

Barriers and Enablers to Implementing Artificial Intelligence in Life-Sciences Education: A Mixed-Methods Study

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Abstract: With the emergence of Artificial Intelligence (AI), learning can be personalized, intelligent tutoring is now possible, predictive analytics can be generated, and automated assessment can be performed. AI technologies in the teaching of life-sciences, including, but not limited to, machine learning, virtual laboratories, adaptive learning environments, and bioinformatics tools, can play a major role in supporting education in teaching, scientific research training, and scientific learning based on data. Even with such benefits, AI has not been successfully integrated in the life-sciences curricula across most institutions of higher learning. Various barriers such as technology infrastructure, inadequate training of faculty, institutional support, ethical issues of privacy of data, and the resistance to technological change, among others, have remained a hindrance to proper implementation. The proposed paper will focus on the existing impediments and facilitating elements that affect AI implementation in life-sciences education. The mixed-methods research design was taken to gain an in-depth perspective on the issue. The quantitative data were gathered using a structured questionnaire of life-science students and faculty members and the qualitative data were collected using semi-structured interviews with educators and academic administrators. The results have shown that the key obstacles are the lack of AI literacy among teachers, institutional insufficiency, academic integrity issues, and the absence of explicit educational policies assisting the implementation of AI. On the other hand, it has named institutional investment in digital infrastructure, faculty professional development programs, interdisciplinary collaboration, and supportive educational policies as key enablers to learners using AI to drive learning. The paper makes a case of the significance of strategic planning and institutional readiness in effective adoption of AI in the field of life-sciences education. The findings offer practical implications to teachers, administrators and policymakers who want to incorporate AI technologies in the teaching and learning process in order to improve learning outcomes and equip students with the ability to do scientific research with the help of AI.

Keywords: Artificial Intelligence, Life Sciences Education, Educational Technology Adoption, AI Integration, Mixed-Methods Research.

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I. INTRODUCTION

➤ Background

The advent of Artificial Intelligence (AI) has opened up as a transformative technology in contemporary pedagogy whereby systems of adaptive learning are realized, systems of smart tutoring, systems of automated assessment, and systems of data-driven decision making in pedagogical settings. Educational tools based on AI are able to improve learning and customize it, analyze student performance, and aid tutors with the work on the curriculum and assessment (Chen, Chen and Lin, 2020). In tertiary education, especially in the field of science, AI technologies are becoming part of

online learning platforms to support improved critical thinking and research-based education. In education In the field of life-sciences, applications of artificial intelligence are increasing at a high rate, including bio-medical data analysis, bioinformatics education, virtual laboratories, and simulation-based medical learning spaces (Yu & Kohane, 2021). Through these tools, students can handle large biological data sets, genomic data and predictive models which are a reflection of real-life scientific studies. Moreover, the continued process of digitalizing education has increased the pace of the use of emerging technologies, such as machine learning and generative AI systems, that facilitate collaborative and interactive learning (Bond et al., 2021).

Scientific research is becoming more and more data-intensive, and to train students with the necessary computational and analytical abilities in the biological and medical research of the day, it is important to integrate AI into life-science education (Kasneji et al., 2023).

➤ *Problem Statement*

The implementation of AI technologies in life-science learning is, nevertheless, not evenly distributed across institutions and educational programs despite the rapid expansion and increasing capabilities of the AI technologies. Most institutions of higher learning have institutional, technological and pedagogical challenges that restrict successful adoption of AI tools in teaching and learning activities. Such challenges as a lack of digital infrastructure, the lack of faculty training, and confusion over ethical and academic integrity-related matters remain obstacles to a widespread adoption (Bond et al., 2021).

➤ *Research Gap*

The available literature regarding the adoption of AI in education has mainly centered on generic higher education or engineering and computer science fields. The number of empirical studies investigating particular challenges and opportunities of the integration of AI in life-sciences education is comparatively lower than that of disciplinary necessities and laboratory-based learning settings, which are unique factors of implementation (Kasneji et al., 2023).

➤ *Research Objectives*

The current research will identify the obstacles that impede introduction of AI in teaching life-sciences, as well as establish the enablers that will help in successful adoption of AI in educational institutions. It also aims at examining how educators and students feel about the usefulness and effectiveness of AI-based learning tools. Lastly, the research will aim at offering practical suggestions that will enable successful adoption of AI technologies in life-science educational and learning settings.

➤ *Research Questions*

This paper will provide answers to three research questions, namely: What are the obstacles to the application of AI in life-sciences teaching? What are the facilitating factors of successful AI application in higher education institutions? What is the perception of educators and students regarding the use of AI-related tools in the learning settings of life-sciences?

