Unizik Orient Journal of Education (UNIOJE), Vol. 12, No. 1, December, 2025.
----------ISSN: 0794-9525----------

STUDENTS' USE OF REFLECTIVE THINKING SKILL WHILE ENGAGING WITH AI-GENERATED DATA AND ITS ASSOCIATION WITH GENDER AMONG UNIVERSITY STUDENTS IN ANAMBRA STATE.

Anthony Obinna Ezennaka[1] (PhD) ao.ezennaka@unizik.edu.ng
Victory Unoaku Agu[2] uv.agu@unizik.edu.ng, **Getrude Chinonso Ezema[2]**
gc.ezema@unizik.edu.ng
Esther Njideka Ndubuisi[2] okonkwoesther59@gmail.com
[1] Department of Educational Foundations, Nnamdi Azikiwe University Awka.
[2] Department of Educational Management & Policy, Nnamdi Azikiwe University Awka.

Abstract
This study focused on understanding the relationship between gender and reflective thinking skills among university students in Anambra state while engaging with AI-generated data. Four research questions and three hypotheses guided the study. Ex-post facto research design was used for the study and students' assignment scores was used as the data for the study. The study was carried out in Nnamdi Azikiwe University Awka, Anambra State, Nigeria. Multi-stage sampling procedures was used for the study. The population comprised nine departments in the department of Education. Purposive sampling technique was used to select 3rd year students of department of Adult Education, which has 105 students. For the scoring of the assignment, a rubric titled Rubric for Reflective thinking scores (RRTS) was developed by the authors with the help of ChatGPT-AI. With the scores from the RRTS, the students were categorized into levels as either exemplary reflective thinker, competent reflective thinker, developing reflective thinker, Emerging reflective thinker. The mean and standard deviation were used for the descriptive statistics while t-test and Pearson Product Moment Co-relational analysis were used for the inferential statistics. The findings revealed that gender did not significantly correlate with students' reflective thinking skills while engaging with AI-generated data. The study concluded that both genders have equal capacity for reflective thinking engagement with AI-generated data, and reflective thinking subcomponents are interconnected process while answering the assignment questions.

Key words: Gender, reflective thinking skills, AI-generated data

Introduction

Artificial Intelligence (AI) chatbot technology has been ascribed to have the potential of augmenting human cognition in learning (Molenaar, 2022; Tuomi, 2018), gamify learning, offering rewards and incentives for completing tasks and achieving learning goals (Stoica, *et al.,* 2022). However, some of the inherent worries about its negative impact on human learning abilities like critical and reflective thinking skills (Diaz, 2025; Saritepeci & Durak, 2024; Yildiz-Durak, 2023a,2023b) among students abound among cognitive learning researchers. Among the concerns raised about AI that could impact on cognition and reflective thinking are AI gender-biased governance against women and feminists (Attard-Frost, 2025; Gross, 2023; Hyejin, 2025), Frankenstein syndrome and Artificial Stupidity (Falk, 2021). Frankenstein syndrome, the fear that AI may highjack thinking and evade human control (Falk, 2021) implies that AI may detrimentally impede cognitive skill development and acquisition among learners (Holmes & Tuomi, 2022). Reactionary measures taken to encourage natural cognitive development include the banning of some AI tools, as seen by Chinese Ministry of Education, of AI-assisted homework apps that furnish students with solved answers to their assignments (Dan, 2021). Artificial Stupidity (AS) which is an AI output that offers incorrect answers as solution to any task assigned, which consequently leads to incongruous solutions (Lieber, 2023) has been adjudged by some authors to be necessary evil that is beneficial to the development of AI (Fall, 2021; Lieber, 2023). Reflective thinking, a sensitive aspect of metacognition may be at risk of underdevelopment among students if they fail to acquire and apply the skills in their interaction with AI-generated data. Consequently, this may perpetuate the concerned negative impacts of AI technology. To this effect, this study aims at ascertaining the level of students' acquisition and application of reflective thinking

skill while engaging with AI-generated data, irrespective of students' gender. The findings of this study will also help in building a robust approach in countering other challenges of AI-driven technology which authors have identified as AI-growing concern for family, peer and school disengagement, tech-driven sexual harassment and bullying (Centre for democary and technology, 2025), ethical consideration and limited ability to understand context (Alshater, 2023; Harry, 2023), and lack of trust, potential bias, transparency, responding to human emotions (Harry, 2023).

