.

C3. What improvements would you suggest for better integrating ethics of AI in STEAM education? (Select all that apply)

59 responses

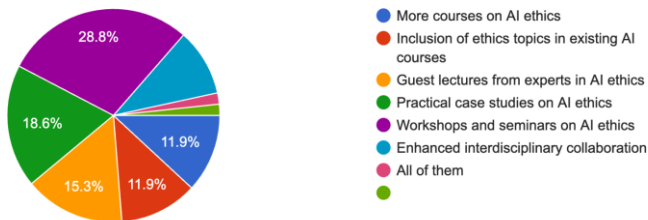


Fig. 2. Preferences

The data reveals diverse preferences among participants regarding how to address AI ethics in STEAM education. Workshops and seminars on AI ethics are the most popular choice, favored by 28.8% of participants, indicating a strong preference for interactive and immersive learning experiences. Practical case studies on AI ethics are

also highly valued, with 18.6% support, emphasizing the importance of real-world applications. Guest lectures from experts in AI ethics, preferred by 15.3% of participants, highlight the desire for authoritative insights. Both the inclusion of ethics topics in existing AI courses and the introduction of more courses specifically on AI ethics each received 11.9% support, showing moderate interest in curricular integration. Enhanced interdisciplinary collaboration, supported by 10.2% of participants, underscores the need for diverse academic perspectives. Only 1.7% of participants believed that all these methods should be combined. This data underscores the necessity of varied educational strategies to effectively integrate AI ethics into STEAM education.

#### 4.4 Open Ended

In addition to the Likert scales-based findings, there are two open ended questions. The findings from the two open-ended questions (D1, D2) were derived from thematic analysis. The 59 responses to “D1. In your opinion, what are the most pressing ethical issues related to AI in your field of study?” resulted in four main themes: Equity in AI, Data Privacy, AI Decision Transparency, and Non-sequential (for responses that could not be meaningfully categorized). Table 11 provides example quotations for D1.

**Table 11.** Themes for the most pressing ethical issues related to AI

Themes	Number of answers	Sample answers to D1. In your opinion, what are the most pressing ethical issues related to AI in your field of study?
Equity in AI	21	<ul style="list-style-type: none"> <li>● Paraphrase thing and plagiarism (p6)</li> <li>● Equity in access. not all students have the access to AI for their learning purposes. this will be seen as bias when some schools or students cannot afford and provide it. (p24)</li> </ul>
Data Privacy	9	<ul style="list-style-type: none"> <li>● Data privacy (p5)</li> </ul>
AI Decision Transparency	14	<ul style="list-style-type: none"> <li>● In my opinion, it is lack of transparency of AI tools. AI decisions are not always intelligible to humans. AI is not neutral. AI-based decisions are susceptible to inaccuracies, discriminatory outcomes, embedded or inserted bias. (p17)</li> </ul>
Nonsequential	13	<ul style="list-style-type: none"> <li>● Good (p7)</li> <li>● No (p8)</li> </ul>
*no answer	2	
<b>TOTAL</b>	<b>59</b>	

Findings from the two open-ended questions (D1, D2) were derived from thematic analysis. The 59 responses to “D1. In your opinion, what are the most pressing ethical issues related to AI in your field of study?” resulted in four main themes: Equity in AI, Data Privacy, AI Decision Transparency, and Non-sequential (for responses that could not be meaningfully categorized). Table 12 provides example quotations for D1.

**Table 12.** Themes for the most pressing ethical issues related to AI

Themes	Number of answers	Sample answers to D1 with participant’s number to the question: In your opinion, what are the most pressing ethical issues related to AI in your field of study?
Equity in AI	21	<ul style="list-style-type: none"> <li>● Paraphrase thing and plagiarism (p6)</li> <li>● Equity in access. not all students have the access to AI for their learning purposes. this will be seen as bias when some schools or students cannot afford and provide it. (p24)</li> </ul>
Data Privacy	9	<ul style="list-style-type: none"> <li>● Data privacy (p5)</li> </ul>
AI Decision Transparency	14	<ul style="list-style-type: none"> <li>● In my opinion, it is lack of transparency of AI tools. AI decisions are not always intelligible to humans. AI is not neutral. AI-based decisions are susceptible to inaccuracies, discriminatory outcomes, embedded or inserted bias. (p17)</li> </ul>
Nonsequential	13	<ul style="list-style-type: none"> <li>● Good (p7)</li> <li>● No (p8)</li> </ul>
*no answer	2	
<b>TOTAL</b>	<b>59</b>	

The 59 responses to “D2. What additional resources or support do you think would help you better understand and engage with the ethical implications of AI?” resulted in four main themes: Integrated Curriculum, Educator Training, Collaborative Platforms, and Non-sequential (for responses that could not be meaningfully categorized). Table 13 provides example quotations for D2.