II. LITERATURE REVIEW

➤ *Artificial Intelligence in Education (AIED)*

Artificial Intelligence in Education (AIED) is the use of machine learning, natural language processing, and predictive analytics to improve teaching, learning, and educational management with the use of AI technologies. Such systems allow customized learning, intelligent tutoring services and automated feedback systems that enhance the learning efficiency and student interaction. The development of AIED has been boosted by the modern capabilities in computational power and big data analysis, enabling educational colleges

and universities to adopt AI-based technologies to support adaptive learning and academic performance measurement (Zawacki-Richter et al., 2020). Recent reports emphasize that AI-based educational systems have the potential to facilitate personalized learning trajectories and help educators make decisions based on the analysis of massive educational data (Holmes and Tuomi, 2022).

➤ *Applications of AI in LSE.*

The utilisation of AI technologies in education of life-sciences is becoming a common practice to enhance the process of learning complex sciences. AI is utilized in bioinformatics education, where students learn to compute biological networks, protein structures, and genomics to enhance their computational biology ability (Angermueller et al., 2020). Artificial intelligence-based virtual laboratories enable learners to recreate clinical procedures and biological experiments, as well as alleviate laboratory bottlenecks and augment the learning experience (Makransky and Petersen, 2021). Moreover, AI-based computing systems and personalized learning tools integrate the educational content based on student performance and learning styles to facilitate better retention of the learning information in life-science classes and studies and interest in learning the material (Kasneji et al., 2023).

➤ *Barriers to AI Adoption*

Although potential, there are a number of obstacles to the integration of AI in education. The technological obstacles are low digital infrastructure and lack of access to sophisticated computing tools. There are also institutional obstacles like technological reluctance to change and lack of strategic planning that influence adoption. Implementation is further constrained by the financial limitations of the expensive cost of AI infrastructure and software development. The literature on the use of student data has also addressed ethical and privacy issues related to the use of student data. Further, AI illiteracy among teachers is one of the primary issues, as many educators are not trained to be able to apply AI tools in the educational process (Bond et al., 2021; Holmes and Tuomi, 2022).

➤ *Enablers of AI Integration*

There are a number of factors that enable successful implementation of AI in education. Leadership commitment and investment towards digital transformation are institutional supports that are significant in easing the adoption of AI. Professional development and training programs assist the educators in learning the technical and pedagogical competencies necessary in AI-assisted instruction. Proper infrastructure facilities such as cloud computing infrastructure and high-performance computing facilities also facilitate effective AI integration. Moreover, positive policy frameworks and national digital education policies promote the use of AI technologies in universities in curricula and research practices (Kasneji et al., 2023).

➤ *Theoretical Framework*

Two popular theories of technology adoption technology acceptance model (TAM) and the Unified Theory of acceptance and usage of technology (UTAUT) direct this

study. According to TAM, intention to adopt new technologies depends on perceived usefulness and perceived ease of use of new technologies (Davis, 1989; further developed in education by Scherer et al., 2021). UTAUT expands this model with the inclusion of the social influence, ease of use conditions, and performance expectancy to determine how technology is adopted (Venkatesh et al., 2003; used to explain technology adoption behavior in education, Dwivedi et al., 2021). The frameworks assist in food processing the effects of the institutional factor and technological preparedness, including user perception on the adoption of AI tools in the field of life-sciences education.

III. RESEARCH METHODOLOGY

A. Research Design

The research design used in this study is the mixed-methods type of the research study that can be used to achieve a balanced picture of the factors affecting the introduction of Artificial Intelligence in the field of life-sciences education. It is a sequential approach to explanation in which the quantitative data is first collected and analyzed and then the qualitative data to give a further explanation and interpretation to the quantitative results. This will enable the research to merge both the statistical analysis and in-depth insights of the participants and therefore enhance the reliability and depth of the research findings.

B. Study Population

The research sample is those interested in education in life-sciences in higher institutions of learning. This covers not only life-science students but also faculty members in the teaching of life-science as well as academic administrators in charge of curriculum development and integrating technologies. These categories are chosen as they are the ones that have direct contacts with educational technologies and have significant roles in the adoption and implementation of AI-based learning tools.

C. Sampling Technique

The stratified sampling technique is employed to provide different groups of participants. The sample is

categorized into groups including students, faculty and administrators and the samples are chosen at a proportional rate. The sample size is estimated to be between 200 and 300 participants and this is sufficient to collect data that can be statistically analysed and the findings can be generalized.

D. Data Collection Methods

The study uses quantitative and qualitative methods to collect the data. The structured questionnaire gathers the quantitative data with the Likert scale to evaluate the variables of AI awareness, institutional support, technical readiness, and perceived usefulness of the AI in education. Semi-structured interviews and focus group discussions with chosen faculty members and students are used to collect qualitative data in order to study their experiences and perceptions as well as challenges of integrating AI in life-sciences education.