What is Reflective Thinking

Reflective thinking is a metacognitive skill for critical analysis of one's assumptions and how this may influence one's learning during and after learning (Ezennaka & Unachukwu, 2023). Metacognition, is 'thinking about thinking' which comprises two dimensions: *knowledge of cognition* (awareness of strategies-*what*, tasks-*how*, and condition -*when & why*) and *regulation of cognition* (planning, monitoring, and evaluation) (Flavell, 1979). Reflective thinking is of regulation of cognition in which learners think about what they know or want to know by planning, monitoring and evaluating their learning outcomes with a view to individualizing and strengthening them. When students are guided on reflective thinking skills and its interconnected sub-skills while assessing AI tools, it is expected that they move from passive receivers of information to active managers of their cognitive resources. Hence, reflective thinking in this research is operationalized as students' ability to evaluate a given situation within a context by applying innate cognitive faculties, supported by external knowledge to bring out reasonable interpretation.

Studies continue to support that reflective thinking skills function as an interconnected process rather than as distinct abilities. Accordingly, Mohamed et al. (2022) conceptualized reflection as a dynamic and cyclical exercise, while Kember et al. (2000) categorized reflection into sub-dimensions as habitual action, understanding, reflection, and critical reflection and demonstrated their correlation. Afshar, & Rahimi (2015) studied the association among reflective thinking, emotional intelligence, and speaking ability of English as a Foreign Language (EFL) learners among Iranian University students. The study revealed strong positive correlation among the variables and their subscales. Nonetheless, some researchers pointed out that the integrated nature of reflective thinking may not always be consistent across contexts or learners. Park et al. (2022) observed insignificant longitudinal improvement as well as decrease in medical students' reflective thinking ability and writing, implying that reflection process may not develop at the same time and rate among learners. This could influence the interconnected nature of reflective thinking skills at different developmental levels because of learners' unique characteristics.

AI Interventions in Cognitive and Reflective Thinking Learning

Artificial Intelligence (AI) with the help of Internet of Things (IOT) has aided in deepening learning in different spheres of life endeavours like medicine, education and engineering (Mohamed, 2020). IOT is the network of interconnected physical devices like phones, toys, cameras computers, even human beings that aid in collection, transmission and exchange of information with each other (Mohamed, 2020). These two technologies are advancing the learning and usage of information in the 21st century. Hence, AI systems such as Learning Analytics Dashboards (LADs), Intelligent Tutoring Systems (ITS), and AI-Driven Reflective Journals can provide real-time feedback, performance tracking, and personalized suggestions for cognitive enhancement (Martin, Ndoye, & Kimmons, 2022; Uchenna & Adewale, 2023). These systems allow students to visualize their learning trends and adapt their strategies accordingly. Artificial Intelligence in Education (AIED) is useful for Educational Data Mining and Learning Analytics, which helps in policy-making (Hakimi et al., 2021; Verbert et al., 2020).

For Gen-Z students, the advent of AI and Internet of Things (IOT) innovation in education may have limited their exposure to the era when learning demanded rigorous independent reasoning*, unassisted by artificial or automated tools* that characterized the traditional learning and problem solving. In the traditional learning era, searching through a problem space consists of procedural abstract thought mechanism through the initial (current) state, the goal state, and all possible states in between (Newell & Simon1972). Therefore, the revolutionizing positive effect of AI educational chatbots are

welcomed but it comes with some challenges that need to be addressed (Abbas, *et al.,* 2022). For instance, students have observed that the use of AI in classroom environment makes them feel somewhat disengaged from their teachers, and reduced the family and peer bond outside the school (Centre for democary and technology, 2025).

Some of these interventions adapted in addressing the challenges of AI and enhancing its usage in educational learning outcomes are Intelligent tutoring system (ITS), Personalized learning (PL), Educational data mining (EDM) or Learning analytics (LA), Design-based learning (DBL), and Assessment and feedback (AF).

ITS is the AI provision of guide to learners during the learning process by providing personalized and automated feedback (Kochmar, et al., 2020; Rastegarmoghadam & Ziarati, 2017). PL environment is an AI powered system that puts into considerations the specific and individualized characteristics of learners. It predicts and attends to students' needs, enhances micro-learning strategies (Almuqhim, & Berri, 2025) and bridges the gap between traditional educational content learning pattern and dynamic students' needs which enhances academic performance, engagement, satisfaction and inclusivity (Naseer, et al., 2024). EDM or LA is AI system in education that helps in strategic development of patterns for data collection and analysis using algorithms that characterize them (Hooda, et al., 2022b). Studies have shown that it helped to improve digital education (Munir, et al., 2022) and students' English writing performance, self-efficacy, self-regulated learning and reduced cognitive load. The use of DBL is an AI intervention in cognitive learning and teaching, which fosters design-thinking mindset, creative and reflective thinking skills (Saritepeci & Durak, 2024). A review of 46 peer reviewed articles on ITS observed that ITS helped in personalized learning, real-time feedback and progress monitoring in students (Rodrigues et al., 2025); it also provided adaptive learning experiences among STEM students (Villegas-Ch et al., 2025) . AF is an AI intervention process in education that aid learners, especially during COVID-19 era, in learning through offering feedback and improved learning outcomes (Hooda, et al., 2022a). It has aided learners in improving on their reflective thinking skills (Liu, et al., 2023).

