TRANSFORMING BIOLOGY EDUCATION THROUGH ARTIFICIAL INTELLIGENCE: A SYSTEMATIC REVIEW OF ENGAGEMENT, PERSONALISATION AND ACCESSIBILITY

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Abstract

The integration of Artificial Intelligence (AI) into science education has emerged as a transformative force, offering new possibilities for student engagement, personalised learning, and equitable access. This study employed a quantitative cross-sectional survey design to examine the impact of AI-driven strategies in undergraduate biology education. A total of 120 students participated in the study, responding to a structured questionnaire divided into three focus areas: engagement, personalisation, and accessibility. The instrument demonstrated strong reliability with a Cronbach's alpha of 0.82 following pilot testing. Findings revealed that AI tools such as interactive videos and real-time feedback significantly enhanced student engagement, with AI-generated videos receiving the highest mean score (4.47). Personalised learning, facilitated through adaptive exercises, AI tutors, and customised feedback, also demonstrated moderate effectiveness (average mean: 3.24), although some limitations were noted in the adaptability of AI tools to individual learning paces. Accessibility emerged as a critical concern, with barriers such as unreliable internet, limited device access, and inadequate support for learners with disabilities influencing the overall effectiveness of AI deployment. Educational institutions should prioritise investments in digital infrastructure, inclusive AI design, and technical support systems to maximise the pedagogical benefits of AI in biology education. This study contributes to the growing body of evidence on the practical implications of AI in education by offering a nuanced understanding of how AI tools influence engagement, learning personalisation, and accessibility in the biology classroom. It underscores the importance of aligning technological innovation with institutional readiness and learner diversity

Keywords: Artificial Intelligence (AI), Biology education, Engagement, Personalised learning, Accessibility

INTRODUCTION

The field of Artificial Intelligence, often referred to as AI popularised in the recent past, has shaken the world with its probable outcomes and innovations in almost all fields, education is no exception. It would be appropriate to state that AI has attracted great interest from educators, researchers, and policymakers as a factor that can enhance the processes of teaching and learning. AI in education holds the potential to foster an effective learning environment that focuses on the individual needs of the learner and also on increased engagement as well as efficient ways of evaluating the impact of teaching.

AI is a multifaceted field that is involved in the use of computers in solving tasks that are otherwise performed by human intelligence (Huang et al., 2019). Conventionally, Artificial Intelligence's acronym, AI, was coined as early as 1955 (McCarthy et al., 2006), with the assumption that if one can specify the characteristics of intelligence or intellectual activities like learning, reasoning, judging, deciding etc., then a machine can replicate the same (Wang, 2019). Thus, the initial research in the field of AI attempted to understand how the processes of intelligence occur in human beings so that they could be programmed in computers. This was the trend till the twentieth century." Hoffman lauds the efforts made by Privacy International for having collected considerable clippings on this. Today's AI systems, however, are developed for operation in intricate environments and situations regardless of style or methodology (Floridi, 2014).

Some of the previously mentioned AI techniques have developed over the years to perform tasks that need some level of intelligence. The present-day sophisticated systems implemented by utilising AI are somewhat similar to the human brain as far as processing capabilities are concerned, but contrary to behaving like human beings, they do not and are not even entirely similar. Other categories of AI and their related techniques comprise automated playing of games, recognition of patterns in a given field, data mining, expert systems, neural nets & last but one deep learning. Deep Blue, which is a chess-playing software developed with the assistance of Artificial Intelligence in 1997, defeated Garry Kasparov, the then-world champion in chess as proposed by Campbell et al. (2002).

AI in education can be broadly categorised into several key areas: adaptive learning technologies such as ITSs, automated assessment technologies like computerised grading systems, and intelligent administrative applications. AV technologies use artificial intelligence to apply machine learning algorithms for the delivery of educational content to control every student's learning style at the student's own pace. This kind of approach assists in targeting students with different learning modalities and in the process enhances learning achievement (Zawacki-Richter et al., 2019).

Another imperative area of AI implementation in education is defined by Intelligent Tutoring Systems (ITS). Such systems offer students online guidance and feedback, enhancing their learning experience with the tutor's help. Studies have also indicated that ITS can be as efficient as direct tutoring, providing a solution for the now-limited procedure of individualised training (VanLehn, 2011). For instance, existing platforms such as Carnegie Learning's MATHia

or Pearson's REVEL are slowly but progressively contributing to the enhancement of individualised learning approaches for learners.