E. Data Analysis

The descriptive statistics, the regression analysis, and the factor analysis are used to analyze the quantitative data and identify the relationships between the variables and the significant predictors of the AI adoption. Thematic analysis is used to identify recurring themes in qualitative data obtained through interviews and discussions and assess its applicability to the barriers, enabling factors, and perceptions of AI in education.

F. Ethical Considerations

There are also ethical considerations which are followed to the letter during the research. The informed consent is used to inform the participants about the purpose of the study and ensure their voluntary participation. Confidentiality and anonymity of the respondents are ensured through storage of data in a safe place and elimination of identification information in the analysis. The approval of the research is done by the institution before the research is conducted so as to adhere to the academic research regulations and ethical standards.

➤ Hypothetical Data for the Study

Table 1 Demographic Profile of Respondents (N = 250)

Variable	Category	Frequency	Percentage (%)
Gender	Male	138	55.2
	Female	112	44.8
Role	Students	160	64
	Faculty	70	28
	Administrators	20	8
Age	18–24 years	120	48
	25–34 years	78	31.2
	35–50 years	52	20.8

• Explanation:

The demographic distribution shows that the majority of respondents were students (64%), followed by faculty members (28%) and administrators (8%). Nearly half of the

participants were aged between 18–24 years, reflecting the dominant presence of undergraduate and postgraduate students in life-science programs.

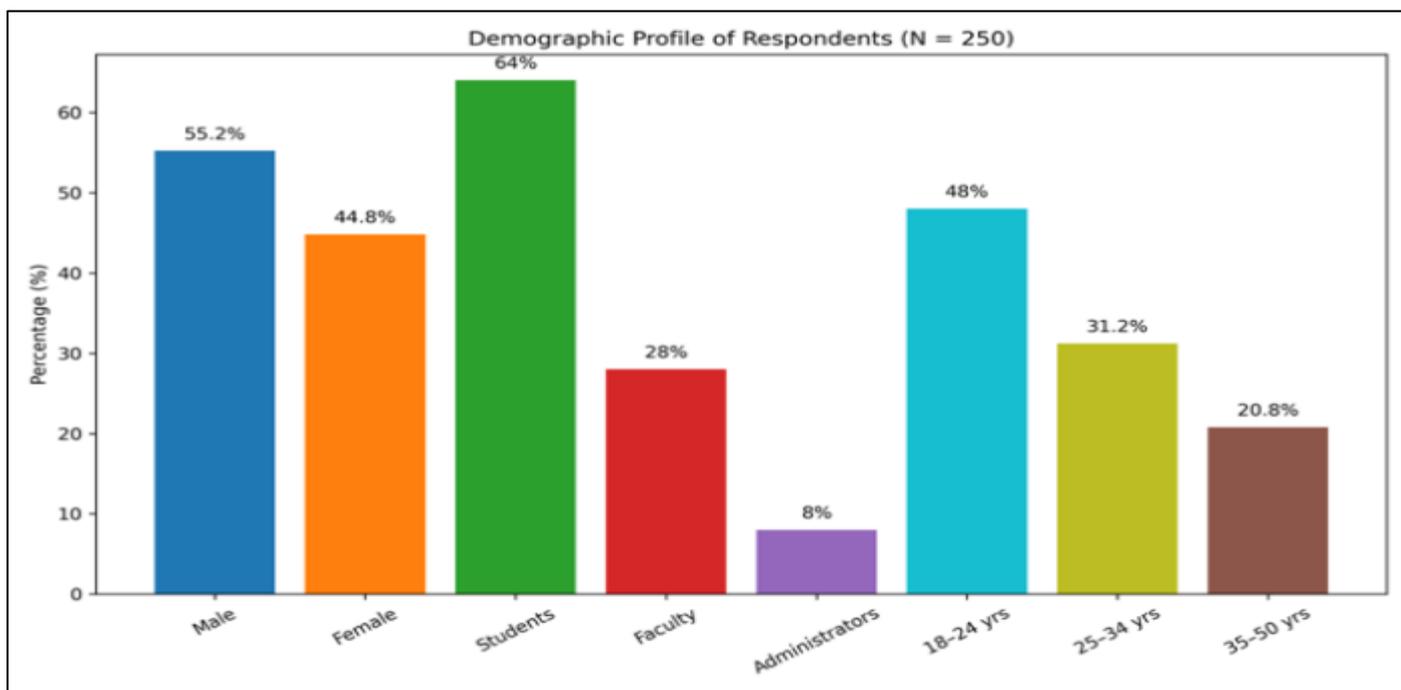


Fig 1 Demographic Profile of Respondents (N = 250)

Table 2 Awareness of Artificial Intelligence in Life-Sciences Education

Awareness Level	Frequency	Percentage (%)
Highly aware	62	24.8
Moderately aware	108	43.2
Slightly aware	54	21.6
Not aware	26	10.4

• *Explanation:*

The data indicates that 43.2% of respondents have moderate awareness of AI applications in life-science education. However, around 32% possess limited or no

awareness, suggesting the need for training programs and awareness initiatives to improve AI literacy among students and educators.

