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A Critical Analysis Of Ai's Purpose In Stem Higher Education

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Higher education is not an exception to how artificial intelligence (AI) is emerging as a disruptive force that has the potential to change many industries. Examining the growing role of artificial intelligence (AI) in STEM (science, technology, engineering, and mathematics) higher education is the goal of this critical review paper. The impact of AI on curriculum design, student involvement, teaching and learning approaches, assessment procedures, and institutional tactics is examined in this article.AI now forms a vital part of educational establishments and exerts influence over both educators and learners. The review also identifies important areas for further research and development and underlines the possible advantages and difficulties of incorporating AI into STEM education. Overall, this essay gives suggestions for maximizing AI's potential as well as insights on how it can transform STEM higher education. Higher education institutions may fully utilize AI to improve teaching and learning results, administrative efficiency, and the development of a future-ready educational ecosystem by adopting AI technology in a responsible and moral manner.

Keywords: *Artificial Intelligence, STEM Education, Teaching and Learning, Higher Education, human resource management.*

1. Introduction

The technology known as artificial intelligence (AI) has come to revolutionize several industries, including education. Artificial Intelligence (AI) has great promise for revolutionizing teaching and learning approaches, boosting student involvement, and

enhancing overall academic results in higher education. More specifically, the incorporation of AI has great potential to support students' creativity, critical thinking, and problem-solving abilities in the STEM fields (Science, Technology, Engineering, and Mathematics) [1, 2]. To give kids, the knowledge and abilities they need to prosper in a society that is becoming more and more dependent on technology, STEM education is essential. But conventional teaching methods frequently find it difficult to keep up with the quickly changing needs of the STEM fields. In traditional learning, the teacher delivers knowledge to the students in the school. However, online teaching came into fashion during the Covid-19 pandemic, when all the countries were affected globally, especially the education sector. The Covid-19 global pandemic has dramatically impacted education, leading to the shift from the traditional classroom to an online setting. Varied modes of teaching can be used, such as one-on-one video calls, group video calls, and webinars at several apps, such as Zoom, Google meets, and so on. Here, artificial intelligence (AI) can significantly contribute by enhancing and changing conventional teaching methods [3, 4]. This critical review article's goal is to investigate AI's growing influence in STEM higher education. We seek to provide light on how AI is affecting teaching and learning approaches, curriculum development, student involvement, assessment procedures, and institutional tactics by critically analyzing the body of current work. In addition, we will evaluate the possible advantages and difficulties of incorporating AI into STEM education and pinpoint important areas for further study and advancement [5, 6]. By utilizing AI, educational institutions and instructors may design more individualized and flexible learning programs, give students industry-relevant skills for the future, and encourage creativity and innovation in STEM fields [7, 8]. The goal of this review article is to add to the body of knowledge by compiling and evaluating the most recent findings and applications of artificial intelligence in STEM higher education. The potential of artificial intelligence (AI) in education to personalize learning is among its biggest advantages. AI systems can adjust to each person's demands and learning preferences of every kid, enabling them to succeed more academically. AI systems, for instance, may offer students guidance, feedback, and individualized lesson plans. The potential to increase learning effectiveness is a further advantage of utilizing AI in education. Many of the jobs presently completed by humans can be automated by AI systems instructors, including editing papers, offering suggestions, and helping. This gives the teacher the chance to concentrate more on difficult assignments such as creating curricula and teaching pupils. In the following sections, we will delve into specific areas where AI has the potential to revolutionize STEM education, discuss the benefits and challenges associated with its implementation, and outline future directions and recommendations for effective integration. Through this critical review, we hope to shed light on the transformative power of AI in STEM higher education and inspire further exploration and innovation in this field.

2. Literature Review

Artificial intelligence is already in widespread use in some areas of society. However, in terms of its direct impact on teaching and learning, much has been promised but, yet little has been accomplished.