These AI-supported intervention in education has shown that AI with collaborative learning processes can advance learner's creativity (Kafai & Burke, 2014; Kandlhofer et al., 2016; Lim & Leinonen, 2021; Marrone et al., 2022), critical thinking skills (Lund & Wang, 2023) and reflection skill (Singh, et al., 2024).

Reflective Thinking Skills and AI in Education

Considering the importance of reflective thinking in cognitive education, reflective thinking skills should be one of the crucial drive behind the development of AI in education. If it turns to the contrary, whereby AI takes over the place of reflective thinking in learning, some results will be incongruent and bizarre to the realities of life. For instance, the suicide case of 16 year old of Adam Raine in which the lawsuit alleges that chatGPT AI misguided the emotionally challenged teenager to commit suicide (Hill, 2025). A similar case is Alexa AI's challenge to a 10 year old girl to touch a half-inserted live plug with a coin (BBC-UK, Dec. 2021). Another behavioural twist was discovered in a study which revealed that one in five high school students admitted that they or somebody they know have had romantic relationship with AI (Centre for Democracy and Technology, 2025). These show the extent AI-generated information influence the cognitive and affective domains of learning. This implies that the integration of reflective thinking skills in AI-generated data is indispensable for behavioral and cognitive training.

Studies on reflective thinking and AI have consistently shown the indispensability of the former to latter (Lewis & Sarkadi, 2024; Liu et al, 2023; Singh*, et al., 2024*). Lewis & Sarkadi, (2024) in addressing the issue of increasing allocation of human task to machines and imitating of human mind in AI. The authors observed that such attempts devoid of reflective AI, a mechanism that adopts and builds on human reflective thinking skill pattern, could be detrimental to the future of reflective thinking and meta-reasoning. Liu et al., (2021) investigated on how to improve students' knowledge of English as Foreign Language. The result showed that reflective thinking AI-supported English

writing (RTP-AIEW) intervention significantly improved it and reduced their cognitive task. Singh*, et al.,* (2024) studied the level of engineering students' application of reflective thinking skill while engaging with AI-generated data when handling their weekly assignments. The result showed that the students need reflective thinking training in their planning, monitoring and evaluation because their level of application of reflective thinking was low. Diaz (2025) investigated how university students interact with AI-generated data, and if such AI usage could undermine students' critical thinking ability. The study focused on the 5 key areas of 'how AI is used, how users verify information, the cognitive effort involved, decision-making strategies, and reflective behavior'. Data from 1273 students showed that Cluster 0 has 1193 instances characterized by balanced confidence on AI generated information with moderate level of reflection skill while engaging with AI generated information. Cluster 1 has 43 instances characterized by high confidence on AI generated information with low-level application of reflective thinking while engaging with AI generated information. Cluster 2 has 128 instances characterized by low confidence on AI generated information and high level of reflection skill while engaging with AI generated information. An experimental study by Nam & Lee (2025) investigated on the application of reflective thinking while creating AI-integrated design education by using AI-image prompts. The experimental group that received greater reflective thinking prompts performed better in the writing output than the control group.

For a robust appreciation of AI studies with reflective thinking skills, its gender sensitivity for Sustainable Development Goals (SDGs-5 gender equality) is a necessary variable to be investigated also.

Studies on Reflective Thinking Skill, AI and Gender

As AI technology makes inroads in all spheres of life, perceived as threat or opportunity (Kim, 2025), it unsettles many scholars with emerging ethical, behavioural, learning and socio-cultural concerns. Gender, a sensitive demographic variable has its educational concern while studying AI development with metacognitive skill of reflective thinking. Hence, reflexivity, the relationship between research background and researcher's background (Kim, 2025) comes into place when students per gender, reflectively interact with AI-generated data. For Leavy (2018) the worry is that the data for machine learning and AI algorithm is already sitting on volumes of data that is gender biased against the womenfolk. It is from this data that AI builds, develops and generates most of its data which could widen the threat to eradicating gender sensitivity, and achieving gender equality in the SDGs.