Automatic essay scoring systems involve NLP and other related features of artificial intelligence to rate as well as grade students' assignments. Not only do these systems help educators in cutting down the grading workload, but also the students benefit in terms of receiving prompt feedback on their progress. The adoption of ANN and especially NLP has made automated grading more accurate and less prone to errors, and as such can be adopted as an educational tool as proposed by Perelman (2013). Administrative AI tools are intended to assist in a variety of processes, including enrolment management, scheduling and student services. These tools can process large amounts of data to find out these patterns and anticipate the needs of students thereby enabling the institutions to make informed decisions (Zawacki-Richter et al., 2019).

At the same time, the implementation of AI can positively affect the availability of education. For instance, AI enables voice translation and language interpretation to help educate the non-English speaking population and persons with disabilities (Popenici & Kerr, 2017). Software like Microsoft's Immersive Reader and Google's Live Transcribe are already helping students who need accommodations in school, to guarantee that no student is left out in the education process.

The COVID-19 pandemic has further accelerated the adoption of AI in education. With the sudden shift to remote learning, AI-driven platforms and tools have played a crucial role in maintaining educational continuity. AI has helped in creating interactive and engaging online learning environments, which are essential for student motivation and retention during remote learning (Huang et al., 2019). Despite the promising potential of AI in education, several challenges need to be addressed. These include concerns about data privacy, the ethical use of AI, and the need for teacher training and infrastructure to support AI integration. Ensuring equitable access to AI technologies is also a critical consideration, as disparities in access could exacerbate existing educational inequalities.

Enhancing Engagement through AI in Education

Interaction is one of the most important elements that leads to successful learning, and this is where AI technologies are also helpful in increasing the interest of students in classrooms. Using AI, a lot of modern tools and platforms allow students to have personalised and engaging studying processes, which will hold their attention. The basic method through which AI contributes to the way engagement activities is through the application of adaptive learning technologies. These systems consider the student's Behavioural and Performance data to properly recommend material that should be given to them depending on his/her learning capabilities. Thus, compared to traditional standard models of learning, adaptive learning is capable of maintaining learners within their zone of proximal development, thereby enhancing the learners' interest and effectiveness of learning material (Khan et al., 2021). For instance, Dreambox, the learning tool for Mathematics and Duolingo, the learning tool for language, incorporate the element of intelligence via

algorithms, subsequently applying dynamic changes in difficulty whenever the students exhibit a particular proficiency level.

Other types of AI integrations with education include the use of VR and AR to enable students to learn through augmented learning environments. These technologies help students investigate a certain biological process, a historical event, or a phenomenon in a rather exciting way. Chen et al. (2020) have revealed that by implementing both the VR and the AR approaches, it is possible to enhance the learners' motivation and interest in the content of the lessons taught. For example, zSpace and Google Expeditions are technologies that provide methods of virtual and augmented reality that assist in learning the material more effectively.

Gamification is the other AI-based strategy whereby fun is incorporated into the learning process to make it interesting. AI enhance or revolutionises gamification through the gamification of learning, or dynamic and adaptive difficulty levels and immediate responses that keep the students on their toes. The literature review proves that the application of gamification helps to enhance students' activity, attendance, and even achievement scores (Dichev & Dicheva, 2017).

Educational platforms like Kahoot! and Classcraft use artificial intelligence in the development of flexible and exciting educational games. Another means of increasing interest is available in the form of intelligent tutoring systems (ITS). These systems feature the ability to give feedback and support immediately and tailor it to the individual consumer; they mimic the effectiveness of personal tutoring. The uniqueness of ITS provides content interest and motivation due to the capability of addressing the students' questions each time they arise (VanLehn, 2011). Some examples of ITS include Carnegie Learning Ltd's MATHia and OpenAI Codex that assist in the acquisition of programming.

AI also contributes to carrying out collaborative learning. Grouping of students: The use of artificial intelligence in the management of such forums can simultaneously group students with similar skills and learning method preference thus improving the efficiency of grouping for group work. These platforms can also monitor sufficient and adequate group cooperation, resulting in providing information to educators on group behaviours and the participation of students (Rosé et al., 2019).