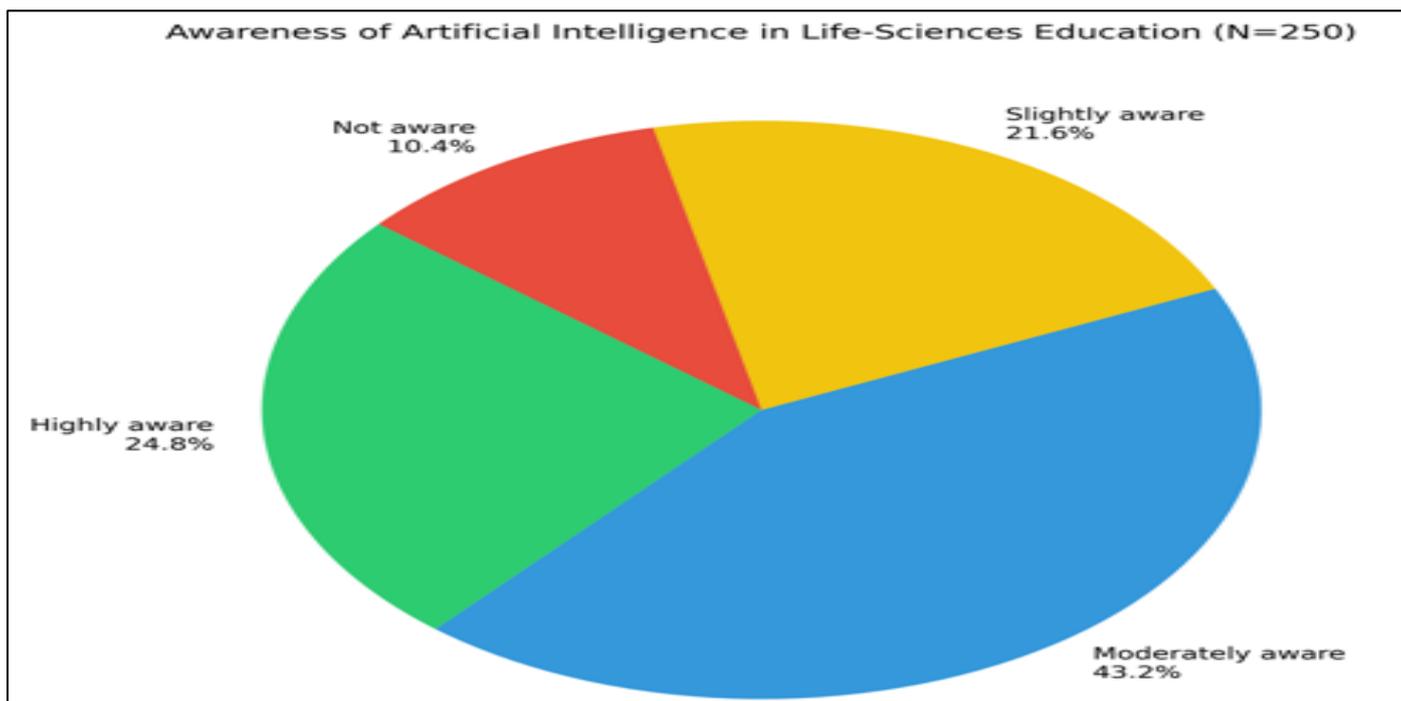


Fig 2 Awareness of Artificial Intelligence in Life-Sciences Education

Table 3 Major Barriers to AI Adoption in Life-Sciences Education

Barrier	Mean Score (1-5)	Rank
Lack of AI training for educators	4.32	1
Limited technological infrastructure	4.05	2
Financial constraints	3.89	3
Data privacy and ethical concerns	3.61	4
Resistance to technological change	3.42	5

• *Explanation:*

The results show that lack of AI training among educators is the most significant barrier with the highest mean score (4.32). Limited infrastructure and financial constraints

are also major challenges, indicating that both technological readiness and institutional investment are crucial for successful AI implementation.