Nonetheless, examining some empirical work on gender, AI and reflective thinking skill will help in understanding the situations proposed as threat or opportunity to gender equality. Kalyani et al. (2025) investigated on how AI-based assessment tools could impact on the reflective practice of pre-service teachers. The result showed a significant improvement especially for the female students than their male counterparts. This shows that the SDG-5 target is being achieved in education. Attard-Frost (2025) conducted a research on Transfeminist challenges from AI governace- a domain study in AI that seeks to minimize harm and maximize the benefits of AI. The findings revealed that based on the author's reflections backed by some empirical reviews, trans-feminists are marginalized which stemmed from historical and cultural background AI is emerging from. Hyejin (2025) researched on how AI chatGPT could help in teaching and learning that would address gender-bias in education against female folk. The study revealed that building an AI structure that will enhance feminist pedagogical reflexivity would help in addressing the gender issue in AI governance. Study on how students apply ethical reflection and critical evaluation in handling AI-generated data shows that female students significantly outperformed their male counterparts in this regard (Wang et al., 2025). More so, Møgelvang et al (2024) investigated on the extent of education students' engagement with AI-generated materials. The findings revealed that though male students have higher engagement with AI-chatbot for future life plan, female students outperformed them in applying critical, ethical and independent thinking while assessing AI-generated materials. A comparative study on human and AI generated summaries on University student reflections was carried out. Gender-biased indices on the study showed that AI-generated summarizes of students' reflection had gender-bias against male students (Baghel et al., 2024). The above reviews on the relationship between reflective thinking skill, AI and gender show that female gender are conscious of the AI emerging reflective thinking challenges and are responding positively to it.

Statement of the Problem

The emergence and integration of AI into modern education system, that is, AI literacy (Holmes & Tuomi, 2022) is revolutionizing the traditional landscape of teaching and learning by restructuring the direction of educational tools usage. The modus of thought production and data management became easier though demanding a synergy of smarter natural and artificial skill application. Hence, AI usage still needs natural intelligence for robust outcome. Nonetheless, there is an observation and looming tendency of students generating and submitting AI information in their assignments and academic works devoid of or with little personal cognitive input. This would be a great disservice to learning in schools if not checked. Accordingly, the need to understand the extend students, of either genders, engage with AI generated data without being lost to AI control is expedient. In Nigeria, there is a dearth of studies on the relationship among the variables AI, reflective thinking and gender among university students. Olojede (2025) investigated on gender equality and diversity in AI in Africa, it was not on reflective thinking skill. Study on affective, behavioural, cognitive and ethical perspective to AI in Nigeria and Ghana by Asghar et al. (2025), though dealt with reflective thinking skill, has no gender variable. Omeh et al. (2025) studied on how AI technology could impact on computational and reflective thinking skill of south-eastern Nigeria University students, the study has no gender variable result and it was on how AI would help to improve reflective thinking skill. Based on these academic gaps and concerns, this current study is on assessing the relationship between gender and reflective thinking, and students' level of application of reflective thinking skill to AI-generated data.

Research Questions

The study was guided by three research questions and two hypotheses.

1. What is the level of reflective thinking skills of the students while engaging with AI-generated data?
2. What is the mean scores of the reflective thinking skills of male and female students while engaging with AI-generated data?
3. To what extent does gender correlate with students' reflective thinking skills while engaging with AI-generated data?
4. To what extent do students' reflective thinking skills subscales correlate among themselves while engaging with AI-generated data?
5. Is there a significant difference in the mean scores of the reflective thinking skills of male and female students while engaging with AI-generated data?
6. Is there a significant difference in the correlation of gender with students' reflective thinking skills while engaging with AI-generated data?
7. Is there a significant difference in the relationship among the students' reflective thinking skills subscales while engaging with AI-generated data?

Methods

This study adopted Ex-post Facto research design. This was conducted among 3rd year students of the Department of Adult Education, Nnamdi Azikiwe University in Anambra State. The population of study is 1,278 students from 9 departments in the Faculty of Education. Multi-stage sampling procedures was used for the sampling. Purposive sampling techniques was used to select 3rd year students because they have been taught cognitive and reflective thinking skills in their previous semesters. Simple random sampling was used to select department of Adult Education which comprise an intact class of 105 students. The instrument for data collection was a standardized assignment question validated by the lecturers in the Educational Psychology unit of the Department of Educational Foundations. It was based on the topic taught in the course – Special Education. The instruction for the assignment supported students' use of Artificial Intelligence (AI) tools and be critical and reflective in answering the question. The page was limited between 4 to 7 and the assignment was collected after 2 weeks.

For the scoring of the assignment, the authors developed a rubric with the help of Chatgpt-AI which was titled Rubric for Reflective Thinking Scores (RRTS). RRTS represents reflective thinking skills needed for the answering of the assignment and scoring was continuous not categorical. RRTS has 7

subscales, which are Description of Experience, Awareness & Assumptions, Evaluation & Judgment, Connection to Theory or Prior Knowledge, Perspective Taking & Openness (which includes other viewpoints, biases), Application & Action Plan (future-oriented), Depth of Reflection (transformative insight). For each of the 7 criteria above, score was assigned from 0 to 4 based on the level of application of the skills. The minimum total score used was 1, while the maximum total score is 28. (7 × 4 = 28). With the scores obtain from the rubrics, students' total scores were categorized as Emerging reflective thinkers (1-7 points), Developing reflective thinkers (8-14 points), Competent reflective thinkers (15-21 points), Exemplary reflective thinkers (22-28 points)

The research questions were answered using mean, standard deviation and percentage while t-test and Pearson Product Moment Co-relation Coefficient were used to analyze the inferential statistics.