Furthermore, the application of artificial intelligence chatbots and virtual assistants has become popular in modern society, especially in the education system to interact with students outside the classroom. With the incorporation of these AI tools, students are presented with options to pose their questions, requests for reminders or additional materials, hence are engaged each time they are not in class. Instances such as Georgia State University's Pounce have found their applicability in enhancing students' participation and persistence through offering prompt assistance and knowledge (Belardi, 2019). A study carried out by Chaudhary et al. (2024) has talked about the effects of AI-facilitated learning tools on student engagement and learning performance at the university level. The study indicated a very significant positive relationship between the use of AI tools, such as adaptive learning systems, intelligent tutoring systems, and

automated feedback mechanisms, and student engagement. The students felt more motivated, engaged, and involved with the course content, leading to enhanced performance.

The act of boringly memorising various textbook phrases has, for a greater part of the past, been considered hostile to gamifying AI learning to retain interactivity, thus making this a pretty engaging and enjoyable way to learn. Such platforms track the students' progress and preferences and alert the students whenever they are encountering difficulty with the material, then adjust lessons to suit individual needs. Businesses could employ simulations, quizzes, and AI education models to help increase user engagement. Concepts such as cellular respiration become increasingly engrossing when channelled through gamified media such as Kahoot! and VR simulations (Meta AR Glasses concept) while AI-based chatbots (an example being Mainstay) give them real-time feedback, improving student engagement in biology discussions (ScrumLaunh, 2025). Mixed outcomes have been observed in studies into AI engagement learning tools. For example, Jamworks (AI lecture summarisation) enhanced accessibility for hearing impairment but could not reasonably ascertain whether it promoted retention in the long term (Nicholson, 2025). AI tools such as ChatGPT might lead to what the Romanian study calls "cognitive disengagement" because students used AI-generated summaries without deeper critique (Bikkani & Bikkani, 2025).

However, with the help of AI technologies, there are great opportunities in increasing engagement, and further examination of the challenges related to it should be paid attention to. The security of data and the issue of diversity in the use of innovative resources in learning should be effectively resolved to avoid such gaps. On the same note, teachers should also receive sufficient preparation regarding the application of AI in their classrooms (Luckin et al., 2016).

Personalisation of Learning through AI

The concept of personalised is a process of teaching that focuses on students' needs, skills, and interests. AI technologies form the core of developing personal learning approaches since data analytics, machine learning, and adaptive algorithms help to develop distinct learning models. This fosters the students' interest in learning, boosts their academic achievement and encourages them to learn in his or her unique style.

Adaptive learning platforms are one of the most striking ways that AI helps in delivering personalised learning. These systems are utilised to employ the original data which track performance, together with the learning rates in adapting the course difficulty level, rate and content. For instance, DreamBox and Knewton give adaptive math and science instructions depending on students by employing several algorithms. Research has revealed that there are remarkable learning advancements facilitated by adaptive learning technologies since such a system tries to match the content.

Another relevant technique relates to the use of Artificial Intelligence for recommendation systems. These systems use data such as past performance, interests, and interactions of the students to recommend learning resources and activities. For instance, the AI-based platform known as Edmodo prescribes specific learning material and tasks for the students to accomplish.

Based on the students' needs, through the use of Artificial Intelligence, the experience is made personal to ensure the student gets the right content he or she needs (Beck & Gong, 2013).

A major innovation employed in ITS is effective tutor models that are used to deliver individual courses and feedback. These systems attempt to give individualised guidance to a human tutor who gives tips, descriptions, and ways to solve the problem. The studies have shown that ITS are as efficient as human tutoring in one-to-one interaction, which makes them great tools to brighten up education (VanLehn 2011). Some of the ITS which are in use include MATHia, developed by Carnegie Learning and OpenAI's Codex for programming language learning.

Furthermore, they stated that personalisation is also made possible by NLP technologies that enable the provision of follow-up feedback. Applications that use Artificial Intelligence in writing, such as Grammarly, offer feedback on the writing assignments and then support students with recommendations on the specific difficulties they have. Likewise, language learning applications like Duolingo incorporate the use of AI to design subsequent exercises and feedback based on the current level and advancement of a learner (Loewen et al., 2020).