**Table 13.** Resources for better understanding and engagement

Themes	Number of answers	Sample answers to D2 with participant's number to the question: What additional resources or support do you think would help you better understand and engage with the ethical implications of AI?
Integrated Curriculum	14	<ul style="list-style-type: none"> <li>• Maybe a proper way of what should we do when we use AI and if we need to cite them too like other journal article p33</li> </ul>
Educator Training	19	<ul style="list-style-type: none"> <li>• Seminars &amp; workshops (p4)</li> <li>• To better grapple with the ethical impacts of AI in education, I think having regular workshops and seminars focused on ethics would be incredibly helpful. These sessions could be designed specifically for educators like me, offering practical examples and open discussions on real-world ethical dilemmas we might face with AI. p34</li> </ul>
Collaborative Platforms	6	<ul style="list-style-type: none"> <li>• Ultimately, creating a community where educators, technologists, and ethicists can come together to share ideas and best practices would be key. This collaborative approach would not only enrich our understanding but also empower us to navigate these ethical challenges with confidence and empathy for our students' well-being. p37</li> </ul>
Nonsequential	15	<ul style="list-style-type: none"> <li>• Perplexity p4</li> <li>• Not sure. p18</li> </ul>
*no answer	5	
<b>TOTAL</b>	<b>59</b>	

The research findings are discussed in the final section of discussions and conclusions.

## 5 Discussions and Conclusions

In this discussion, we explore the ethics of AI in STEAM education, synthesizing findings and interpreting them through the lens of existing literature. The research highlights several key ethical considerations of the participants' understanding and engagement of AI in STEAM education.

## 5.1 Understanding

The significant familiarity with AI ethics across all three universities (UiTM, Unram, and UBG) indicates that students have a baseline awareness of AI ethics. This suggests that students recognize the importance of ethical considerations in AI.

The findings also indicate that respondents from UiTM and Unram show frequent discussions on AI ethics, which supports the notion that students have opportunities to engage with ethical topics. Both universities also indicate a greater understanding of AI's ethical challenges among students. However, UBG's lack of significant intercept suggests infrequent discussions, pointing to potential disparities in how AI ethics are integrated into curricula across institutions. This variation emphasizes the importance of discussion frequency in shaping students' understanding and engagement with ethical issues. In addition, UBG respondents do not demonstrate a significant effect, suggesting that students there may struggle to grasp these challenges, likely due to the infrequent discussions noted in Table 4. This highlights a potential correlation between the frequency of discussions and students' understanding of ethical issues.

However, while AI familiarity is established in all three universities and the AI concept comprehension is imprinted by most of the students, it does not necessarily translate to in-depth understanding or practical application in educational settings. This issue can be inferred from Table 2 highlighting important distinctions between students' familiarity with AI concepts and their understanding of the ethical implications associated with it. The highest mean score of 4.16 for item A1 indicates that students feel confident in their familiarity with AI itself. However, the subsequent scores reveal a concerning trend: a mean of 3.47 for ethical implications in AI suggests some awareness, yet the lower scores for A3 indicate that discussions around these ethical issues are infrequent in their courses. The overall mean score of 3.53 suggests that students generally lack a deeper understanding of the ethical implications of AI within their STEAM education.

This finding can be related to the study "Vision, challenges, roles and research issues of Artificial Intelligence in Education" by Hwang et al. (2020). The authors discuss the importance of integrating ethical considerations into AI education, emphasizing that while technological proficiency is crucial, understanding the ethical dimensions is equally vital for the responsible use of AI.

Hwang et al. outline several challenges in AI education, including the need for educators to incorporate discussions on ethics into the curriculum. They argue that without these discussions, students may develop technical skills without a comprehensive understanding of the potential societal impacts of AI technologies. This aligns with the findings, which highlight a significant gap in students' engagement with ethical issues despite their familiarity with AI.

