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The Impact of Artificial Intelligence (AI) Tools on Cognitive and Emotional Engagement of Biology Education Students in Rivers State Universities

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ABSTRACT

This study examined the impact of Artificial Intelligence (AI) tools on the cognitive and emotional engagement of Biology Education students in Rivers State Universities. Four objectives and four corresponding null hypotheses guided the study. The study adopted a descriptive survey research design. The population comprised 1,738 Biology Education students from Rivers State University and Ignatius Ajuru University of Education. A sample of 350 students was selected using the Taro Yamane formula, while simple random and proportionate sampling techniques were employed in selecting the respondents. Data were collected using a self-structured questionnaire titled Impact of AI Tools on Cognitive and Emotional Engagement among Biology Education Students Questionnaire (IAITCEEBSQ). The instrument was validated by experts and a reliability coefficient of 0.87 was obtained using the test retest method. Mean and standard deviation were used to answer the research questions, while independent samples t-test was used to test the hypotheses at the 0.05 level of significance. The findings revealed that AI tools had a low influence on the cognitive and emotional engagements of Biology Education students in Rivers State Universities. Although AI tools supported students' understanding of Biology concepts, concentration, problem solving, and retention of learning materials, their overall influence on cognitive and cognitive and emotional engagement was not statistically significant. The findings further showed that there was no significant difference between the mean responses of male and female students regarding the influence of AI tools on cognitive and emotional engagements. The study concluded that although AI tools possess the potential to support both cognitive and emotional engagement among Biology Education students, their overall influence remains limited. The study recommended that Biology lecturers should integrate more interactive and student centred AI based learning activities into instruction and that university management should provide adequate training and support to enhance students' effective use of AI tools for improved engagement

Introduction

The rapid advancement of Artificial Intelligence (AI) has transformed various sectors of society, including education. AI refers to the capability of machines to perform tasks that typically require human intelligence, such as learning, reasoning, problem solving, and decision making (Russell & Norvig, 2016). In recent years, AI powered tools such as intelligent tutoring systems, adaptive learning platforms, virtual laboratories, educational chatbots, and content generation applications have gained increasing attention in educational settings. These tools provide personalized learning experiences, instant feedback, and data driven support that can enhance students' learning outcomes and overall engagement (Luckin, et al., 2016; Holmes, Bialik, & Fadel, 2017).

Learning engagement is a multidimensional construct that encompasses students' cognitive, emotional, and behavioural involvement in learning activities (Fredricks et al., 2004). Among these dimensions, cognitive engagement reflects the mental effort, critical thinking, and strategic learning students invest in academic tasks, while emotional engagement relates to students' interest, enjoyment, motivation, and positive feelings toward learning. These dimensions are particularly important in Biology education, which requires learners to understand complex concepts, visualize microscopic processes, and apply scientific reasoning to solve problems. However, many students experience

difficulties engaging meaningfully with Biology when instruction relies heavily on traditional lecture based methods, a challenge that is often more pronounced in developing countries such as Nigeria where educational resources may be limited (Popenici & Kerr, 2017).

The emergence of AI tools presents new opportunities for enhancing both cognitive and emotional engagement among Biology Education students. Through personalized instruction, adaptive learning pathways, interactive simulations, and immediate feedback, AI tools can support deeper understanding of biological concepts while simultaneously fostering students' motivation, interest, and confidence in learning. For instance, virtual laboratories and simulation tools enable students to explore abstract biological processes in an engaging and interactive manner, thereby promoting meaningful learning experiences (Moreno, 2019). Similarly, adaptive learning systems and educational chatbots provide individualized support that can encourage active participation and sustained interest in learning.

Despite the growing adoption of AI technologies in higher education globally, empirical evidence regarding their impact on the cognitive and emotional engagement of Biology Education students in Nigerian universities remains limited. In Rivers State Universities, where efforts are being made to modernize teaching and learning practices, there is a need to determine the extent to which AI tools influence students' cognitive and emotional engagement. Furthermore, examining whether these effects differ between male and female students can provide valuable insights for educators, curriculum developers, and policy makers. Therefore, this study investigates the impact of Artificial Intelligence (AI) tools on the cognitive and emotional engagement of Biology Education students in Rivers State Universities, with particular attention to gender differences in engagement outcomes.