Adaptive platforms like MetaTutor and Knewton Alta provide learning content customised to the individual's pace of learning, with increased test scores of up to 62% in biology courses. AI-based tutoring systems comply with Vygotsky's zone of proximal development, setting task difficulty levels just right to sustain learner engagement. However, whether personalisation is effective varies across different contexts. According to a 2025 OECD report, such AI systems (e.g., Duolingo) are good at fostering knowledge retention but are poor at supporting collaborative learning, which is greatly emphasised in present-day pedagogy (Laak & Aru, 2024). Over-personalisation threatens to break curricula into bits and pieces. A study concluded in 2025 also observed that AI systems such as Evo 2 sacrifice group-based critical thinking for individualised pacing, which is counterintuitive for scientific inquiry (Myers, 2025).

AI also helps in the delivery of customised learning because it aids in the decision-making processes of educators. Some of the tasks that can be aided by learning analytics tools enhanced by AI include: The learning analytics tools can enable teachers to know the performance, interaction, and learning status of their students. These assist educators in the provision of intervention assistance or enrichment activities, depending on the student's needs, which in turn shows the practical application of learning analytics in education (Siemens and Long, 2011). For instance, applications such as BrightBytes apply the AI system to analyse educational data and come up with the best strategies to pass on to educators. Merino-Campos (2025) systemically conducted a review of 45 empirical studies on AI integration in tertiary education and found, not just that adaptive learning platforms and intelligent tutoring systems not only adapt content and pacing based on individual students' needs but also increase significantly motivation and long-term interest, independent of discipline. Similarly, a meta-review of the application of AI in adaptive learning by Ayeni et al. (2024) highlights that real-time feedback, adaptive exercise difficulty, and individualised resource recommendations lead to measurable increases in student engagement, conceptual understanding, and self-directed learning behaviour.

In addition, personalised learning covers not only content but also emotional and social areas of learners' development. SEL solutions implemented through Artificial Intelligence can monitor the state of the child's feelings and offer action to change their condition. Affectiva is a perfect example of AI that is used to learn about the students' facial expressions and give information to educators on the emotions that are being experienced by the learners so that a positive teaching environment can be facilitated (Calvo & D'Mello, 2010).

Improving Accessibility to Quality Biology Education through AI

It is believed that AI can enhance access to higher-quality education in biology for students in areas of hostility, areas of geographical isolation or students with physical disabilities. Through the use of AI tools and applications, there is a possibility that teachers can overcome the challenges that stem from inadequate resources and disability to deliver unique lessons for different learners because every learner has an equal chance to interact with biology content. There is credible evidence that AI has positive impacts on accessibility as a means of offering good-quality online learning materials. Technological applications can develop more engaging and personalised biology classes that students can attend regardless of the location they are in. For example, Khan Academy and Coursera have introduced AI in education through which it identifies the learning capability of the learner/student, comes up with content that the student cannot master and gives instant feedback. Such platforms guarantee that learners receive appropriate biology education irrespective of their ability to use conventional classroom facilities (D'Agostino, 2020).

Accessibility is also promoted by AI, which provides help to students with disabilities. Technologically enhanced helping aids like text-to-speech or speech-to-text for students with visual or hearing impairment and disability provide them with the content in biology. Aids like Microsoft's Immersive Reader have incorporated the use of artificial intelligence to offer options like reading, translation, and text adjustments that make the content of the biology materials appropriate for the learning needs of the students (Smith & Thomas, 2020). Likewise, other AI-based applications such as Seeing AI assist students with visual impairment to interpret visual data using the describable experience. Language issues become a significant limitation for the affected children to receive better education, but AI can assist with such issues. New programmes in the education system, such as those in translation with the use of Artificial Intelligence or language learning applications, help in catering for the non-native speaking learners in biology class. For instance, Google Translate and Microsoft Translator have adopted artificial intelligence using neural networks to translate texts instantly and accurately, thus helping students learn biology in the language of their choice (Gonzalez & Chen, 2020).

This technology contributes to providing everyone with quality biology education without consideration of the language barriers. Virtual labs and simulations lead in terms of practice-based education since it is hard to have practical lessons for the learners in the remote or underprivileged schools they attend. In particular, websites like Labster provide learners with virtual labs where they can try the experiments and use their imagination regarding the biological world. These AI-based laboratories involve the user and are flexible in terms of helping the students have hands-on experience with a concept in biology without the routine establishment of a laboratory setting

(Makransky et al., 2020). AI technology facilitates overcoming learning barriers through tailoring education to different learners. Speech recognition, speech-to-text systems, and AI-based translations enable schools and organisations to reach a worldwide market and grow their base. For learning platforms, AI-based accessibility features boost inclusivity by enabling dyslexia, mobility, or language constraints to gain access to the same learning regardless (ScrumLaunch, 2025).