Table 1: AI-Reflective thinking score levels of the students

SN	Categorical variables	Score range	NO. of Male	No. of Female	Gender Cumulative Frequency	Percentage	Cumulative percentage
1	Emerging reflective thinker	1-7	5	7	12	11.4	11.4
2	Developing reflective thinker	8-14	0	4	4	3.8	15.2
3	Competent reflective thinker	15-21	22	55	77	73.3	88.6
4	Exemplary reflective thinker	22-28	2	10	12	11.4	100.0
	Total		29	76	105	100	

Table 2: Correlation analysis of the relationship between gender and AI reflective thinking scores

Variables	No.	Mean	SD	R	Sig.	*F*	Sig.	t	df	Sig.
Gender	105	1.72	.45	.080	.418	1.094	.298	-.813	103	.418
AI Reflective thinking scores		17.03	4.24							
Male	29	16.48	4.77							
Female	76	17.24	4.04							

p = ≤ 0.05

Table 3: Bivariate relationships among reflective thinking skill variables
(gender p = ≤ 0.05; reflective thinking subscales p = ≤ 0.01)

SN	**Variables**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Gender	-							
2	description of experience	.084	-						
3	Awareness & Assumptions	.074	.782**	-					
4	Evaluation & Judgment	.042	.739**	.650**	-				
5	Connection to Theory or Prior Knowledge	.020	.667**	.627**	.551**	-			
6	Perspective Taking & Openness	.089	.695**	.687**	.613**	.502**	-		
7	Application & Action Plan	.124	.646**	.661*	.610**	.636**	.519**	-	
8	Depth of Reflection (Transformative Learning)	.038	.674**	.602**	.597**	.713**	.455**	.727**	-

Result

Based on our categorization of reflective thinkers in the rubrics, the result in table 1 showed that 12 students representing 11.4% got into the range of Exemplary reflective thinkers**.** Developing reflective thinkers have 4 students representing 3.8% of the students; Competent reflective thinkers has 77 students representing 73.3% of the students while Exemplary reflective thinkers have 12 students representing 11.4% of the students. Students whose scripts have evidence of copying from each other were marked under 1-7 points (Emerging reflective thinker), irrespective of their output.

This is because it shows sign of lack of reflective thinking skill from either which we cannot detect within the duration of this research.
For research question 2 and its hypothesis in number 5, the mean scores of the reflective thinking skills of the students (M= 1.72; SD= .45) (male=16.48; SD=4.77; female =17.24; SD=4.04) while engaging with AI-generated data has no significant difference [$t(103)$= -.813, p=.418]. This was obtained having checked Levene's test of homogeneity to test for the assumption of equal variance which showed that the mean difference among groups was not significant [$F(1.094, p=.298)$].
For research question 3 and its hypothesis in number 6 shows a very low positive correlation (r= .080) and has no significant difference in the correlation coefficient between gender and reflective thinking skills (p=.418) (see table 1). This shows that students' reflective thinking ability was equal across the genders.
For research question 4 and its null hypothesis in number 7, the result in table 3 showed that there is a strong positive and significant correlation among the variables of reflective thinking subscales **(p<.01)**, with r ranging from .455** to .782**. This shows an interconnectedness of the reflective thinking skills of the students while engaging with AI generated learning data.

Students' description of experience, and Awareness & Assumptions (r= .782**, p<.01) showed the strongest positive correlation while Perspective Taking & Openness, and Depth of Reflection (Transformative Learning) recorded the lowest correlation coefficient (r= .455**, p < .01). Students' depth of reflection had between moderate and strong correlation coefficient range in all the reflective thinking subscales ($.455 \leq r \leq .727$, $p < .01$). However, Application & Action (r = .727) and Connection to Theory (r=.713) were the strongest predictors of students' depth of reflection.

Discussion of Findings
The study aimed at assessing the relationship between gender and reflective thinking, and students' level of application of reflective thinking skill to AI-generated data. This study is very timely because of the inevitable use of AI in learning. The findings of this study is very critical towards understanding the role of AI in education.