Statement of the Problem

Biology is a subject that requires students to invest considerable mental effort and maintain positive attitudes toward learning in order to understand complex and abstract concepts. However, many Biology Education students in Rivers State Universities continue to experience difficulties in sustaining both cognitive and emotional engagement due to the predominance of conventional teaching methods that often encourage passive learning. Consequently, students may struggle to think critically, maintain interest in learning activities, remain motivated, and develop positive emotional connections with Biology as a subject. Artificial Intelligence (AI) tools have emerged as innovative educational technologies capable of enhancing students' learning experiences through personalized instruction, instant feedback, adaptive learning, and interactive learning environments. These tools have the potential to improve both cognitive engagement by promoting deeper understanding and critical thinking, and emotional engagement by increasing students' interest, motivation, confidence, and enjoyment of learning. Despite the growing adoption of AI technologies in education globally, there is limited empirical evidence on their impact on the cognitive and emotional engagement of Biology Education students in Rivers State Universities. Furthermore, it remains unclear whether the influence of AI tools on cognitive and emotional engagement differs between male and female students. This lack of empirical evidence creates a gap in knowledge that necessitates investigation. Therefore, this study seeks to examine the impact of Artificial Intelligence (AI) tools on the cognitive and emotional engagement of Biology Education students in Rivers State Universities, with particular emphasis on gender differences in engagement outcomes.

Purpose of the Study

The purpose of this study is to examine the Impact of Artificial Intelligence (AI) Tools on cognitive and emotional Engagement of Biology Education Students in Rivers State Universities.

Specifically, the study sought to:

1. Examine the impact of AI tools on cognitive engagement of Biology Education students in Rivers State Universities.
2. Assess the impact of AI tools in cognitive engagement of male and female Biology Education students in Rivers State Universities.
3. Determine the impact of AI tools on emotional engagement of Biology Education students in Rivers State Universities.
4. Examine the impact of AI tools on emotional engagement of male and female Biology Education students in Rivers State Universities.

Research Questions

The ensuing research questions guided the study:

1. To what extent do AI tools impact cognitive engagement of Biology Education students in Rivers State Universities?
2. To what extent do AI tools impact cognitive engagement of male and female Biology Education students in Rivers State Universities?
3. To what extent do AI tools impact emotional engagement of Biology Education students in Rivers State Universities?
4. To what extent do AI tools impact emotional engagement of male and female Biology Education students in Rivers State Universities?

Hypotheses

The following null hypotheses were formulated in this study:

Ho_1: AI tools have no significant impact on the cognitive engagement of Biology Education students in Rivers State Universities.

Ho_2: There is no significant difference between the mean rating of male and female Biology Education students on the impact of AI tools on cognitive engagement.

Ho_3: AI tools have no significant impact on the emotional engagement of Biology Education students in Rivers State Universities.

Ho_4: There is no significant difference between the mean rating of male and female Biology Education students on the impact of AI tools on emotional engagement.

Literature Review

Artificial Intelligence in Education

Artificial Intelligence in Education (AIED) refers to the application of artificial intelligence technologies to support teaching, learning, assessment, and educational administration. AI systems are designed to simulate human intelligence by performing tasks such as learning, reasoning, problem solving, and decision making. In educational settings, AI tools facilitate personalized learning, adaptive instruction, intelligent feedback, and learner support, thereby improving the quality and effectiveness of learning experiences (Chaudhry & Kazim, 2022; Zawacki Richter et al., 2019). The development of AIED can be traced to the emergence of intelligent tutoring systems in the 1980s, but advances in machine learning, learning analytics, and generative AI have significantly expanded its educational applications in recent years (Zawacki Richter et al., 2019). Various AI tools are currently used in higher education, including intelligent tutoring systems, adaptive learning platforms, educational chatbots, learning analytics systems, virtual assistants, automated assessment tools, and generative AI applications. These technologies support individualized instruction, continuous assessment, and enhanced learner engagement (Crompton & Burke, 2023; Zawacki Richter et al., 2019). In science and Biology education specifically, AI tools such as virtual laboratories, simulation platforms, intelligent tutoring systems, and AI powered content generation tools are increasingly employed to simplify complex scientific concepts, promote inquiry based learning, and improve students' understanding of abstract biological processes (Almasri, 2024). Globally, the adoption of AI in universities has increased substantially due to its potential to enhance learning outcomes, student support, and institutional efficiency (Crompton & Burke, 2023). Although AI integration is more advanced in developed countries, universities in Africa, including Nigeria, are increasingly embracing AI technologies for teaching, learning, and research. However, challenges such as inadequate infrastructure, limited digital literacy, insufficient institutional policies, and unequal access to technology continue to affect the effective implementation of AI in higher education across many African countries (Zawacki Richter et al., 2019). Despite these challenges, the growing interest in AI adoption presents significant opportunities for improving educational quality and student engagement in Nigerian universities.