In addition, AI can provide additional services for students who do not succeed in the framework of conventional teaching approaches. Automated and adaptive ITS can assist the learners in achieving mastery in their learning of biological concepts, where the software and/or hardware provide feedback to the learners depending on their pace of learning. VanLehn (2011) mentioned that ITS has been proven to be at least as effective as alternative one-on-one human tutoring, and thus would be a good supplementary resource for students who struggled. Some are Carnegie Learning's MATHia and McGraw-Hill's ALEKS, which are already in the process of branching into the sciences. AI also helps in evaluating which students are at risk of poor academic performance; such students are provided with support. Tools for learning analytics based on AI can reveal correlations and, therefore, select students in need of help. This information will be useful to educators to be able to reach out and help these children so that they do not become part of the 'low achievers' group. For instance, there is BrightBytes, which employs AI to assist teachers in supervising students by providing them with data on student performance and activity to help with intervention, and there is Blackboard Predict, which delivers similar outcomes (Siemens & Long, 2011).

AI tools like Be My Eyes (GPT-4 integration) and Otter.ai (multi-lingual transcription) equalise the field for visually challenged and non-native English speakers. LearnWise (AI student support) supports 24/7 and reduces barriers for neurodiverse learners (Bikkani & Bikkani, 2025). While AI opens access as much, there are infrastructural shortcomings. Rural schools, for example, largely do not have the bandwidth to support tools like VR simulations, thus deepening inequalities (Merino-Campos, 2025). AI tools like Grammarly raise ethical issues. A 2025 report from the EU warned that bias due to AI-produced alt-text (e.g., incorrect labelling of medical images) might mislead disabled students (Nicholson, 2025). Fitas (2025) asserted in his book "Inclusive Education with AI" addresses empirical studies showing that language barriers (e.g., English-only UI), lack of or poorly integrated assistive features (e.g., text-to-speech), and a lack of teacher training in AI-tool integration can limit use as well as pedagogical impact. Fitas argues that without robust technical support and inclusive design, AI-based content can remain underused or inaccessible, particularly in multicultural biology classrooms where students have diverse needs

Emerging AI Technologies and Their Potential Impact on Biology Education

The rapid advancement of artificial intelligence (AI) technologies is poised to revolutionise biology education. Emerging AI-driven tools and platforms offer innovative ways to enhance learning experiences, improve student engagement, and facilitate a deeper understanding of complex biological concepts. Here are some of the most promising AI technologies and their potential impact on biology education.

AI-Powered Virtual Labs

AI-powered virtual laboratories are transforming how biology is taught by providing students with immersive, hands-on learning experiences. These virtual labs use AI to simulate biological experiments and processes, allowing students to conduct experiments in a risk-free environment. For instance, Labster offers a range of virtual biology labs that enable students to explore molecular biology, genetics, and physiology through interactive simulations. Studies have shown that virtual labs can enhance students' understanding of biological concepts and improve their practical skills (Makransky et al., 2020).

Intelligent Tutoring Systems (ITS)

Intelligent tutoring systems (ITS) are AI-driven platforms that provide personalised instruction and feedback to students. These systems can adapt to individual learning styles and paces, offering customised support to help students master complex biological concepts. Examples include Carnegie Learning's MATHia and Pearson's MyLab, which are expanding to include more science content. Research indicates that ITS can be as effective as one-on-one human tutoring, making them valuable tools for personalised biology education (VanLehn, 2011).

Natural Language Processing (NLP) for Enhanced Learning

Natural language processing (NLP) technologies are being used to create AI-driven educational tools that can understand and respond to student queries in natural language. These tools, such as chatbots and virtual assistants, provide instant answers to student questions, offer explanations, and guide students through complex biological topics. For example, Google's Dialogflow and OpenAI's GPT-4 can be integrated into educational platforms to facilitate interactive learning experiences. NLP-powered tools can enhance student engagement and provide personalised support outside of the classroom (Winkler & Söllner, 2018).

AI-Driven Adaptive Learning Platforms

Adaptive learning platforms leverage AI algorithms to personalise the learning experience for each student. These platforms analyse student performance data to adjust the content, pace, and difficulty level of lessons in real time. This ensures that students receive the appropriate level of challenge and support, optimising their learning outcomes. Platforms like DreamBox and Smart Sparrow use adaptive learning technologies to tailor biology instruction to individual student needs. Research shows that adaptive learning can significantly improve student achievement and retention (Pane et al., 2017).