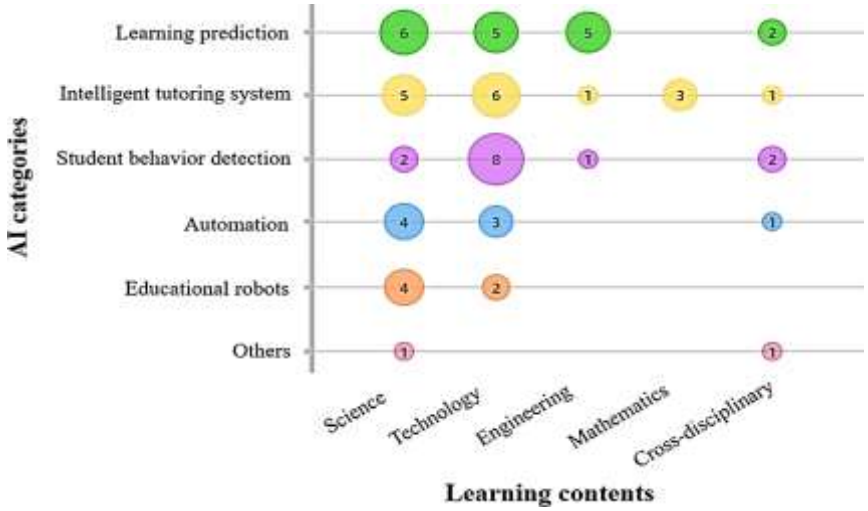

Figure 1-The different areas in which AI is being applied in higher education

Zuboff (2019) provides a good overview of the different areas in which AI is being applied in higher education and an indication of which areas researchers have tended to focus on. He identifies four key applications of AI in teaching and learning:

- profiling and prediction
- intelligent tutoring systems
- assessment and evaluation
- adaptive systems and personalization.

The development of deep learning, machine intelligence, and cognitive architectures has accelerated recently, and many observers believe that artificial intelligence will have a bright future in many spheres of society. Nowadays, students are at the vanguard of an enormous range of opportunities as well as difficulties in teaching and learning in higher education. Furthermore, there are currently tools for collaborating and interacting between humans and AI that can assist those with impairments. They can encourage teachers to implement them in classroom settings to make learning more interesting for both teachers and students. Complex computer systems that use machine learning algorithms can interact and support users of various skill levels to some extent, in tasks involving complex processing and human-like processes that are also applicable to teaching and learning. Alan Turing put up a theory in the 1950s regarding the threshold at which a human-designed system might be considered "intelligent." Turing came up with the idea of the imitation game, which evaluates a person's ability to discern between a human and computer discourse. We refer to a system as intelligent, or "artificial intelligence (AI)," if such a distinction is not recognized. The field of artificial intelligence is developing quickly now, and this is already changing the way services are offered in higher education. To assist adaptive group creation based on learner models, to

facilitate online group interaction, or to summarize discussions so that a human tutor may utilize them to educate students toward the goals and objectives of a given course, AIEd can promote collaborative learning. These advancements are sometimes referred to as "modern" AI to distinguish them from past computer-based learning applications that may have been mistakenly labeled as AI in the past. Except for learning analytics, there isn't much evidence at this time to suggest that "modern" AI will significantly advance teaching and learning in higher education. Technology has a vital role in fostering curiosity, creativity, and teamwork in addition to providing students with information and communications technology (ICT) skills and enabling high-quality education that is not limited by time or place. Not only is high-quality education a basic human right, but it also has a direct impact on a country's and its residents' ability to make money. Artificial intelligence (AI) has great promise for education. For example, technology can help students learn at their own pace, customize their education based on their preferences, and manage repetitions to increase their comprehension of a subject. According to Alexander et al. (2019), university administrators anticipate that one advantage of artificial intelligence in the future would be its capacity to "evaluate students, offer feedback, and generate and test scientific hypotheses at least as well as humans can." In the section that follows, we look at a few instances of AI being used in higher education.

2.1 Theoretical framework

A theoretical framework known as general system theory (GST) contends that the world is made up of several organic systems, each of which has elements that interact dynamically and are related to one another (Rapoport, 1986; Von Bertalanffy, 1950). According to Rack and Pouvreau (2015) and Von Bertalanffy (1968), the fundamental tenet of GST is that a system is larger than the sum of its components rather than only equal to the sum of its parts. GST emphasizes the system's holistic principle to identify the internal constituents, their functional linkages, and the external impacts upon a system to fully comprehend the complex nature and general norms of systems (Crawford, 1974).