Artificial Intelligence in Biology Education

Artificial Intelligence (AI) has emerged as an innovative technology with significant potential to transform teaching and learning across various disciplines, including Biology education. AI refers to the capability of computer systems to perform tasks that normally require human intelligence, such as learning, reasoning, problem solving, and decision making (Russell & Norvig, 2016). In Biology education, AI tools are increasingly being used to enhance students' learning experiences by providing

personalized instruction, interactive learning environments, immediate feedback, and access to a wide range of educational resources. The application of AI in Biology education is particularly important because Biology involves the study of complex and often abstract concepts such as genetics, cellular processes, physiology, and ecological interactions. Traditional teaching methods may not always provide students with adequate opportunities to visualize and understand these concepts effectively. AI powered tools such as virtual laboratories, intelligent tutoring systems, adaptive learning platforms, and educational chatbots help bridge this gap by enabling students to explore biological phenomena through simulations, guided learning experiences, and interactive problem solving activities (Moreno, 2019; VanLehn, 2006).

Furthermore, AI tools support individualized learning by adapting instructional content to students' learning needs and pace, thereby promoting deeper understanding and active participation in the learning process (Luckin & Holmes, 2017). Through continuous assessment and instant feedback, these technologies help students identify learning gaps and improve their comprehension of biological concepts. AI tools also facilitate inquiry based learning by encouraging students to investigate scientific problems, formulate hypotheses, and engage in critical thinking activities that are essential in Biology education (Moreno, 2019).

The integration of AI into Biology education therefore provides opportunities for creating student centred learning environments that foster meaningful learning and intellectual development. By promoting active interaction with learning materials and enhancing conceptual understanding, AI tools have the potential to improve the cognitive engagement of Biology Education students and contribute to more effective learning outcomes.

AI Tools and Cognitive Engagement

Artificial Intelligence (AI) tools are intelligent technologies such as chatbots, virtual tutors, adaptive learning platforms, simulations, and automated content generators that support teaching and learning through personalized instruction, instant feedback, and interactive learning experiences (Chen et al., 2020; Holmes et al., 2019). The growing adoption of these tools in higher education is driven by their potential to enhance students' learning experiences and improve academic outcomes (Hwang et al., 2020; Luckin et al., 2016). Cognitive engagement refers to the degree of mental effort, strategic thinking, self-regulation, and persistence that students invest in the learning process (Fredricks et al., 2004). It reflects learners' willingness to go beyond surface learning by applying critical thinking skills, solving problems, and seeking deeper understanding of academic content. Cognitive engagement is particularly important in Biology education, where students are required to understand complex concepts, analyse scientific information, and apply knowledge to real world situations.

AI tools can enhance cognitive engagement by providing adaptive learning experiences that match students' learning needs and abilities. Through personalized feedback, intelligent guidance, and interactive learning environments, these tools encourage learners to actively process information, monitor their understanding, and engage in higher order thinking activities. The effectiveness of AI tools in promoting cognitive engagement can be explained by constructivist learning theory and Self Determination Theory, which emphasize active knowledge construction, learner autonomy, and motivation (Piaget, 1947; Deci & Ryan, 2017). Empirical studies have shown that AI powered learning systems can improve students' critical thinking, problem solving abilities, and depth of learning when effectively integrated into instruction (VanLehn, 2006; Zawacki Richter et al., 2019). Therefore, AI tools have considerable potential to enhance the cognitive engagement of Biology Education students when appropriately implemented in the teaching and learning process.

AI Tools and Emotional Engagement

Emotional engagement refers to the feelings and emotional reactions students experience during the learning process. It encompasses students' interest, enjoyment, enthusiasm, motivation, and sense of belonging in the learning environment (Kahu, 2013; Wong & Liem, 2022). It reflects the degree to which students develop positive attitudes towards learning activities and remain emotionally invested in their academic pursuits. Students who are emotionally engaged tend to show greater enthusiasm, persistence, and commitment to learning tasks, which can contribute positively to their academic success (Skinner & Belmont, 1993; Reeve, 2012). The use of Artificial Intelligence (AI) tools in education has created new opportunities for improving students' emotional engagement. AI powered learning systems can

provide personalized learning experiences, immediate feedback, and tailored support that address individual learning needs. These features can help reduce feelings of frustration and anxiety, particularly when students encounter challenging concepts. By receiving timely assistance and guidance, students are more likely to develop confidence and sustain their interest in learning.