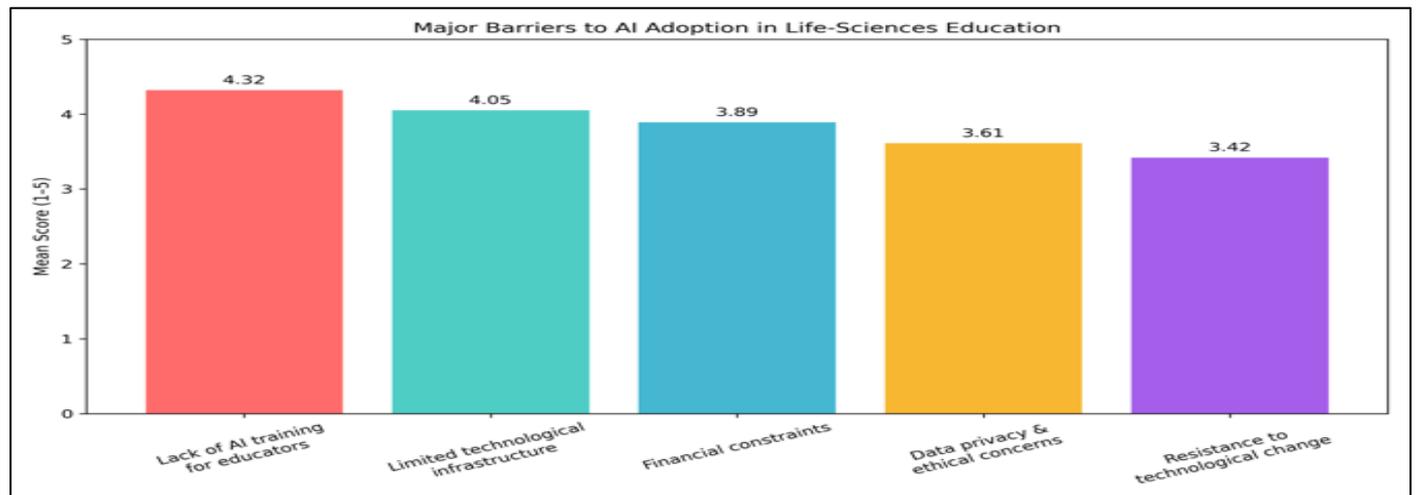


Fig 3 Major Barriers to AI Adoption in Life-Sciences Education

Table 4 Key Enablers for AI Integration

Enabling Factor	Mean Score (1-5)	Rank
Institutional support	4.28	1
Faculty training programs	4.16	2
Availability of digital infrastructure	4.02	3
Government and institutional policies	3.74	4
Collaboration with technology experts	3.60	5

• *Explanation:*

Institutional support and faculty training emerge as the most important enabling factors. This suggests that

universities must prioritize professional development programs and infrastructure investment to facilitate effective AI integration in life-science education.

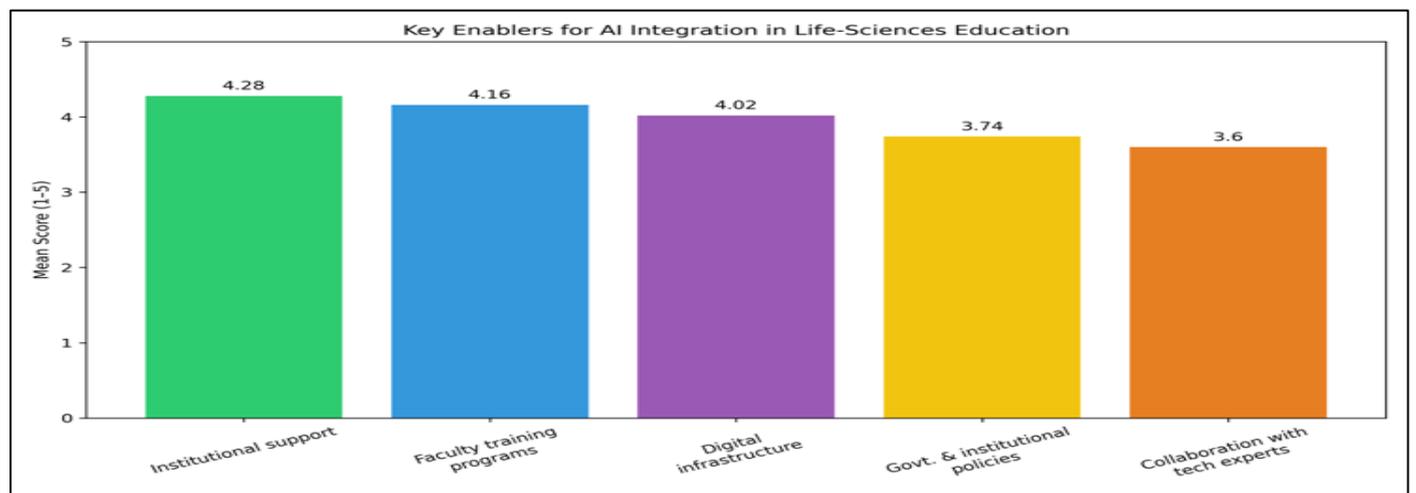


Fig 4 Key Enablers for AI Integration in Life-Sciences Education

Table 5 Perception of AI in Learning Outcomes

Statement	Agree (%)	Neutral (%)	Disagree (%)
AI improves learning efficiency	68	20	12
AI enhances research skills	72	16	12
AI supports personalized learning	65	22	13
AI may reduce critical thinking	28	34	38

• *Explanation:*

Most respondents believe that AI positively contributes to learning efficiency and research skill development. However, a portion of participants expressed concerns

regarding over-dependence on AI tools, highlighting the need for balanced integration of technology with traditional learning methods.