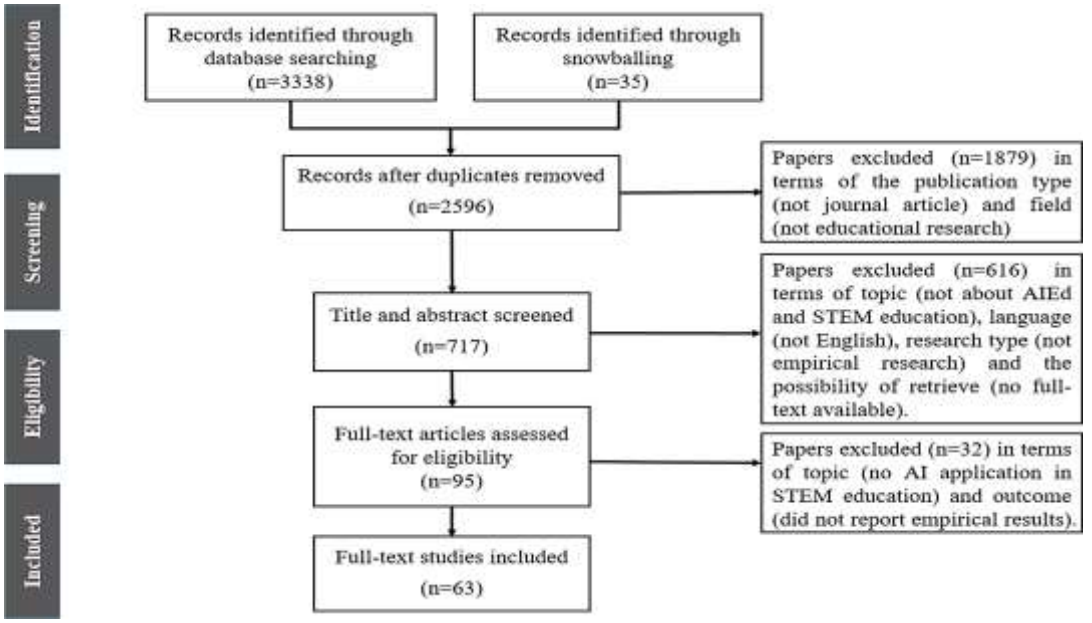

Figure 2-The integration of technology in an educational system from the GST perspective

The GST theoretical framework has been extensively used in many domains to examine diverse kinds of systems, including physical, systems of education, society, and biology (Drack & Pouvreau, 2015; Kitto, 2014). For instance, Chen and Stroup (1993) emphasized the integration of science curriculum to prevent the segregated learning of physics, biology, and chemistry and proposed utilizing GST as an underpinning theoretical framework to guide the reform of science education. With this in mind, we contend that GST can offer a fresh, comprehensive viewpoint on how AI technology might be integrated with STEM education. From the standpoint of GST, AI-STEM can be seen as an organic system, with subject, information, medium, environment, and technology as its five fundamental components (Von Bertalanffy, 1968). In an educational system, a subject is first and foremost described as a person. Various topics of individuals, such as students and instructors, can exercise agency to engage in ongoing, adaptive interactions with one another. Second, information in an educational system refers to knowledge that is created and disseminated among subjects, including learning materials, artifacts, and course topics. Third, a medium connects subjects within a system and serves as a means of information transmission. Fourth, an educational system's environment acts as an underlying background that affects how the entire system operates. Fifth, technology—such as artificial intelligence techniques—usually shows up as an outside force that affects how the educational system operates. Based on GST, integrating AI as an external technological component into a STEM educational system is a challenging process that affects the subject, information, medium, and environment as well as the connections between them. In conclusion, the GST framework (see Fig. 3) gives us a

comprehensive understanding of how to employ AI technology in STEM education by highlighting the various components and their interrelationships in the AI-STEM system.