In Biology education, AI tools such as intelligent tutoring systems and educational chatbots can offer continuous academic support and constructive feedback in a manner that encourages learning without fear of criticism. This supportive learning environment can increase students' motivation, interest, and enjoyment of Biology lessons (Baker et al., 2019). Consequently, AI tools can promote positive emotional experiences that strengthen students' connection to the learning process and encourage active involvement in academic activities.

Gender and AI Engagement

Gender has been identified as one of the factors that may influence students' engagement with Artificial Intelligence (AI) tools in educational settings. Existing studies indicate that both male and female students recognize the potential of AI technologies to support learning; however, differences have been observed in their patterns of use and engagement. Male students are often reported to demonstrate higher levels of confidence and willingness to adopt AI tools for academic tasks, while female students tend to be more concerned with the accuracy, reliability, and ethical use of AI generated content (Draxler et al., 2023; Ofosu Ampong, 2023). Research has also shown that although male students may use AI tools more frequently, female students often engage more critically with AI generated outputs by paying closer attention to the quality and credibility of the information provided. However, evidence suggests that these differences are generally not substantial when students have equal access to technological resources, adequate training, and the necessary digital skills. This implies that factors such as digital literacy, access to technology, and prior experience with AI tools may have a greater influence on engagement than gender itself (Draxler et al., 2023; Ofosu Ampong, 2023). Consequently, it is important to examine gender in studies on AI tools and cognitive engagement. Understanding whether male and female Biology Education students differ in their level of cognitive engagement when using AI tools will provide useful insights into the extent to which AI supported learning environments promote active participation, critical thinking, problem solving, and knowledge construction among learners. This will also help determine whether gender sensitive interventions are necessary to ensure equitable benefits from the use of AI technologies in education.

Cognitive Constructivism Theory

This study is anchored on the Cognitive Constructivism Theory propounded by Jean Piaget (1952). The theory posits that learning is an active process in which individuals construct knowledge through interaction with their environment rather than passively receiving information. According to Piaget, learners develop understanding by integrating new experiences into their existing cognitive structures through the processes of assimilation and accommodation. The theory emphasizes that meaningful learning occurs when learners actively explore, think, solve problems, and make sense of information based on prior knowledge. In addition to fostering intellectual development, the theory recognizes that learners are more likely to engage meaningfully with learning experiences when they find them interesting, relevant, and personally rewarding. Cognitive Constructivism Theory is relevant to this study because Artificial Intelligence (AI) tools provide interactive and learner centred environments that support both cognitive and emotional engagement. Through features such as personalized learning, instant feedback, intelligent tutoring, and adaptive learning experiences, AI tools enable Biology Education students to engage deeply with learning content, explore biological concepts, and develop critical thinking skills. These opportunities enhance cognitive engagement by encouraging students to invest mental effort in understanding and applying knowledge rather than merely memorizing information. Furthermore, the interactive and supportive nature of AI tools can increase students' interest, enjoyment, confidence, and motivation toward learning Biology, thereby promoting emotional engagement. Therefore, the theory provides a suitable framework for explaining how AI tools can enhance the cognitive and emotional engagement of Biology Education students in Rivers State Universities.

Methodology

This study adopted a descriptive survey research design. The study was conducted in two universities in Rivers State, Nigeria: Rivers State University (RSU) and Ignatius Ajuru University of Education (IAUE). These institutions were selected because they offer Biology Education programmes and provide a suitable context for examining the use of AI tools among undergraduate students. The population of the study comprised 1,738 Biology Education students from 100 to 400 levels in the Departments of Science Education of Rivers State University and Ignatius Ajuru University of Education during the 2025 academic session. A sample size of 350 students was selected using the Taro Yamane formula. Simple random sampling technique was employed to select the respondents, while proportionate sampling was used to ensure adequate representation of male and female students. Data were collected using a self-structured questionnaire titled Impact of AI Tools on Cognitive and Emotional Engagement among Biology Education Students Questionnaire (IAITCEEBESQ). The instrument was subjected to face and content validation by three experts comprising two Biology Education lecturers and one expert in Measurement and Evaluation. To establish reliability, the test retest method was employed using 20 Biology Education students from the University of Port Harcourt who were not part of the study population. The two sets of scores obtained within an interval of two weeks were correlated using the Pearson Product Moment Correlation Coefficient, yielding a reliability coefficient of 0.87, indicating that the instrument was reliable. The researcher, with the assistance of two trained research assistants, administered the questionnaire directly to the respondents. Completed copies of the questionnaire were collected immediately after administration. Data collected were analysed using mean and standard deviation to answer the research questions, while an independent samples t test was used to test the hypothesis at the 0.05 level of significance.

Results

Research Question 1: To what extent do AI tools impact cognitive engagement of Biology Education students in Rivers State Universities?