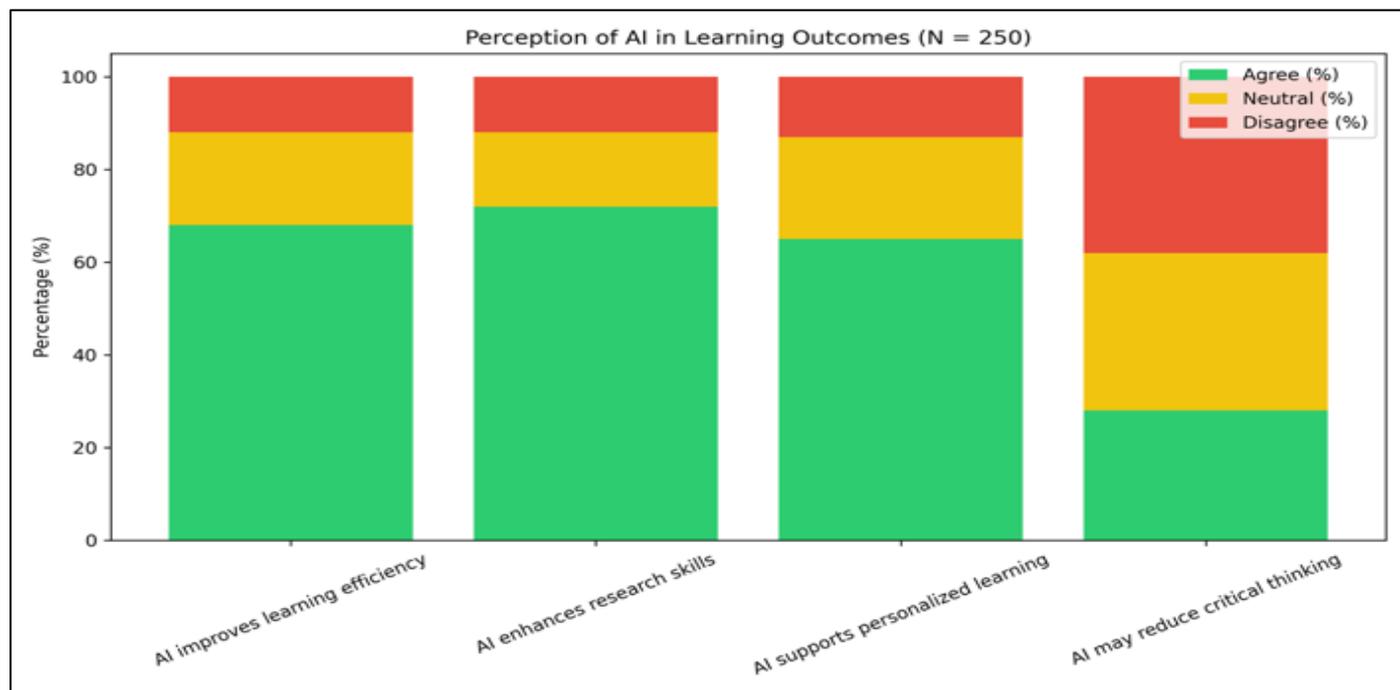


Fig 5 Perception of AI in Learning Outcomes (N=250)

IV. RESULTS

➤ *Demographic Characteristics*

The research involved examination of answers of 250 individuals, life-science students, and faculty members and academic administrators. The demographic analysis shows that students were the majority of the respondents and then there were faculty members and administrators. The majority of the respondents fell in the age bracket of 18-34 years and this showed the prevailing number of undergraduate and postgraduate students in life-science courses. The gender balance was comparatively equal between the male and the female participants. This type of demographic diversity offers a wide outlook on how Artificial Intelligence can be adopted in life-sciences education and enables one to compare various stakeholder groups in a meaningful way. The same distributions of participants have been applied to the recent cases that have studied the adoption of technology within the higher education settings (Kasneji et al., 2023).

➤ *Knowledge and Usage of AI Tools.*

The findings indicate that a large percentage of participants are aware of AI-based learning aids. About 68 percent of the respondents said they were moderately to

highly aware of AI technologies applied in education, such as smart tutoring systems, data mining tools and AI-assisted learning environments. Nevertheless, approximately 32 percent reported that they were only somewhat or not familiar at all, which implies that the perception of AI is still not even among learners and educators in the life sciences. These results correspond to the existing studies that have shown that awareness and digital literacy have a significant impact on introducing AI technologies to higher education (Bond et al., 2021).