Overall, the results reveal a significant connection: although there is a basic level of familiarity with AI ethics, the regularity and depth of discussions on these topics significantly influence students' grasp of ethical challenges and their overall participation. Universities that promote frequent discussions, such as UiTM and Unram, cultivate a deeper understanding of ethical implications. In contrast, institutions like UBG, which do not engage in such discussions, show lower levels of engagement and comprehension. This highlights the importance of consistently incorporating ethical discussions

into STEAM education to improve students' understanding and application of AI ethics.

## 5.2 Engagement

The analysis of the mean score as in Table 3 highlights important insights regarding students' perceptions of ethics in AI within STEAM education. The highest mean score of 4.19 for item **B1. "How important do you think it is to include ethics in AI in STEAM education?"** indicates that students recognize the significance of ethical considerations in using AI. However, the lower mean scores for items B2, B3, and B4 suggest a gap between this recognition and their actual preparedness and engagement with ethical issues.

Specifically, the mean score of 3.44 for item B2 indicates that while students acknowledge the importance of ethics, they feel less prepared to address these issues in their future careers. The significantly lower scores of 1.78 and 2.93 for items B3 and B4 further illustrate that students have limited exposure to workshops and discussions about the ethical implications of AI.

This finding resonates with the study "Enhancing Computational Thinking Skills Through Artificial Intelligence Education at a STEAM High School" by Huang and Qiao (2022). The authors advocate for a comprehensive approach to AI education that not only enhances computational thinking skills but also emphasizes the integration of ethics. They argue that without proper engagement in discussions about ethical implications, students may struggle to apply their knowledge responsibly in real-world situations. Furthermore, a study entitled "Is It Possible for Young Students to Learn the AI-STEAM Application with Experiential Learning?" by Hsu et al. (2021) resonates with the current research. The authors advocate for experiential learning as a way to enhance understanding and application of AI in STEAM education. They emphasize that hands-on experiences, including discussions about ethical implications, are crucial for deepening students' understanding of AI technologies and their societal impacts. Hsu et al. suggest that integrating experiential learning opportunities can lead to better engagement and preparedness among students when addressing complex ethical issues. This aligns with the findings – while students value the inclusion of ethics, the lack of workshops and discussions indicates a need for more interactive and applied learning experiences that address these concerns.

As highlighted in the analysis of open-ended answers, most of the students suggest some approaches that will help them better understand and engage with the ethical implications of AI which are through integrated curriculum and training on ethical implication on AI.

Thus, this study points to a critical need for educational strategies that not only acknowledge the importance of ethics in AI but also actively engage students in experiential learning. This approach could bridge the gap between students' recognition of ethical issues and their ability to effectively address them in real-world scenarios.

### 5.3 Context

The findings reveal a significant perception among both science and arts students that their curriculum adequately addresses AI ethics ( $p < .001$ ,  $F$  values of 758.521 for science, 183.975 for arts students). This indicates a strong, cross-disciplinary belief in the sufficiency of current AI ethics education within their respective programs.

Additionally, students from both fields overwhelmingly believe that incorporating AI ethics into STEAM education will positively impact their learning and comprehension ( $F$  values 686.881 for science, 290.251 arts students,  $p < .001$ ). The data underscores a consensus on the critical importance and benefits of integrating AI ethics into the STEAM curriculum, emphasizing a shared recognition of its value in equipping students to navigate the ethical complexities of AI in their professional and personal lives.

These results depict the findings of Huang (2024) on AI computational skills that highlight the necessity of maintaining and enhancing AI ethics education across disciplines. P37 aptly shared the point “Ultimately, creating a community where educators, technologists, and ethicists can come together to share ideas and best practices would be key. This collaborative approach would not only enrich our understanding but also empower us to navigate these ethical challenges with confidence and empathy for our students’ well-being.” For science students, who might encounter AI in technical and research capacities, and arts students, who might engage with AI in creative and societal contexts, the integration of AI ethics is crucial. This interdisciplinary consensus suggests that AI ethics education is not only relevant but essential across various academic domains, reinforcing the need for a comprehensive and inclusive approach to curriculum development that addresses the ethical dimensions of AI.