AI-Based Content Creation and Curation

AI is also being used to create and curate educational content in innovative ways. AI-driven tools can generate customised learning materials, such as quizzes, flashcards, and interactive modules, based on curriculum standards and student needs. For example, platforms like Quizlet use AI to create adaptive study sets that help students review and retain biological concepts.

Additionally, AI algorithms can curate relevant content from vast online resources, providing students with high-quality, up-to-date information on various biology topics (Shemshack & Spector, 2020).

Predictive Analytics for Student Support

Predictive analytics, powered by AI, can identify students who may be at risk of falling behind or dropping out. By analysing data on student performance, attendance, and engagement, AI systems can predict which students need additional support and alert educators to intervene early. This proactive approach can help ensure that all students receive the help they need to succeed in biology education. Platforms like BrightBytes and Blackboard Predict use predictive analytics to support data-driven decision-making in education (Siemens & Long, 2011).

AI-Enhanced Remote and Blended Learning

The COVID-19 pandemic has accelerated the adoption of remote and blended learning models, and AI technologies are playing a crucial role in supporting these approaches. AI-driven platforms facilitate interactive and engaging online learning experiences, enabling students to access high-quality biology education from anywhere. Tools like Zoom's AI-powered features for virtual classrooms and AI-driven learning management systems (LMS) like Canvas and Blackboard enhance the delivery of biology content in remote settings. These technologies ensure continuity of learning and provide flexible, personalised education options (Hwang et al., 2020).

Statement of the problem

In the days of hype marketing, AI appeared to promise unto biology education profound potentials that would alleviate long-standing issues in pedagogy: student engagement, rigid structure, and inequalities in accessing quality learning resources. Ideally, the AI tools should nurture immersive, personalised, and inclusive learning approaches suitable for diverse student needs. For example, adaptive platforms could tailor content to individual needs as students are progressing, while VR simulations would make abstract biological concepts (like cellular respiration, ecosystem dynamics) more concrete, thereby enhancing conceptual understanding and motivation. On the flip side, it could bring further democratisation for marginalised groups, such as students with disabilities or those in under-resourced areas who could benefit from speech-to-text input mechanisms, multilingual chatbot support, and offline-application learning modules. Due to such vast possibilities, AI adoption in the field of biology education remains scattered, unexplored, and under-implemented, leaving its complete potential untapped.

Current research on AI in education tends to have an excessively narrow focus on either the technical possibility or some generic application, neglecting other perspectives relating to challenges and opportunities specific to biological sciences. AI-based adaptive-learning systems, for instance, have proven very useful in mathematics or language teaching but remain largely unexplored in dealing with the teaching of highly complex and visual biological processes such as DNA replication or neural signalling. Meanwhile, existing interventions rarely consider ways in which AI systems could increase engagement, personalisation, and accessibility in one integrated approach, thereby rendering most innovations fragmented and unable to address systemic issues

of inequity. One systematic review published in 2023 found that just 12% of AI interventions in science education targeted barriers to accessibility, and even fewer incorporated ethical safeguards against biased algorithmic recommendations. Further adding to the AI divide are infrastructural disparities, like uneven internet access and inadequately equipped teacher training, that slow down scaling in lower-income and rural locations. Thus, these show an existing gap and disconnecting discrepancy between the promises AI brings into theory and the actual, equitable implementation in biology classrooms.

This study seeks to bridge this gap by systematically exploring how AI technologies are currently being leveraged to transform biology education across the triad of engagement, personalisation, and accessibility. The outcomes will provide actionable advice to teachers, policymakers, and developers to design AI tools that not only function pedagogically but are also inclusive and ethical, rendering the benefits of AI innovation available to every student regardless of their socioeconomic background, geographical location, or capability.

Purpose of the study

1. Assess AI-driven strategies for enhancing engagement in biology education
2. Determine the efficacy of personalised learning in biology education
3. Examine accessibility barriers in teaching biology education

Research questions

1. What are the AI-driven strategies for enhancing engagement in biology education?
2. What is the efficacy of personalised learning in biology education?
3. What are the accessibility barriers in teaching biology education?