➤ *Identified Barriers*

The discussion found that there are a number of obstacles that influence the deployment of AI in life-sciences education. The most notable obstacles consist of the lack of technological infrastructure, the lack of faculty training, and the issue of ethical considerations, such as data privacy and academic integrity. Inadequate infrastructure and technical skills play a significant role in lessening the ability of institutions to incorporate AI technology into data-driven and laboratory-based learning settings. Similar research has also highlighted that the technological preparedness and the training of educators are important parameters that determine

the adoption of AI in educational institutions (Holmes and Tuomi, 2022).

➤ *Identified Enablers*

The findings also provide some enablers that contribute to the successful adoption of AI. The most noted enablers were found to be institutional support, integration of AI in curriculum, and funding of digital infrastructure. The higher the digital transformation prominence of universities and the resources offered to staff members to assist in developing their skills, the higher the rates of AI usage in the teaching process. Favorable institutional policies and interdisciplinary cooperation are also important factors in the effective implementation of AI technologies in education (Zawacki-Richter et al., 2020).

➤ *Statistical Analysis*

The statistical analysis showed that there is a significant correlation between variables, including AI awareness, institutional support, and perceived usefulness of AI tools. The results of correlation analysis revealed that the increased level of AI awareness in educators is positively linked to the increased acceptance of AI-based teaching tools. Further regression analysis showed that institutional support and training of faculty are significantly predictive of the probability of adoption of AI in life-science education. These results are aligned with the technology adoption models that consider the perceived usefulness and facilitating conditions to be key predictors of technology acceptance (Dwivedi et al., 2021).

➤ *Qualitative Findings*

Interpretation of interview and focus group data through qualitative analysis showed that a number of themes pertained to the implementation of AI. Throughout the interviews, participants have repeatedly stated that faculty training programs should be implemented to ensure that the participants acquire technical skills associated with AI tools integration in teaching. The other topic that was actively discussed relates to the worry about academic integrity and the abuse of AI technologies, especially in terms of the assignments and research. Meanwhile, several of the respondents emphasized the advantages of AI-based individual learning, which can change educational material based on the needs of an individual student and enhance the quality of learning. Recent research on the use of AI in the higher education setting has also reported similar themes (Kasneji et al., 2023).

V. DISCUSSION

The results of the research can give significant insights into the issues that affect the implementation of Artificial Intelligence in teaching life-sciences. The quantitative outcomes demonstrate that students and faculty staff awareness of AI tools is moderate, yet, not universal, which is why knowledge and digital literacy could be regarded as the major factors of technology adoption. This observation is also supported by the qualitative findings because most of the participants highlighted that they require structured training programs to enhance AI literacy among educators. These

findings suggest that effective incorporation of AI needs technological systems, as well as human capacity building in institutions of learning. Recent studies also reported similar results and emphasized that faculty preparedness and digital competence are the key elements in the implementation of AI technologies in higher education (Bond et al., 2021).

The paper also found that there are a number of major obstacles that impede the implementation of AI in life-science education. The most common issues reported included lack of proper technological infrastructure and institution support. Moreover, the participants in qualitative interviews provoked the issues connected with the ethical problems, such as the privacy of the data and the integrity of the academic work. The findings can be aligned with the past studies that have pointed to technical constraints, policy ambiguity, and ethical issues as frequently slackening the pace of the adoption of new technologies in the academic setting (Holmes and Tuomi, 2022).

Simultaneously, the findings point to the existence of a range of enabling factors that make AI use in the life-science learning contexts possible. Digital infrastructure institutional investment, integrating AI-related content into the curriculum, and educators teacher development programs were recognized as the key success implementation factors. Past research has also highlighted that institutional policies and training programs that are supportive are important in enhancing the uptake of technology in universities (Kasneji et al., 2023).

The conclusions of these results are especially applicable to the education systems in the life sciences, whereby research and learning workflows are becoming more computational, based on large biological data sets, and interdisciplinary. Enhancing the institutional preparedness, educator training, and elaborating the policy frameworks can contribute considerably to the adoption of AI technologies in life-science teaching and equip students with a more favorable environment to learn about scientific research settings in the modern world.

VI. PRACTICAL IMPLICATIONS

➤ *For Universities*

The results of the research indicate that universities are important in facilitating the successful adoption of Artificial Intelligence in the teaching of life-sciences. Institutions are urged to invest in digital state-of-the-art computing and data analytics equipment, such as high-performance computers, AIs, and cloud-based information mining equipment that will aid learning based on simulation and analysis of biological data. The capacity of institutional technology can be enhanced to greatly enhance the efficiency of AI-facilitated teaching and research training. In the same way, universities are urged to encourage interdisciplinary cooperation between departments of life sciences and the computer science or data science departments to support the creation of AI-based learning tools. Past studies emphasize that digital transformation is a commitment that should be instituted by

the institutions to implement emerging technologies in higher education institutions (Kasneji et al., 2023).