Our findings showed that most of the students are competent reflective thinkers while engaging with AI-generated learning data because of the moderately high points scored in their assignment. This suggests that many students were able to apply reflective thinking skills while using AI-generated data. The reason could be due to their exposure to cognitive and reflective thinking skills in their previous semester. This result supports the findings of Diaz (2025) who observed that while engaging with AI generated information, greater number of students have balanced confidence on AI generated information with adequate level of reflection skill. Accordingly, studies have shown that those who apply reflective thinking skill while engaging with AI-generated learning data perform better in their cognitive tasks than those who apply little level of reflective thinking (Liu et al., 2021; Nam & Lee, 2025; Singh et al., 2024). Our findings suggests that Frankenstein syndrome, the phobia that AI may takeover thinking and evade human control (Falk, 2021) thereby impeding cognitive skill development among learners (Holmes & Tuomi, 2022) is not supported by our finding. This is because a good number of the students demonstrated a sufficient use of reflective thinking skill over AI generated data. Our findings also suggests that students were conscious in handling Artificial Stupidity, a limitation in AI generation of output that offers incorrect answers as solution to any task assigned, which consequently leads to inappropriate solutions (Lieber, 2023).
Contrary to our finding, Singh et al., (2021) observed that most students have low level of application of reflective thinking skills while engaging with AI-generated learning data. The difference in result may be due to training effect and course used for the data collection. Our study used students from the department of educational foundations who have received lectures on cognitive learning in which reflective thinking skill was taught. The course used was on Special Education. The students for Singh's study were from civil engineering department offering environmental engineering course and may not have been exposed to the training.
The mean scores of the reflective thinking skills of the students while engaging with AI-generated data has no significant difference. The result also showed that the correlation coefficient between gender and reflective thinking scores has a very low positive relationship with no significant

difference. This shows that students' reflective thinking ability was equal across the genders while engaging with AI-generated learning data in their assignment. Our finding is not consistent with the findings that observed female students' better performance than their male counterparts in their reflective thinking ability while engaging with AI-generated learning data (Baghel et al., 2024; Kalyani et al., 2025; Møgelvang et al., 2024) nor findings that revealed male dominance in generative-AI engagements (Attard-Frost, 2025; Leavy, 2018). Exposure and method of exposure to cognitive and reflective thinking skills may account for the difference in the findings. Our findings purports that the SDG-5 that sought for gender equality and girl/women access to digital technology in education is being achieved among Nnamdi Azikiwe university students.

Our findings observed strong positive correlation among the subscales of students' reflective thinking skills while engaging with AI-generated data. This showed that reflective thinking, as a metacognitive structure is an interconnected process, which may have predictive effects when investigated. Our finding aligns with the findings of Mohamed et al. (2022) and Kember (2000) that reflective thinking subscales are significantly interconnected. However, the findings of Park et al. (2022) is inconsistent with this findings. The difference in findings may be due to longitudinal method by Park et al that followed the developmental stages of the students' reflective thinking which our study did not do.

Implications of the Study

Our findings have some implications for teaching and learning, policy development and specifically for achieving the Sustainable Development Goals (SDGs) of Quality Education and Gender Equality in Nigeria before 2030. Our findings on gender show that both male and female students have equal capacity to engage meaningfully in metacognitive activities of reflective thinking. This implies that training the girl-child in reflective thinking will offer her the leverage of competing favourably with the male counterpart and bridging the gap in AI technology and digital education which some researchers have observed a widening gap against the female folk. So gender is no demographic disadvantage to female students' reflective ability in their interaction with AI generative data.

The researchers found that a majority of the students were within the range of Competent reflective thinkers which was associated to their past exposure to reflective thinking skills in their previous semester. This implies that teaching of reflective thinking skills and other cognitive skills should be fundamental in learning curriculum across all departments of learning because it helps to deepen reflective thinking ability. As students are increasingly exposed to AI-generative data, their reflective thinking skill will help to forestall the looming danger of AI Frankenstein syndrome, the fear that AI may takeover thinking and elude human control; and Artificial stupidity- the problem of not censoring AI data which usage may lead to fundamental mistakes.

Conclusion

The study focused on understanding the relationship between gender and reflective thinking skills among university students while engaging with AI-generated learning data. Based on the findings, the researchers concluded that many of the students are Competent reflective thinkers, which is second to the first level of the four grading we used. The researchers also concluded that gender was not a significant factor in the depth or quality of reflection when using AI-generated data. From the findings, the researchers concluded that reflective thinking as a metacognitive structure is an interconnected process because of the strong positive correlation found among the subscales of students' reflective thinking skills while engaging with AI-generated data.

REFERENCES

Afshar, H. S., & Rahimi, M. (2015). Reflective thinking, emotional intelligence, and speaking ability of EFL learners: Is there a relation? *Thinking Skills and Creativity, 19*, 97-111. **https://doi.org/10.1016/j.tsc.2015.10.005**

Almuqhim, S., & Berri, J. (2025). AI-Driven Personalized Microlearning Framework for Enhanced E Learning. *Computer Applications in Engineering Education*, *33*(3). **https://doi.org/10.1002/cae.70040**

Attard-Frost, B. (2025). Transfeminist AI governance. *First Monday, 30*(4). https://doi.org/10.5210/fm.v30i4.14121

Baghel, B. K., Narayanan, A. B. L., & Yoder, M. M. (2024). A fairness analysis of human- and AIgenerated student reflection summaries. Proceedings of the 5th Workshop on Gender Bias in Natural Language Processing (GeBNLP), 6077. **https://doi.org/10.18653/v1/2024.gebnlp-1.5**