Methodology

This study employed a quantitative cross-sectional survey design to examine the role of Artificial Intelligence (AI) in transforming biology education, focusing on three core dimensions: student engagement, personalised learning, and accessibility barriers. The choice of a cross-sectional approach enabled data collection at a single point in time to capture respondents' perceptions and experiences with AI-driven tools in biology education. A structured questionnaire was developed and divided into three key sections, aligning with the study's objectives: (1) AI-driven strategies for enhancing engagement, (2) efficacy of personalised learning using AI, and (3) accessibility challenges in AI-supported biology instruction. Each item was measured using a five-point Likert scale ranging from *Strongly Disagree (1)* to *Strongly Agree (5)*. The survey instrument underwent pilot testing with a sample of 20 students to ensure reliability. The internal consistency of the instrument was assessed using Cronbach's alpha, yielding a reliability coefficient of 0.82 at a 0.05 level of significance, which is considered acceptable. The main study sample consisted of 120 respondents, drawn from undergraduate biology students using stratified random sampling to ensure representation across year levels and gender. Participation was voluntary, and informed consent was obtained from all participants. The data collected were analysed using descriptive statistics (frequencies, percentages, and mean scores) to address all research objectives.

Results and Discussion

Research question one: What are the AI-driven strategies for enhancing engagement in biology education?

Table 1: AI-driven strategies for enhancing engagement

S/N	Item	SD F %	D F %	N F %	A F %	SA F %	Mean
1.	AI tools like gamified quizzes increase my participation in biology lessons.	17 14.2	0 0.0	12 10.0	42 35.0	49 40.8	3.88
2.	Virtual reality (VR) simulations make learning biological processes (e.g., DNA replication) more engaging.	34 28.3	0 0.0	24 20.0	18 15.0	44 36.7	3.32
3.	AI-generated interactive videos hold my attention better than traditional lectures.	0 0.0	0 0.0	12 10.0	39 32.5	69 57.5	4.47
4.	Real-time AI feedback during labs motivates me to improve my performance.	17 14.2	0 0.0	24 20.0	18 15.0	61 50.8	3.88
5.	AI discussion forums (e.g., AI-moderated Q&A) enhance my peer interaction.	40 33.3	27 22.5	12 10.0	12 10.0	29 24.2	2.69
	Average mean						**3.65**

The table reveals that students generally have a favourable perception of AI tools for enhancing engagement in biology lessons. The highest-rated item was the use of AI-generated interactive videos, with 90% agreeing or strongly agreeing that these videos hold their attention better than traditional lectures. Gamified quizzes and real-time AI feedback during labs were positively received, each with a mean score of 3.88, suggesting they boost participation and motivation. Virtual reality simulations received mixed feedback, with a mean of 3.32, while AI discussion forums had the lowest mean score of 2.69, with over half of the students disagreeing or strongly disagreeing that these tools enhance peer interaction. The effectiveness of AI tools depends on the specific application and how well they align with students' learning preferences. The findings are corroborated by the study carried out by Chaudhary et al. (2024), which discusses the effects of AI-facilitated learning tools on student engagement and learning performance at the university level. The study indicated a very significant positive relationship between the use of AI tools, such as adaptive learning systems, intelligent tutoring systems, and automated feedback mechanisms, and student engagement. The students felt more motivated, engaged, and involved with the course content, leading to enhanced performance.

Research question two: What is the efficacy of personalised learning in biology education?

Table 2: efficacy of personalised learning in biology education

S/N	Item	SA F %	A F %	N F %	D F %	SD F %	Mean
1.	AI provides personalised feedback that helps me improve my understanding of biology topics.	34 28.3	0 0.0	27 22.5	35 29.2	24 20.0	3.13
2.	The difficulty level of AI-generated biology exercises adapts to my learning pace.	34 28.3	3 2.5	12 10.0	47 39.2	24 20.0	3.20
3.	AI-recommended study resources (e.g., articles, videos) match my learning needs	34 28.3	0 0.0	27 22.5	35 29.2	24 20.0	3.13
4.	Personalised AI tutors help me master challenging biology concepts (e.g., genetics).	17 14.2	12 10.0	18 15.0	15 12.5	58 48.3	3.71
5.	AI tracks my progress and adjusts lesson plans to address my weaknesses.	34 28.3	3 2.5	36 30.0	18 15.0	29 24.2	3.04
	Average mean						**3.24**