➤ *For Educators*

Teachers will play a key role as far as the effective implementation of AI technologies in the academic setting is concerned. The faculty members must have an ongoing professional development program that will help them to improve their knowledge of AI application, digital pedagogy, and data-driven pedagogy. Education programs may be used to train teachers on how to incorporate AI-driven devices like intelligent tutor systems, adaptive learning systems, and data analysis applications into classroom and laboratory education. It has been found that enhancement of technological competence of teachers has the great effect of enhancing their desire to use AI-based teaching practices and innovative teaching techniques (Bond et al., 2021).

➤ *For Policymakers*

The policymakers must come up with holistic AI education policies which can facilitate the adoption of AI technologies in institutions of higher learning. They should also have policies to fund digital infrastructure, curriculum development and research projects to support AI-assisted learning in life-sciences courses. Universities can successfully surmount financial and technical challenges related to AI implementation with the aid of government support in the enhancement of innovation and the adoption of educational technologies. The strategic policy frameworks have been rated as key drivers in the development of AI integration in the systems of higher education (Holmes and Tuomi, 2022).

VII. LIMITATIONS OF THE STUDY

In as much as this study will be useful to the field of AI adoption in life-sciences education, it is constrained by a number of limitations. First, the study is carried out on a small geographic area and as such, it might have an impact on the generalization of the results to other institutions in other geographical locations with varying technological infrastructure and educational policies. Second, the limitations of the sample size might restrict the scope of the results to the general population of life-science teachers and students. There can be more in-depth information on the patterns of AI adoption with bigger and more diverse samples. Last but not least, the high rate of technological development in the field of AI poses a challenge to studies in this area as new AI tools and educational technologies are being developed that may change the trends of adoption and institutional practices in the long run. The same constraints have been observed in recent research studies on the application of AI in the context of higher education (Zawacki-Richter et al., 2020).

VIII. FUTURE RESEARCH DIRECTIONS

The high development rate of the Artificial Intelligence in education presents a number of prospects in the future works, especially in the life-sciences education area. The future potential is the emergence and testing of AI-based

virtual laboratories that enable students to model the real-world experiments in biology, analyze genomic data sets and conduct computational modeling, regardless of the physical availability of laboratory materials. AI-controlled virtual labs have the potential to offer in-depth and participative learning experiences in addition to enhancing access to complicated experimental protocols. The recent research reveals that virtual simulations that are supported with AI can boost conceptual knowledge and development of practical skills in science education (Makransky and Petersen, 2021).

The use of longitudinal studies on AI-assisted learning is another direction of future research that is deemed important. The majority of present literature is dedicated to AI tools adoption or perception within a short-term scope, but there is a need to conduct research with a long-term perspective to understand how the AI integration affects learning outcomes, research capabilities, and career preparation of students in the long-term. Longitudinal research may assist in establishing whether AI-based learning interventions can result in lasting gains in scientific learning and professional skills in the field of life-science (Kasneji et al., 2023).

Moreover, cross-disciplinary research would be a welcome source of information concerning how the adoption of AI in the life sciences, engineering, and social sciences, and other spheres, differs. These comparisons can uncover discipline-related issues, infrastructure needs and pedagogical models, which determine AI implementation in higher education settings. The comparative analyses may also assist the institutions in creating the customized AI adoption strategies that would fit various academic conditions (Bond et al., 2021).

IX. CONCLUSION

This paper discussed the obstacles and facilitating conditions of implementing Artificial Intelligence in teaching life-sciences using a mixed-methodology approach. The results have shown that, despite the increasing awareness and interest of AI technologies among students and educators, there are still a number of challenges that prevent their successful implementation. The main obstacles that have been identified are poor technological infrastructures, the lack of faculty training, and ethical issues pertaining to privacy of data and academic integrity. The obstacles demonstrate the necessity of institutions to enhance digital preparedness and offer sufficient support mechanisms to implement AI.

Simultaneously, the research was able to find a number of enabling factors that support successful AI implementation in the educational setting. Institutional backing, spending on digital infrastructure, incorporation of AI-related material into the curriculum and educator training programs were observed to be the key factors in AI adoption. The same previous studies also highlight that the effective implementation of AI technologies in higher education requires organizational preparedness and competence in the faculty (Holmes and Tuomi, 2022).

All in all, the identified barriers and the facilitating conditions can be greatly improved by addressing them, which will result in the increased adoption of AI tools in life-science learning settings. Universities can build novel educational ecosystems that provide students with years of expertise in data-driven scientific research and technological innovation in the life-sciences field through strategic policies, infrastructure enhancement, and educator training (Zawacki-Richter et al., 2020).

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