Next-Gen Quality Learning: How Can AI Technologies Shape Education 4.0 and 5.0 towards the SDGs from Multiple Stakeholders' Perspective?

Abstract

Purpose: Artificial Intelligence (AI) in education is reshaping education landscapes, reinforcing the global endeavor towards Sustainable Development Goals (SDGs). Therefore, this article aims to explore how AI technologies are at the foundation of the shift towards Education 4.0 (E4.0) and Education 5.0 (E5.0), enabling personalized, adaptive, and lifelong learning opportunities for diverse stakeholders in the system.

Design/methodology/approach: This article takes a qualitative and conceptual orientation, distilling recommendations from academic literature, industry practices, and policy frameworks.

Findings: The findings of this research show the transformative power of AI in E4.0 and E5.0 towards different SDGs, such as SDG 4, SDG 5, SDG 9, SDG 10, SDG 12, SDG 13, SDG 16, and SDG 17 with various stakeholders. Also, the recommendations suggest that a conscious and inclusive strategy concerning AI integration into education can promote the success of the SDGs led by education, producing a more equitable, sustainable, and innovative global education ecosystem.

Originality: The article offers a holistic understanding of the integration of AI technologies with education paradigms in the backdrop of global sustainability. The findings provide practical insights for readily implementable action by policymakers, educators, and technologists to ensure inclusive and sustainable education systems. In doing so, the proposed open research questions (ORQs) of this study can be reference research for education transformative studies.

Keywords: Artificial Intelligence; Education 4.0, Education 5.0, Quality, ChatGPT, SDG

1. Introduction

In the modern rapidly developing technological world, the junction of Artificial Intelligence Technology (AIT) and education is not only a prospective outcome; it is already occurring (Elhussein et al., 2024). The use of AI could be seen as a unique opportunity to help education systems promote Education 4.0 (E4.0), a teaching model that places a very strong emphasis on providing learners with the relevant competencies, skills, attitudes, and values for the future (Elhussein et al., 2024). E4.0 is a methodology of learning related to the fourth industrial revolution that focuses on facilitating modern technology and automation to

transform education (Joshi, 2022). AIT has the potential to make one such incredibly powerful weapon available for management education, equipping students with a conglomerate of technologies like never before (Ellikkal and Rajamohan, 2024). The toolkit blends insights on market trends and data with adaptive learning platforms for personalized learning as well as innovative problem-solving methodologies driven by machine-learning algorithms (Ellikkal and Rajamohan, 2024). With these tools, students can solve complex business problems very well. Moreover, the natural language process (NLP) (Liddy, 2001) is used in the chatbot system providing feedback and learning interventions essential to students (Lin and Mubarok, 2021). In addition, machine learning is used for conducting performance predictions of the students (Ouyang et al., 2023).

In addition, the fifth education revolution was expected because of the students' need to have private tutors and game-based learning. "Education 5.0" (E5.0) is a futuristic concept whose goal is to enhance the quality of education provided by overcoming such barriers to learning as poverty by upgrading the latest information and communication technology within the educational system (Mustafa Kamal et al., 2019). Therefore, using AI, virtual reality (VR), and the Internet of Things (IoT) to promote personalized learning, collaboration, and well-being is one of the goals of E5.0. However, the E5.0 does not take as its basis the need for memorization, so analyzing through VR applications became efficient, with a focus on the development of 21st-century skills including creative skills and critical thinking (Aston et al., 2022). AIT in E5.0 focuses on customized and adaptive learning experiences (Gajek et al., 2022) where sophisticated AI algorithms scan previous performance, interests, and patterns of learning to craft a curriculum that caters to everyone whatever their pace or method best suited to them (Rane, 2023). Furthermore, Intelligent Learning Assistants (ILAS) provide machine learning and NLP to assist students learn hard topics and getting answers to their queries instantly with virtual tutors (Smith et al., 2022). In addition, predictive analytics allows teachers to identify and adapt to possible knowledge gaps (Rane, 2024) and mix AR with VR to provide immersive interaction in 3D space and better engagement (Sanfilippo et al., 2022). It encourages students to learn by providing the opportunity of doing practice through simulations and gamification components and making learning fun, as well then being able to apply it in real ways (Sanfilippo et al., 2022). AI in E5.0 is designed around inclusion, and with ethical principles to ensure that its tools for addressing a broad spectrum of learning needs are just, transparent, and responsible (Liu et al., 2023).