Table 1: Summary of Descriptive (Means & Standard Deviation) on the extent AI Tools impact Cognitive Engagement of Biology Education Students in Rivers State Universities

S/N	AI Tools and Cognitive Engagement	Mean	SD	Remark
1.	AI tools help me understand difficult Biology concepts easily.	2.58	0.84	High Extent
2.	The use of AI tools improves my critical thinking during Biology lessons.	2.10	0.87	Low Extent
3.	AI tools increase my concentration while studying Biology courses.	2.59	0.80	High Extent
4.	AI tools help me solve Biology-related academic problems faster.	2.54	0.88	High Extent
5.	AI tools enhance my ability to remember Biology concepts learned in class.	2.58	0.85	High Extent
	Grand Total	**2.48**	**0.84**	**Low Extent**

Source: Field Survey (2025)

The data in table 1 shows that students agreed that the extent AI tools impact cognitive engagement of Biology Education students in Rivers State Universities is low (Mean=2.37, SD=0.84). The table further reveals that students agreed that AI tools help them understand difficult Biology concepts easily (Mean=2.58, SD=0.84), increase their concentration while studying Biology courses (Mean=2.59, SD=0.80), solve Biology-related academic problems faster (Mean=2.54, SD=0.88) and enhance their ability to remember Biology concepts learned in class (Mean=2.58, SD=0.85). However, they disagreed that the use of AI tools improve their critical thinking during Biology lessons (Mean=2.10, SD=0.87).

Research Question 2: To what extent do AI tools impact cognitive engagement of male and female Biology Education students in Rivers State Universities**?**

Table 2: Summary of Descriptive (Means & Standard Deviation) on the extent AI Tools impact Cognitive Engagement of Male and Female Biology Education Students in Rivers State Universities

	Male	Female

	AI Tools and Cognitive Engagement	(n=161)		(n=189)	
		Mean	SD	Mean	SD
6.	Male students benefit cognitively from AI tools in Biology learning.	2.51	0.86	2.65	0.81
7.	Female students benefit cognitively from AI tools in Biology learning.	2.21	0.90	1.99	0.83
8.	AI tools improve classroom participation among male Biology students.	2.63	0.81	2.54	0.79
9.	AI tools improve classroom participation among female Biology students.	2.57	0.88	2.51	0.87
10.	Male students use AI tools effectively for solving Biology assignments.	2.55	0.83	2.60	0.86
	Grand Total	**2.49**	**0.86**	**2.46**	**0.83**

Source: Field Survey (2025)

The data presented in Table reveal that both male and female students perceived AI tools as having a moderate positive influence on the cognitive engagement of Biology Education students in Rivers State Universities (Male=2.49, Female=2.46). The respondents agreed that AI tools enhance cognitive benefits, improve classroom participation, and support effective completion of Biology assignments among students. Although there was slight variation in the responses of both groups, the grand mean scores for male (Mean=2.49) and female (Mean=2.46) students indicate that respondents generally perceived AI tools as having a moderate positive impact on students' cognitive engagement irrespective of gender.

Research Question 3: To what extent do AI tools impact emotional engagement of Biology Education students in Rivers State Universities?

Table 3: Summary of Descriptive (Means & Standard Deviation) on the extent AI Tools impact Emotional Engagement of Biology Education Students in Rivers State Universities

S/N	AI Tools and Emotional Engagement	Mean	SD	Remark
11.	AI tools make me feel emotionally connected to Biology learning.	2.39	0.79	Low Extent
12.	AI tools improve my confidence during Biology classroom interactions.	2.53	0.89	High Extent
13.	AI tools increase my enthusiasm for studying Biology.	2.40	0.75	Low Extent
14.	AI-assisted learning creates a positive learning experience for me.	2.58	0.85	High Extent
15.	AI tools make me feel motivated to participate in Biology lessons.	2.52	0.92	High Extent
	Grand Total	**2.48**	**0.84**	**Low Extent**

Source: Field Survey (2025)

The data in table 3 shows that students agreed that the extent AI tools impact emotional engagement of Biology Education students in Rivers State Universities is low (Mean=2.48, SD=0.84). The table further reveals that students agreed that AI tools improve their confidence during Biology classroom interactions (Mean=2.53, SD=0.89), make them feel motivated to participate in Biology lessons (Mean=2.52, SD=0.92) and AI-assisted learning creates a positive learning experience for them (Mean=2.58, SD=0.85). However, they disagreed that AI tools make them feel emotionally connected to Biology learning (Mean=2.39, SD=0.79) and increase their enthusiasm for studying Biology (Mean=2.40, SD=0.75).