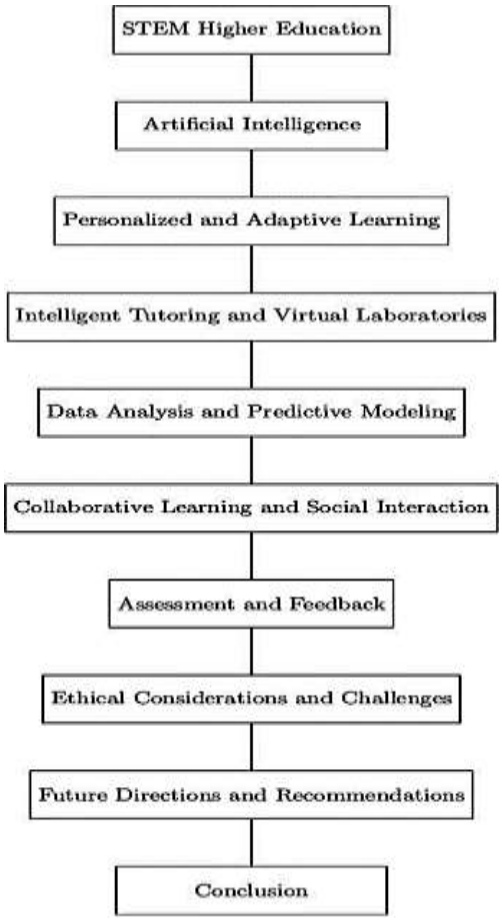

Figure 3-The Flowchart illustrates the research process for this paper

The process of finding articles, reviewing them, determining eligibility, and including them is laid out in Figure 1. It offers an open depiction of the study analysis carried out for this evaluation. The path of article identification, screening, eligibility evaluation, and inclusion is described in detail in the Figure 1 diagram, which then offers an open depiction of the research analysis carried out in this review.

3. Research Methodology

3.1. Research design

The purpose of this review paper is to add to the body of knowledge by compiling and evaluating the most recent findings and applications of artificial intelligence in STEM higher education. To find pertinent English-language peer-reviewed publications on artificial intelligence in education, particularly in the context of STEM education at all levels, the systematic review conducted a thorough search. Artificial Intelligence, STEM education, higher education, teaching and learning, curriculum design, student engagement, assessment procedures, and institutional methods were among the terms included in the search criteria.

3.2. Artificial Intelligence's Significance in STEM Education

Through its revolutionary ability to change traditional teaching and learning methods, boost student engagement, and encourage creativity and critical thinking, artificial intelligence (AI) holds great promise to modernize STEM higher education. This section will look at the several roles that AI can play in STEM education and how it affects the various learning processes.

3.2.1. Customized and Flexible Education

AI's capacity to enable tailored and flexible learning experiences is one of the main advantages for STEM students pursuing higher education in these fields. Artificial intelligence (AI)-driven learning systems can provide personalized recommendations and content by analyzing large volumes of data on student performance, preferences, and learning styles. AI can maximize learning outcomes and assist students in more efficiently understanding complex STEM topics by customizing the pace, depth, and focus of training to each individual student [13, 14]. A key component of utilizing artificial intelligence (AI) in STEM higher education is personalized and adaptive learning. By offering customized learning experiences catered to the individual requirements and preferences of every student, AI-powered learning systems have the potential to completely transform traditional classroom environments. AI algorithms have the capacity to examine large datasets on student performance, which allows them to learn about students' learning preferences, areas of strength, and shortcomings. AI systems can use this data to provide recommendations and content that are tailored to the individual needs of every student.AI can also modify the focus, depth, and tempo of training to meet the needs of individual students. More difficult content can be introduced to students who pick things up quickly, and tailored interventions can be used to reinforce core knowledge for those who need extra help. Personalized and adaptable learning has advantages that go beyond the specific needs of each student. Artificial intelligence (AI) systems can compile and evaluate data from several students, finding common misconceptions or problem areas. Comparing the outcomes to typical classroom education, it was clear that student performance and engagement had improved significantly. In a similar vein, Van Lehn (2011) discovered that by offering tailored feedback and assistance, adaptive learning environments improved student learning outcomes in STEM disciplines [14]. While AI-enabled personalized and adaptive learning in STEM higher education has many advantages, its application presents certain restrictions and difficulties that must be considered. Crucial ethical concerns include guaranteeing the precision and dependability of AI algorithms, resolving biases in data and suggestions, and safeguarding student privacy. AI systems can provide individualized content

and recommendations based on student performance and preference data, improving learning outcomes and encouraging a deeper comprehension of challenging STEM subjects. To guarantee the responsible and successful integration of AI in STEM education, however, great attention needs to be paid to ethical issues and offering educators support.