BBC-UK (28, Dec. 2021). Alexa tells 10-year-old girl to touch live plug with penny. retrieved on January 7th, 2026from https://www.bbc.co.uk/news/technology-59810383

Díaz, G.M. (2025). *Supporting reflective AI use in education: A fuzzy-explainable model for identifying cognitive risk profiles*. ***Education Sciences, 15*** (7), Article 923. https://doi.org/10.3390/educsci15070923

Falk M. (2021). Artificial stupidity. *Interdisciplinary Science Reviews*. *46*(1-2):36-52. doi:10.1080/03080188.2020.1840219

Gross, N. (2023). *What ChatGPT tells us about gender: A cautionary tale about performativity and gender biases in AI.* ***Social Sciences, 12,*** Article 435. https://doi.org/10.3390/socsci12080435

Hooda, M., Rana, C., Dahiya, O., Rizwan, A., & Hossain, M. S. (2022). Artificial intelligence for assessment and feedback to enhance student success in higher education. *Mathematical Problems in Engineering,* 1–19. https://doi.org/10.1155/2022/5215722

Kafai, Y. B., & Burke, Q. (2014). *Connected Code: Why Children Need to Learn Programming*. MIT Press.

Kalyani, K., Praveen Kumar, T. D., & Roopa, A. N. (2025). AI-based tools for enhancing reflective practice and self-efficacy in pre-service teachers. The Scientific Temper, 16(4), 4128-4135. **https://doi.org/10.58414/SCIENTIFICTEMPER.2025.16.4.16**

Kandlhofer, M., Steinbauer, G., Hirschmugl-Gaisch, S., & Huber, P. (2016). Artificial intelligence and computer science in education: From kinder-garten to university. In IEEE Frontiers in Education Conference (pp. 1–9). https://doi.org/10.1109/FIE.2016.7757570

Kember, D., Leung, D. Y. P., Jones, A., Loke, A. Y., McKay, J., Sinclair, K., Tse, H., Webb, C., Wong, F. K. Y., Wong, M., & Yeung, E. (2000). Development of a questionnaire to measure the level of reflective thinking. Assessment & Evaluation in Higher Education, 35(4), 381-395.**https://doi.org/10.1080/713611442**

Kim, D. O. (2025). Reflection-AI: Artificial intelligence or algorithmic instruction problem? Empowering students through situated knowledges-based reflexivity. *Frontiers in Communication, 10*. **https://doi.org/10.3389/fcomm.2025.1598082**

Kochmar, E., Vu, D.D., Belfer, R., Gupta, V., Serban, I.V., Pineau, J. (2020). Automated Personalized Feedback Improves Learning Gains in An Intelligent Tutoring System. *Artificial Intelligence in Education.* doi: 10.1007/978-3-030-52240-7_26.

Leavy, S. (2018). Gender bias in artificial intelligence: the need for diversity and gender theory in machine learning. In GE '18: *Proceedings of the 1st International Workshop on Gender Equality in Software Engineering, 14-16.* **https://doi.org/10.1145/3195570.3195580**

Lewis, P. R., & Sarkadi, Ş. (2024). Reflective artificial intelligence. *Minds and Machines, 34*, 14 44. **https://doi.org/10.1007/s11023-024-09664-2**

Lieber, J., Mailly, J.-G., Marquis, P., Prade, H., & Rollin, F. (2023). Some thoughts about artificialstupidity and artificial dumbness. *AI Communications*, 1–15. **https://doi.org/10.3233/AIC-220322**

Lim, J., & Leinonen, T. (2021). Creative peer system an experimental design for fostering creativity with artificial intelligence in multimodal and sociocultural learning environments. In *CEUR workshop proceedings 2902*, 41–48). RWTH Aachen University. https://research.aalto.fi/en/publi cations/creative-peer-system-an-

experimental-design-for-fostering-creativ

Liu, C., Hou, J., Tu, Y. F., Wang, Y., & Hwang, G. J. (2023). Incorporating a reflective thinking promoting mechanism into artificial intelligence-supported English writing environments. *Interactive Learning Environments, 31*(9), 5614–5632. https://doi.org/10.1080/10494820.2021.2012812

Lund, B. D., & Wang, T. (2023). Chatting about ChatGPT: How may AI and GPT impact academia and libraries? *Library Hi Tech News, 40*(3), 26–29.