Research Question 4: To what extent do AI tools impact emotional engagement of male and female Biology Education students in Rivers State Universities?

Table 4: Summary of Descriptive (Means & Standard Deviation) on the extent AI impact Emotional Engagement of Male and Female Biology Education Students in Rivers State Universities

S/N	AI Tools and Emotional Engagement	Male (n=161)		Female (n=189)	
		Mean	SD	Mean	SD
16.	Male students show greater interest in Biology through AI-assisted learning.	2.67	0.88	2.58	0.92
17.	Female students show greater interest in Biology through AI-assisted learning.	2.51	0.86	2.55	0.97
18.	AI tools improve emotional satisfaction among male Biology students.	2.54	0.78	2.45	1.09
19.	AI tools improve emotional satisfaction among female Biology students.	2.52	0.95	2.63	0.77
20.	Male students become more motivated to learn Biology through AI tools.	2.56	0.82	2.48	1.02
	Grand Total	**2.56**	**0.86**	**2.54**	**0.95**

Source: Field Survey (2025)

The data in Table 4 reveal that both male and female students perceived AI tools as having a positive impact on the emotional engagement of Biology Education students in Rivers State Universities (Male=2.56, Female=2.54). The respondents agreed that students show greater interest in Biology through AI assisted learning and AI tools improve emotional satisfaction. Although there was slight variation in the responses of both groups, the grand mean scores for male and female students indicate that respondents generally perceived AI tools as having a positive impact on students' emotional engagement irrespective of gender.

Testing of Hypotheses

Ho_1: AI tools have no significant impact on the cognitive engagement of Biology Education students in Rivers State Universities.

Table 5: Summary of t-test on the extent AI Tools impact the Cognitive Engagement of Biology Education Students in Rivers State Universities.

University	N	Mean	SD	Df	t-test	Sig.	Remark
AI Tools	161	2.39	0.86	348	0.442	0.659	NS
Cognitive Engagement	189	2.35	0.83				

NS= Not Significant

The table above showed the extent AI tools impact on the cognitive engagement of Biology Education students in Rivers State Universities. The t-test calculated value is 0.442, the corresponded significance value is 0.659 showing > 0.05 at 348 degrees of freedom. Hence, it is concluded that there is no significant impact of AI Tools on the learning engagement of Biology Education students in Rivers State Universities. Hence, the null hypothesis one is retained at 0.05 level of significance.

Ho_2: There is no significant difference between the mean rating of male and female Biology Education students on the impact of AI tools on cognitive engagement.

Table 6: Summary of t-test on the difference between the mean responses of Male and Female Biology Education students on the impact of AI Tools on Cognitive Engagement in Rivers State Universities.

University	N	Mean	SD	Df	t-test	Sig.	Remark
Male	161	2.49	0.84	348	0.331	0.740	NS
Female	189	2.46	0.83				

NS= Not Significant

The table above showed the difference in the mean responses of male and female Biology education students on the extent AI tools impact cognitive engagement in Rivers State Universities. The mean response of the male students is 2.49 and the standard deviation is 0.84, while the mean response of the female students is 2.46 and the standard deviation is 0.83. The t-test calculated value is 0.331, the corresponded significance value is 0.740 showing > 0.05 at 348 degrees of freedom. Hence, it is concluded that there is no significant difference in the mean responses of male and female Biology education students on the extent AI tools impact cognitive engagement in Rivers State Universities. Hence, the null hypothesis two is retained at 0.05 level of significance.

Ho_3: AI tools have no significant impact on the emotional engagement of Biology Education students in Rivers State Universities.

Table 7: Summary of t-test on the extent AI Tools impact the Emotional Engagement of Biology Education Students in Rivers State Universities.

University	N	Mean	SD	Df	t-test	Sig.	Remark
AI Tools	161	2.40	0.45	348	1.993	0.047	NS
Emotional Engagement	189	2.24	0.93				

NS= Not Significant

The table above showed the extent AI tools impact on the emotional engagement of Biology Education students in Rivers State Universities. The t-test calculated value is 1.993, the corresponded significance value is 0.047 showing > 0.05 at 348 degrees of freedom. Hence, it is concluded that there is no significant impact of AI Tools on the emotional engagement of Biology Education students in Rivers State Universities. Hence, the null hypothesis five is retained at 0.05 level of significance.

Ho_4: There is no significant difference between the mean rating of male and female Biology Education students on the impact of AI tools on emotional engagement.

Table 8: Summary of t-test on the difference between the mean responses of Male and Female Biology Education students on the impact of AI Tools on Emotional Engagement in Rivers State Universities..