3.2.2. Virtual Laboratories and Intelligent Tutoring

It is also capable of acting as an intelligent instructor, offering students in STEM fields immediate feedback, direction, and assistance. Intelligent tutoring programs could evaluate students' answers, spot misunderstandings, and provide focused interventions to close learning gaps. Furthermore, AI-powered virtual labs can replicate authentic experiments and give students a secure setting in which to practice practical skills [15, 16]. To meet each student's unique learning needs, the AI tutor can modify its lesson plans and offer more clarifications, examples, or practice questions as needed. This individualized approach encourages active participation in the learning process and improves student understanding. AI-powered virtual labs present a special chance for students to participate in practical STEM learning experiences. Students can perform experiments, change variables, and see results in these virtual environments that mimic actual laboratory conditions. AI systems could analyze and deliver feedback in real time, assisting students in carrying out the experiment and deciphering the findings. The benefits of virtual laboratories include affordability, security, and ease of use. They also help students practice critical laboratory skills and hone their problem-solving techniques. There are many advantages to integrating virtual laboratories and AI-driven intelligent tutoring systems in STEM higher education. By giving students quick, tailored feedback, these tools encourage active learning and the development of metacognitive abilities. Pupils can get experience. To put it succinctly, AI plays a bigger part in STEM higher education than only personalized and adaptive learning. Artificial intelligence (AI)-powered virtual laboratories and intelligent tutoring systems improve student engagement, problem-solving skills, and active learning opportunities. These artificial intelligence (AI)-powered tools offer individualized feedback, direction, and simulated environments that foster greater comprehension and skill development. Notwithstanding certain obstacles, AI has enormous potential to advance STEM education and open new avenues for creative and successful teaching strategies.

3.2.3. Collaborative Education and Social Engagement

AI has the potential to improve STEM students' social interaction and collaborative learning. In virtual learning environments, intelligent technologies can facilitate peer-to-peer feedback, group projects, and online debates, which can build a sense of community and collaboration. A crucial component of STEM education is collaborative learning, which fosters information exchange, critical thinking, and problem-solving abilities. Social interaction is essential to STEM education because it fosters idea sharing, peer learning, and the growth of collaborative abilities. Chatbots and virtual assistants with AI capabilities can mimic human-like interactions, fostering an engaging and encouraging learning environment. Even in online or remote learning environments. AI tools aid in the formation of well-rounded STEM workers who can work well with others and contribute to interdisciplinary projects by encouraging good social interaction. In STEM higher education, artificial intelligence (AI) technologies

are essential for promoting social interaction and collaborative learning. Through the provision of online discussion platforms, group project facilitation, and human-like interaction simulation, artificial intelligence (AI) amplifies student involvement, fosters information dissemination, and cultivates collaborative abilities. AI integration in collaborative learning settings has a lot of promise to produce engaging and inclusive STEM learning opportunities.

3.2.4. Evaluation and Remarks

AI has the power to completely change how STEM higher education assesses students. Intelligent assessment tools can monitor students' progress in real time, give thorough comments, and grade assignments automatically. Artificial intelligence (AI) may evaluate not just information but also higher-order thinking skills, critical reasoning, and problem-solving abilities by utilizing machine learning and natural language processing algorithms [21, 22]. Intelligent assessment tools can evaluate more complicated assignments than just multiple-choice questions. Examples of these types of tasks include research papers, lab reports, and programming projects. AI algorithms can offer comprehensive feedback on students' strengths, weaknesses, and opportunities for progress by examining the content, structure, and coherence of their work. This personalized feedback helps students understand their performance and guides them towards deeper learning and mastery of STEM concepts. Furthermore, AI can support formative assessment, which focuses on providing ongoing feedback and monitoring students' progress. Students can evaluate themselves, think back on what they've learned, and make changes to their performance thanks to this formative feedback. But there are issues with incorporating AI into assessment procedures as well. Teachers must make sure AI systems are in line with learning goals, standards, and evaluation criteria. Maintaining trust and allowing students to comprehend the evaluation process of their work are contingent upon the transparency and explainability of AI algorithms. To safeguard students' personal information, privacy and data security issues must also be properly considered. Through the automation of grading procedures, the provision of individualized feedback, and the encouragement of continual development, AI-powered assessment and feedback systems have the potential to revolutionize STEM education. These systems boost students' metacognitive skills and provide fast feedback while providing objective evaluation using machine learning and natural language processing. When assessing STEM learning outcomes, the use of AI in assessment procedures can improve efficacy, efficiency, and fairness.