The findings of C3 highlight diverse preferences for integrating AI ethics in STEAM education. Practical case studies (18.6%) emphasize real-world applications, while guest lectures (15.3%) reflect a desire for expert insights. P35 supported this finding with the notion that “Additionally, it would be invaluable to have access to case studies and stories from other educators and experts who have navigated these issues. Learning from their experiences would provide practical insights and help us understand how to apply ethical principles in our own classrooms.” The inclusion of ethics in existing AI courses and creating new AI ethics-specific courses (each 11.9%) are valued but not seen as the sole solutions due to feasibility concerns. Interdisciplinary collaboration (10.2%) underscores the need for diverse perspectives. Only 1.7% favor combining all methods, indicating a preference for targeted approaches. These findings are in tandem with the findings from the study by Huang, 2024 on AI computational skills. Overall, the data highlights the necessity of varied educational strategies to integrate AI ethics into STEAM education, emphasizing interactive learning, real-world applications, expert insights, and interdisciplinary collaboration. Addressing these diverse preferences can better prepare students to navigate AI’s ethical complexities in their professional and personal lives.

## 5.4 Conclusions and Recommendations

The investigation into higher education students' understanding and engagement with the ethical implications of artificial intelligence within STEAM education reveals a significant awareness and appreciation of AI ethics across both science and arts disciplines. The data shows that students generally perceive their current curriculum as adequately addressing AI ethics, with robust statistical support indicating a cross-disciplinary recognition of its importance. Furthermore, there is a strong belief among students that incorporating AI ethics into STEAM education will positively impact their learning and comprehension, emphasizing the necessity of integrating ethical considerations into the broader curriculum. This consensus highlights the critical role of AI ethics education in preparing students to navigate the ethical complexities of AI in their professional and personal lives.

To enhance students' understanding and engagement with AI ethics, it is recommended to expand interactive learning experiences by increasing the availability of workshops and seminars focused on AI ethics and incorporating practical case studies into the curriculum. Enhancing expert engagement through guest lectures by AI ethics professionals can provide authoritative, industry-relevant insights. Integrating AI ethics across courses is also essential, both by including ethics topics within existing AI and STEAM courses and by developing specialized courses for in-depth exploration. Promoting interdisciplinary collaboration through collaborative projects and interdisciplinary programs can foster a holistic understanding of AI ethics, drawing on insights from fields such as philosophy, law, social sciences, and technology. Lastly, implementing targeted educational strategies rather than broad approaches will address specific areas of need and interest within AI ethics education effectively.

Future research should include longitudinal studies to track changes in students' understanding and engagement with AI ethics over time, providing insights into the long-term effectiveness of various educational interventions. Comparative studies between different educational institutions and regions should be performed to identify best practices and effective strategies for integrating AI ethics into STEAM education across diverse contexts. Additionally, research should investigate the impact of different teaching methods (e.g., lectures, workshops, case studies, and online modules) on students' comprehension and engagement with AI ethics, helping to identify the most effective pedagogical approaches. Finally, the benefits and challenges of interdisciplinary collaboration in teaching AI ethics should be explored, focusing on how diverse academic perspectives can enhance students' understanding of ethical issues in AI.

By adopting these recommendations and carrying out the research, higher education institutions can effectively enhance students' understanding and engagement with the ethical implications of AI, equipping them with the knowledge and skills necessary to address the ethical challenges posed by AI technologies in various professional contexts.

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## Appendices

### APPENDIX A

Ethic of AI within STEAM Education\_UITM, UM, BGU

Questions Responses Settings

Section 1 of 6

### Investigating Higher Education Students' Understanding and Engagement with the Ethical Implications of Artificial Intelligence within STEAM Education

The purpose of this study is to investigate the understanding and engagement of Malaysia and Indonesia higher education students on the ethical implications of artificial intelligence in STEAM (Science, Technology, Engineering, the Arts, and Mathematics) education.

If you have any questions or concerns about this study, please contact:  
- A.P. Dr. Siti Mahubah Damis at mahubah@uitm.edu.my  
- Muhd Azhar Kholidi at azhar.kholidi.cendekiaedu@gmail.com  
- Susiaty Ramdhani at susi.ramdhani@gmail.com  
- Zulinda Ayo Zulfitri at zulinda@uitm.edu.my

Participation in this study is voluntary, and you may withdraw at any time without consequences. Your decision will not affect your academic standing or institutional relationship. All responses are confidential, anonymised, and used solely for research. Results will be presented in aggregate form, ensuring individual responses are not identifiable.

Yes No

I agree to take part in this research...

Ethic of AI within STEAM Education\_UITM, UM, BGU

Questions Responses Settings

Section 2 of 6

### Demographic

Please answer all question by placing a tick (✓) in the box next to your chosen response.

Age \*

18-20

21-23

24-26

27 and above

Gender \*

Male

Female

Universities \*

Universiti Teknologi MARA, Malaysia

University of Mataram, Indonesia

Burnigora University, Indonesia

Other...