University	N	Mean	SD	Df	t-test	Sig.	Remark
Male	161	2.56	0.86	348	0.205	0.838	NS
Female	189	2.54	0.95				

NS= Not Significant

The table above showed the difference in the mean responses of male and female Biology education students on the extent AI tools impact emotional engagement in Rivers State Universities. The mean response of the male students is 2.56 and the standard deviation is 0.86, while the mean response of the female students is 2.54 and the standard deviation is 0.95. The t-test calculated value is 0.205, the corresponded significance value is 0.838 showing > 0.05 at 348 degrees of freedom. Hence, it is concluded that there is no significant difference in the mean responses of male and female Biology education students on the extent AI tools impact emotional engagement in Rivers State Universities. Hence, the null hypothesis six is retained at 0.05 level of significance.

Discussion

The Impact of AI tools on Cognitive Engagement of Biology Education students in Rivers State Universities

The result presented in Table 1 showed that the extent to which AI tools impact the cognitive engagement of Biology Education students in Rivers State universities is low. This suggests that while AI tools may support basic cognitive processes such as comprehension, concentration, problem solving, and retention of learning materials, they are less effective in developing higher order thinking skills such as critical thinking and analytical reasoning which are essential for meaningful cognitive engagement in Biology education. This finding aligns with the submission of Holmes et al (2017) that the educational effectiveness of AI technologies depends on the extent to which such tools promote deeper intellectual interaction and reflective thinking rather than mere access to information. Furthermore, the result of the t test analysis revealed that there is no significant impact of AI tools on the learning engagement of Biology Education students in Rivers State universities. This indicates that the perceived influence of AI tools on students' cognitive engagement was not statistically significant among the respondents. The finding implies that despite the availability and usage of AI tools, their contribution to meaningful cognitive engagement among Biology Education students remains limited. This may be attributed to factors such as inadequate integration of AI tools into instructional activities, insufficient digital competence among students, or lack of proper guidance on the effective educational use of AI technologies. The finding agrees with Lo et al (2020) who maintained that the effectiveness of AI tools in enhancing students' engagement and learning outcomes depends largely on proper implementation, students' digital literacy, and pedagogical support from educators. Overall, the findings indicate that although AI tools provide some support for understanding and remembering Biology concepts, they have not significantly enhanced the cognitive engagement of Biology Education students in Rivers State universities. The finding therefore underscores the need for improved pedagogical integration and guided usage of AI tools in order to promote deeper cognitive engagement and critical thinking among students in Biology education.

The Impact of AI Tools in Cognitive Engagement of Male and Female Biology Education Students in Rivers State Universities

The result presented in Tables 4.2 and 4.8 revealed that AI tools have a moderate positive influence on the cognitive engagement of Biology Education students in Rivers State universities. Both male and female students agreed that AI tools enhance cognitive benefits, improve classroom participation, and support the effective completion of Biology assignments among students. This suggests that AI tools are capable of supporting students' active mental involvement in learning through improved participation, better understanding of course content, and enhanced academic task performance. However, the moderate level of influence implies that the impact of AI tools on students' cognitive engagement has not yet reached a highly effective level. This finding agrees with Moreno (2019) who maintained that technology based learning tools can improve students' cognitive engagement when properly utilised to support active participation and meaningful learning experiences. Furthermore, the result of the t test analysis showed that there is no significant difference in the mean responses of male and female Biology Education students on the extent AI tools impact cognitive engagement in Rivers State universities. This indicates that both male and female students shared similar perceptions regarding the influence of AI tools on their cognitive engagement. The finding implies that gender did not significantly influence students' views on the effectiveness of AI tools in enhancing their engagement with Biology learning tasks. This may be because students in both groups are exposed to similar learning environments, instructional methods, and levels of access to AI technologies within the universities. The finding supports the position of Dai and Ke (2022) who asserted that the effectiveness of AI supported learning tools is largely dependent on the quality of implementation and accessibility rather than demographic characteristics such as gender. The finding therefore highlights the need for improved integration and effective utilisation of AI tools in Biology instruction in order to further strengthen students' cognitive engagement and participation in learning activities.