3.2.5. Ethical Issues and Difficulties

While there are many advantages to integrating AI into STEM higher education, there are also significant ethical issues and difficulties. Critical considerations include resolving potential biases, ensuring justice, transparency, and accountability in AI algorithms, safeguarding student privacy, and fostering inclusive access to AI-driven resources [23, 24]. The possibility of bias in AI algorithms is one of the most important ethical issues. Since AI systems are taught on historical data, they might be biased against certain social injustices. AI systems have the potential to reinforce or magnify already-existing inequalities in STEM education if these biases are not addressed. Important ethical considerations include also explainability

and transparency. It is important for educators and students to comprehend how AI algorithms assess their work and make decisions. Teachers' ought to encourage algorithmic openness in AI and give pupils the chance to comprehend and challenge automated evaluation systems. The privacy of students is another ethical factor to consider. Large volumes of data, including learning analytics and personal information, are gathered and analyzed by AI systems. In STEM higher education, equitable access to AI-driven resources is another concern. Students with differing access to resources may experience inequalities due to the need for gear, software, or internet connectivity for AI-powered tools and technologies. Institutional support and professional development for professors are also necessary for the effective integration of AI in STEM higher education. For integrating AI technologies into their teaching practices, educators require both continuing assistance and training. Working together, educators, researchers, legislators, and stakeholders in STEM education must address these ethical issues and problems. To direct the creation, application, and assessment of AI technologies in educational settings, frameworks and guidelines for ethical AI in education have been put forth [23, 24].

4. Present Uses and Upcoming Prospects

4.1. AI's current uses in STEM higher education

Numerous applications in a variety of fields have already resulted from the incorporation of AI into STEM higher education. AI-driven tutoring programs in mathematics have been created to help students practice problem-solving techniques, get individualized feedback, and advance their mathematical reasoning abilities [25, 16]. These technologies enable tailored training and flexible learning opportunities by analyzing students' answers and delivering focused interventions. Artificial Intelligence has been applied to computer science to improve the teaching of programming. Artificial intelligence (AI) algorithms have been used in the natural sciences for predictive modeling and data analysis. Large datasets in the domains of biology, chemistry, and physics have been analyzed using machine learning approaches, which have allowed researchers to find patterns, anticipate outcomes, and acquire understanding of complicated phenomena [26, 27]. Students can envision and interact with intricate engineering designs and systems using virtual reality (VR) and augmented reality (AR) technologies, which are driven by AI algorithms [28, 29]. Students' understanding of engineering principles, problem-solving techniques, and spatial reasoning are all improved by these immersive experiences.

4.2. Issues & Things to Think About for AI Integration

Even though AI has a lot of potential applications in STEM higher education, there are a few issues that need to be resolved before it can be successfully used.

4.2.1. Explainability and Transparency of Algorithms

When integrating AI into STEM higher education, explainability and transparency of algorithms are essential components to consider. It can be difficult to comprehend how AI algorithms, especially sophisticated models like deep neural networks, arrive at their conclusions or suggestions because of their opacity. The absence of transparency in AI

systems can impede their trust and acceptability, as stakeholders may harbor doubts about depending on algorithmic conclusions in the absence of a comprehensive grasp of the underlying mechanisms [31]. Transparency and explainability are particularly crucial in educational settings. To engage in meaningful learning experiences, instructors and students must understand how AI systems arrive at their suggestions or assessments. Explainable AI facilitates users' comprehension of AI system outputs while also allowing them to spot biases, spot potential flaws or restrictions, and base judgments on the insights given by the AI. It gives teachers the ability to engage in meaningful dialogue with students, break down difficult ideas, and clarify any biases or misconceptions that might result from the AI system's suggestions. It takes a multidisciplinary team to promote algorithmic transparency and explainability in AI systems for STEM education. To create standardized frameworks and criteria for integrating transparency and explainability into AI systems, researchers, educators, and legislators must work together.