Ethic of AI within STEAM Education\_UITM, UM, BGU ☆

Questions Responses 12 Settings

Field of Study \*

- Science
- Technology
- Engineering
- Arts
- Mathematics
- Other...

After section 2 Continue to next section

Section 3 of 6

Understanding of Ethics of AI in STEAM Education

Please answer all question by placing a tick (✓) in the box next to your chosen response.

Familiarity \*

	Very unfamiliar	Somewhat un...	Neutral	Somewhat fam...	Very familiar
A1. How famil...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A2. How famil...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

After section 3 Continue to next section

Ethic of AI within STEAM Education\_UITM, UM, BGU ☆

Questions Responses 12 Settings

Frequency \*

	Never	Rarely	Sometimes	Often	Very Often
A3. How often ...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Thoughts \*

	Very poorly	Poorly	Neutral	Well	Very well
A4. To what ext...	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

After section 3 Continue to next section

Section 4 of 6

Engagement with Ethical Implications of AI in STEAM Education

Please answer all question by placing a tick (✓) in the box next to your chosen response.

B1. Have you participated in any workshops or seminars focused on the ethical implications of AI in STEAM education?

- Yes
- No

After section 3 Continue to next section



Ethic of AI within STEAM Education\_UTM, UM, BGU

Questions Responses Settings

111

B2. How important do you think it is to include ethics in AI in STEAM education? \*

- Not important at all
- Not very important
- Neutral
- Important
- Very Important

B3. How often do you engage in discussions about the ethical implications of AI in STEAM education with friends or lecturers? \*

- Never
- Rarely
- Sometimes
- Often
- Very often

B4. How prepared do you feel to address ethical issues related to AI in your future career? \*

- Very unprepared
- Unprepared
- Neutral
- Prepared
- Very prepared

Ethic of AI within STEAM Education\_UTM, UM, BGU

Questions Responses Settings

Context and Recommendations

Please answer all question by placing a tick (✓) in the box next to your chosen response.

111

Question Multiple choice grid

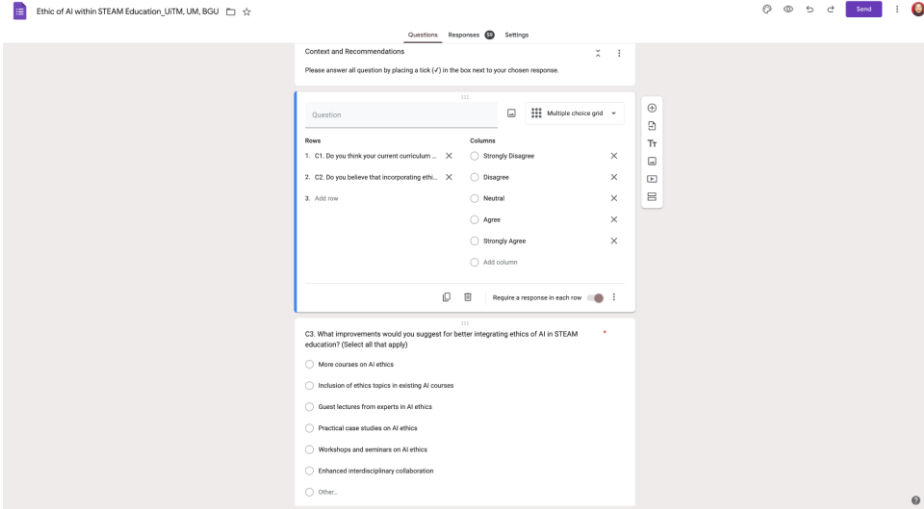
Rows	Columns
1. C1. Do you think your current curriculum ...	<input type="checkbox"/> Strongly Disagree
2. C2. Do you believe that incorporating ethi...	<input type="checkbox"/> Disagree
3. Add row	<input type="checkbox"/> Neutral
	<input type="checkbox"/> Agree
	<input type="checkbox"/> Strongly Agree
	<input type="checkbox"/> Add column

Require a response in each row

111

C3. What improvements would you suggest for better integrating ethics of AI in STEAM education? (Select all that apply)

- More courses on AI ethics
- Inclusion of ethics topics in existing AI courses
- Guest lectures from experts in AI ethics
- Practical case studies on AI ethics
- Workshops and seminars on AI ethics
- Enhanced interdisciplinary collaboration
- Other...



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