The Impact of AI tools on Emotional Engagement of Biology Education Students in Rivers State Universities

The findings from Tables 3 and 7 revealed that the extent to which AI tools impact the emotional engagement of Biology Education students in Rivers State universities is low. This suggests that although AI tools may provide supportive learning experiences that encourage confidence and participation, they are not sufficiently promoting deeper emotional attachment and sustained enthusiasm towards Biology learning among students. The finding further implies that AI tools currently support only limited aspects of students' emotional engagement in Biology education. This finding agrees with Baker, et al (2019), who noted that AI tools can improve emotional engagement by providing supportive and non-judgemental feedback that reduces anxiety and encourages participation in learning activities. Furthermore, the result of the t test analysis showed that there is no significant impact of AI tools on the emotional engagement of Biology Education students in Rivers State universities. This indicates that the influence of AI tools on students' emotional engagement was not statistically significant among the respondents. The finding implies that despite some positive emotional experiences associated with AI assisted learning, the tools have not significantly enhanced students' emotional attachment, enthusiasm, and affective involvement in Biology learning. This limited impact may be attributed to factors such as inadequate personalization of learning experiences, poor integration of AI tools into classroom activities, or insufficient institutional support for effective utilisation of AI technologies in learning. The finding is in line with Deci and Ryan (1985), whose Self Determination Theory emphasised that students' engagement is strengthened when learning environments effectively support autonomy, competence, and relatedness. Consequently, the finding highlights the need for improved integration, personalization, and supportive use of AI tools in Biology education in order to foster stronger emotional connection, enthusiasm, and positive learning experiences among students.

The Impact of AI tools on Emotional Engagement of Male and Female Biology Education Students in Rivers State Universities

The findings from Tables 4 and 8 revealed that both male and female students perceived AI tools as having a positive impact on the emotional engagement of Biology Education students in Rivers State universities. Additionally, the result of the t test analysis revealed that there is no significant difference in the mean responses of male and female Biology Education students on the extent AI tools impact emotional engagement in Rivers State universities. This indicates that both male and female students shared similar perceptions regarding the positive influence of AI tools on their emotional engagement. The finding implies that gender did not significantly affect students' views on the ability of AI tools to improve their emotional satisfaction and interest in Biology learning. This similarity in perception may be because both male and female students experience similar learning conditions and exposure to AI assisted instructional activities within the universities. The finding is in line with Deci and Ryan (1985), whose Self Determination Theory emphasised that students' emotional engagement is strengthened when learning environments support feelings of competence, autonomy, and relatedness. Consequently, the finding highlights the need for sustained and effective integration of AI tools into Biology education in order to further enhance students' emotional satisfaction, interest, and positive learning experiences.

Conclusion

The study examined the impact of Artificial Intelligence (AI) tools on the cognitive and emotional engagement of Biology Education students in Rivers State Universities. Based on the findings, it was concluded that AI tools have a low influence on the cognitive engagement of Biology Education students. Although AI tools were found to support students in understanding difficult Biology concepts, improving concentration, enhancing problem solving abilities, and promoting retention of learning materials, their contribution to higher order cognitive activities such as critical thinking was relatively limited. Consequently, the overall impact of AI tools on students' cognitive engagement was not statistically significant. The study further revealed that AI tools have a low influence on the emotional engagement of Biology Education students. While AI assisted learning was found to improve students' confidence during classroom interactions, create positive learning experiences, and motivate participation in Biology lessons, the tools were less effective in fostering emotional connection to Biology learning and increasing students' enthusiasm for studying the subject. As a result, the overall impact of AI tools on emotional engagement was not statistically significant. In addition, the study concluded that AI tools influence both male and female Biology Education students in a similar manner with respect to cognitive and emotional engagement. The findings showed no significant differences

between the mean responses of male and female students, indicating that gender does not significantly determine how students experience AI supported learning. This suggests that the benefits derived from AI tools are not dependent on gender but are more likely influenced by factors such as accessibility, digital competence, and the manner in which the tools are integrated into instructional practices. Therefore, the study concludes that although AI tools possess the potential to enhance both cognitive and emotional engagement in Biology education, their effectiveness can only be maximized when they are properly integrated into teaching and learning activities and supported with adequate guidance, training, and opportunities that encourage meaningful interaction with the technology.

Recommendations

Based on the findings of the study, the following recommendations were proffered by the researcher:

1. Biology lecturers should utilise AI tools to design instructional activities that specifically promote critical thinking, analytical reasoning, and deeper cognitive engagement among Biology Education students.
2. University administrators and lecturers should ensure equal access and effective utilisation of AI tools among both male and female students in order to sustain the moderate positive cognitive engagement recorded across gender.
3. Biology lecturers should integrate more interactive and student centred AI based learning activities, such as virtual simulations and intelligent tutoring systems, to enhance students' emotional connection, interest, and enthusiasm toward Biology learning.
4. University management should provide adequate training and support for both lecturers and students on the effective use of AI tools to create positive learning experiences and strengthen students' motivation and confidence in Biology education.

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