Marrone, R., Taddeo, V., & Hill, G. (2022). Creativity and Artificial Intelligence—A Student Perspective. *Journal of Intelligence, 10*(3), 65. https://doi.org/10.3390/jintelligence10030065

Møgelvang, A., Bjelland, C., Grassini, S., & Ludvigsen, K. (2024). Gender differences in the use of generative artificial intelligence chatbots in higher education: Characteristics and consequences. *Education Sciences, 14*(12), Article 1363. https://doi.org/10.3390/educsci14121363

Mohamed, E. (2020). The relationship between artificial intelligence and internet of things: A quick review. Journal of Cybersecurity and Information Management, 1(1), 30- 34. **https://doi.org/10.5281/zenodo.3686810**

Mohamed, M., Rashid, R.A., Alqaryouti, M.H. (2022) Conceptualizing the complexity of reflective practice in education. *Front Psychol. 19*;13:1008234. doi: 10.3389/fpsyg.2022.1008234.

Munir, H., Vogel, B., & Jacobsson, A. (2022). Artificial intelligence and machine learning approaches in digital education: A systematic revision. Information, 13(4), 203. https://doi.org/10.3390/info13040203

Nam, J., & Lee, Y.-J. (2025). *Study on the role of reflective thinking in image-generating artificial intelligence use for design education.* ***Journal of Digital Contents Society, 26***(6), 1507–1516. https://doi.org/10.9728/dcs.2025.26.6.1507

Naseer, F., Khan, M. N., Tahir, M., Addas, A., & Aejaz, S. M. H. (2024). Integrating deep learning techniques for personalized learning pathways in higher education. *Heliyon 10,* **https://doi.org/10.1016/j.heliyon.2024.e32628**

Ododo, E. P., Essien, N. P., & Etim, A. (2024). Effect of Generative Artificial Intelligence (AI)-based tool utilization and Students' Programming self-efficacy and Computational Thinking skills in JAVA programming course in Nigeria Universities. *International Journal of Contemporary Africa Research Network, 2*(1). **https://doi.org/10.5281/zenodo.12100074**

Olojede, H. T. (2025). Reflecting on Diversity and Gender Equality in Artificial Intelligence in Africa. *The Thinker*. **https://doi.org/10.36615/2XJ82139**

Omeh, C. B., Olelewe, C. J., & Ohanu, I. B. (2025). Impact of Artificial Intelligence Technology on Students' Computational and Reflective Thinking in a Computer Programming Course. *Computer Applications in Engineering Education*. **https://doi.org/10.1002/cae.70052**

Park, K. H., Kam, B. S., Yune, S. J., Lee, S. Y., & Im, S. J. (2022). Changes in self-reflective thinking level in writing and educational needs of medical students: A longitudinal study. *Plos one*, *17*(1), e0262250.

Rastegarmoghadam, M., & Ziarati, K. (2017). Improved modeling of intelligent tutoring systems using ant colony optimization. *Education and Information Technologies, 22*(10), 67–1087. https://doi.org/10.1007/s10639-016-9472-2

Rodrigues, B., Pinto, R., & Gonçalves, G. (2025). A systematic literature review of AI-driven intelligent tutoring systems in engineering education: Emphasizing personalization, feedback, and student monitoring. *IEEE Access*, *13*, 190152-190177. **https://doi.org/10.1109/ACCESS.2025.3626473**

Saritepeci, M., & Durak, H. Y. (2024). Effectiveness of artificial intelligence integration in design- based learning on design thinking mindset, creative and reflective thinking skills: An experimental study. *Education and Information Technologies*, *29*, 25175-25209 **https://doi.org/10.1007/s10639-024-12829-2**

Singh, A., & Diefes-Dux, H. A., & Panther, G., & Perry, L. A. (2024). *Students' MetacognitiveRegulation Strategies in Written Reflections within Third-Year Introductory Environmental Engineering Course.* Paper presented at 2024 *ASEE Annual Conference & Exposition, Portland, Oregon*. 10.18260/1-2—48029

Um, H. (2025). A case study of teaching and learning strategies for addressing gender bias in AI: Focusing on student assignments from a general education course in women's studies using ChatGPT. ***Korean Journal of General Education, 19****(3), 141–155. https://doi.org/10.46392/kjge.2025.19.3.141*

Villegas-Ch, W., Buenano-Fernandez, D., & Navarro, A. M. (2025). Adaptive intelligent tutoring systems for STEM education: analysis of the learning impact and effectiveness of personalized feedback. *Smart Learning Environments*, *12*, 41. **https://doi.org/10.1186/s40561-025-00389-y**

Wang, Z., Chai, C.-S., Li, J., & Lee, V. W. Y. (2025). *Assessment of AI ethical reflection: The development and validation of the AI ethical reflection scale (AIERS) for university students.* ***International Journal of Educational Technology in Higher Education, 22, (***19**)* 1-16. https://doi.org/10.1186/s41239-025-00519-z

Yildiz Durak, H. (2023a). Conversational agent-based guidance: Examining the effect of chatbot usage frequency and satisfaction on visual design self-efficacy, engagement, satisfaction, and learner autonomy. *Education and Information Technologies, 28 471-488.* https://doi.org/10.1007/s10639-022-11149-7