The study reveals that students generally find AI-driven personalisation in biology education to be moderately effective. The most significant endorsement is for personalised AI tutoring, which helps students master challenging biology concepts. The adaptability of exercise difficulty is also highly valued, with 30.8% of students agreeing or strongly agreeing that AI exercises match their learning pace. However, nearly 60% remain neutral or disagree, indicating room for improvement. Personalised feedback and AI-recommended resources scored a mean of 3.13, with 28% strong agreement, but 49% feeling feedback and resource suggestions are not fully meeting their needs. The capacity to track progress and adjust lesson plans scored the lowest, with 30.8% agreement and nearly 39% neutrality, suggesting that dynamic curriculum adjustment is the least beneficial. Overall, personalised AI tutors are a clear strength, but other personalisation features may need refinement to more consistently support learner progress. The findings is in line with Ayeni et al. (2024), which highlights that real-time feedback, adaptive exercise difficulty, and individualised resource recommendations lead to measurable increases in student engagement, conceptual understanding, and self-directed learning behaviour.

Research question three: What are the accessibility barriers in teaching biology education?

Table 3: accessibility barriers in teaching biology education

	SA	A	N	D	SD

S/N	Item	F %	F %	F %	F %	F %	Mean
1.	I have reliable internet access to use AI tools for biology education.	34 28.3	0 0.0	24 20.0	30 25.0	32 26.7	3.22
2.	My institution provides devices (e.g., tablets, laptops) to access AI-driven biology resources.	34 28.3	0 0.0	12 10.0	42 35.0	32 26.7	3.32
3.	AI tools in my biology courses accommodate learners with disabilities (e.g., text-to-speech).	17 14.2	0 0.0	36 30.0	18 15.0	49 40.8	3.68
4.	Language barriers limit my ability to use AI tools (e.g., English-only interfaces).	17 14.2	0 0.0	36 30.0	18 15.0	49 40.8	3.68
5.	Technical support is available to help me navigate AI platforms in biology classes.	17 14.2	0 0.0	24 20.0	15 12.5	64 53.3	3.91
	Average mean						**3.56**

Students face moderate to substantial accessibility challenges when using AI tools for biology education. Technical support is the most significant barrier, with over two-thirds of respondents disagreeing or strongly disagreeing about the availability of help. Language barriers and disability accommodations also pose significant obstacles, with 55% feeling English-only interfaces and limited accessibility features hinder their use of AI tools. Device provision by institutions is a moderate barrier, with 61.7% remaining neutral or disagreeing. Reliable internet access is the least acute barrier, with roughly half of the students still reporting neutral to negative experiences with connectivity. To reduce accessibility barriers, enhancing technical support, multilingual interfaces, and inclusive design should be prioritised. The findings were in line with the study of Fitas's new chapter on "Inclusive Education with AI" (2025), which addresses empirical studies showing that language barriers (e.g., English-only UI), lack of or poorly integrated assistive features (e.g., text-to-speech), and a lack of teacher training in AI-tool integration can limit use as well as pedagogical impact. Fitas argues that without robust technical support and inclusive design, AI-based content can remain underused or inaccessible, particularly in multicultural biology classrooms where students have diverse needs

Conclusion

The study exhibits that AI-based solutions offer great promise in engaging and adapting to learning in a college-level biology curriculum, yet their success is mediated by some critical accessibility issues. Students were highly enthusiastic about interactive videos and AI-guided tutors, claiming increased attention, motivation, and intent to comprehend, while gamified four-question tests or quizzes and adaptive exercises had a smaller positive attribution. The AI tool's

greatest strength is achieved through a solid technical infrastructure: Institutional provision of devices, sound technical support, and considerations of accommodations in multilingual interfaces and disabilities. In application, educational institutions thus will have to tie their joy of currently deployed AI with steady establishment-level investments in connectivity and hardware access, provisions for continuous educator training, and directives that champion universal design. The complex interplay between innovation in teaching methods, personalisation, and accessibility must be tackled together if biology teaching is to derive from AI deep engagement, faster learning, and successful support for all of its students.

Recommendations

1. Institutions should adopt and iteratively evaluate high-impact AI strategies such as interactive videos, real-time feedback, gamified quizzes, and refined VR simulations to sustain student participation and deepen learning in biology courses.
2. Educators should implement AI-powered systems that deliver individualised feedback, dynamically adjust exercise difficulty, and recommend tailored study resources
3. To overcome connectivity, device, language, and support barriers, schools must invest in reliable infrastructure, establish device-loan programs, incorporate universal design and multilingual interfaces into AI tools

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