4.2.2. Privacy and Security

Institutions need to make safeguarding students' privacy a top priority and make sure that data protection laws are followed. It is important to put in place sufficient data security procedures to protect student information from misuse or illegal access. The use of AI in STEM higher education is contingent upon careful evaluation of privacy and security issues. Institutions must prioritize protecting student privacy and adhere to data protection requirements while collecting and analyzing sensitive student data. Strong data security procedures should be put in place by universities to protect student privacy. To stop unwanted access or data breaches, this comprises access restrictions, secure storage systems, authentication methods, and encryption techniques. Effectively addressing privacy and security problems requires collaboration between cyber security specialists and privacy professionals. These professionals can offer advice on putting in place strong security measures, doing privacy effect analyses, and making sure that all applicable laws are followed. Institutions may establish a secure and reliable environment where students can interact with AI technology by giving privacy and security top priority in AI-driven learning environments.

5. Conclusions

Artificial intelligence (AI) has the potential to significantly improve teaching and learning in STEM higher education. AI. These tools and technologies provide effective evaluation and feedback systems, data analysis, collaborative learning, intelligent tutoring, personalized and adaptive learning, and more. These developments could improve learning outcomes, increase student engagement, and better equip students for the demands of the quickly changing STEM sectors. However, ethical, privacy, and equality aspects must be carefully considered for AI to be successfully integrated into STEM higher education. It is necessary to create policies and norms to guarantee AI algorithms' accountability, openness, and fairness. Ensuring the confidentiality of students' information and adhering to data protection laws are critical. Programs for staff and faculty development are essential for providing teachers with the information and abilities they need to successfully incorporate AI into their lesson plans. Partnerships and collaborations between academic institutions, business leaders, and AI specialists promote creativity and quicken the integration of AI. Stakeholders can collaborate

on research initiatives, co-design AI tools and platforms, and exchange best practices. Through the creation of comprehensive policies, financing efforts, and support for collaborations, policymakers play a critical role in fostering an environment that is favorable for the integration of AI. In conclusion, there is a lot of room for improvement in teaching and learning given the growing role AI is playing in STEM higher education. Institutions may embrace the power of AI while guaranteeing inclusivity, equity, and success for all students by addressing ethical issues, offering professional development, encouraging collaborations, and putting supportive policies in place. To optimize artificial intelligence's influence and advantages in STEM higher education, continuous study, assessment, and practice adaptation will be necessary as the technology develops.

6. Future Directions and Recommendations

There are a lot of exciting opportunities for innovation and change when artificial intelligence (AI) is included in STEM higher education. It is crucial to pinpoint future trends and offer suggestions for optimizing the use of AI in STEM education as this field continues to develop. There are a few important topics that need more research as artificial intelligence (AI) in STEM higher education continues to develop. Investigating cutting-edge AI methods to improve the capabilities of AI systems in STEM education, such as deep learning and natural language processing, is one crucial field. Examining the efficacy of various AI-driven teaching strategies, including intelligent tutoring programs or tailored learning algorithms, can also yield insightful information on how they affect student engagement and learning objectives. First off, improving the capabilities of AI systems in STEM education can be achieved by investigating cutting edge AI approaches like deep learning and natural language processing. Furthermore, it is imperative to examine the efficacy of various AI-powered teaching methodologies to maximize student engagement and academic achievements. Learning experiences can be customized by using personalized learning algorithms, which can adjust the pace, content, and method of education to meet the needs of each individual student. Conversely, intelligent tutoring systems could pinpoint learning gaps, provide tailored interventions to enhance students' learning, and provide real-time feedback. These fields of study can be used to determine the best AI-driven teaching practices and offer fact-based understanding of how they affect student motivation and accomplishment. AI privacy and ethical issues must be addressed as it is increasingly included in STEM higher education. Strong ethical frameworks and rules for the application of AI in educational contexts should be the focus of research. The ethical framework ought to consider multiple factors, such as equity, openness, responsibility, and the possible effects of artificial intelligence on the welfare of students. It is recommended that researchers investigate techniques for identifying and reducing biases in algorithms, data, and decision-making procedures. Transparency is yet another important issue to handle. To help educators, students, and other stakeholders understand how AI systems arrive at their conclusions and recommendations, efforts should be undertaken to make AI algorithms more interpretable and intelligible

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