Moving into an AI-powered world also means that we — from universities to research centers to departments — will need to change how we teach and innovate (Winks et al., 2020). Educational institutions need to harmonize their activities with the actual needs of society and use the technology megatrends for innovation that can improve the time of teaching, management and learning environments (Androsch and Redl, 2019). These advancements hold the potential to address the demands of various stakeholders, including students, educators, policymakers, industries, and employers, while contributing to the Sustainable Development Goals (SDGs). For instance, utilising natural language processing capabilities, ChatGPT effectively advances education (SDG 4) by offering accessible and tailored learning experiences (Rane, 2023). Additionally, by enhancing accessibility, personalisation, and inclusivity in education, AI-based innovation can have a significant impact on SDG 4 (Nahar, 2024). Learners with varying abilities can be served via AI-powered online learning platforms, adaptive learning systems, and intelligent tutoring systems that offer personalised feedback, assessments, and learning in real-time. In addition to helping students with disabilities and expanding educational opportunities to underserved and rural locations, this innovation makes education more accessible and inclusive (SDG 5 and SDG 10) overall (Lammers et al., 2022). According to the United Nations (n.d.), innovations powered by AI can help with teacher professional development, offer individualised training and mentoring, and analyse data to find countries' strengths and weaknesses in terms of learning. As a whole, innovations based on AI have the potential to improve education and lend credence to evidence-based decision-making, both of which have a positive impact on SDG 4 (Nahar, 2024). This, in turn, has a multiplier effect on the attainment of all other SDGs, as higher-quality education is associated with greater economic growth, social justice, equality, and clean energy (Boeren, 2019). Furthermore, the new solutions are likely to promote an improvement in the management and teaching-learning processes as well as the surroundings within which crucial pedagogical processes take place (Miranda et al., 2021). Also, in the long run, AI helps improve social welfare and community resilience by increasing access to learning platforms and educational resources, which leads to a workforce that is more informed and flexible (Wahbeh et al., 2020). Therefore, it is indeed an important topic of investigation to know about the role of AIT in these educational innovations (E4.0 and E5.0) towards SDGs, and its impact on different stakeholders, such as students, educators, educational institutions, industry and employers, and policymakers. So, the landing of these innovations (E4.0 and E5.0) could be smoother in terms of their adoption, implementation, and real application in a global society. Some previous studies, such as Rane (2024), Wang et al. (2024), and Rane (2023) have started the investigation of the role of AI in

education and SDGs. However, none of the research offers insights from the multiple stakeholders. Therefore, to fill this gap, to investigate the impact of these innovations towards SDGs from the perspective of different stakeholders, and to understand the role of AIT in this scenario, the present research formulates the following research questions:

RQ1: How are AI technologies shaping Education 4.0 and Education 5.0 towards different SDGs?

RQ2: What is the impact of a reshaped Education 4.0 and Education 5.0 from AI technologies on different stakeholders?

RQ3: What future insights can be taken from the literature for the betterment of educational innovation?

To address the above-stated RQs, the study takes a qualitative and conceptual orientation, distilling recommendations from academic literature, industry practices, and policy frameworks that explore how AIT influences some of the major players on the scene of the education industry as it shapes E4.0 and E5.0 towards SDGs. This study uniquely examines the influence of AIT on E4.0 and E5.0 in relation to SDGs. This study distinguishes itself from prior research by including several stakeholder perspectives—students, educators, educational institutions, industry, employers, and policymakers—rather than concentrating just on AI's technical or pedagogical implications in education. This study employs a qualitative and conceptual methodology to integrate ideas from academic literature, industry practices, and policy frameworks, emphasising the potential and difficulties presented by AIT-driven educational advances. Also, the study transcends traditional discourse on AI in education by examining its effects on equity, accessibility, and inclusion, so matching with SDGs such as quality education (SDG 4), gender equality (SDG 5), and reduced inequailities (SDG 10). Moreover, it addresses a significant gap by examining how AI-driven personalisation, predictive analytics, and immersive technologies such as virtual and augmented reality improve learning experiences and professional growth. This way, the research presents a comprehensive view on the future of education in an AI-driven world and gives strategic suggestions for the successful implementation and acceptance of E4.0 and E5.0 globally.

2. Literature review

This section offers a brief about E4.0 and E5.0 including the key concepts of individuals.

2.1. Education 4.0

The essence of Education 4.0 (E4.0) changes the centreline from educators to students focusing on their learning techniques extracted by experiential methods combined with digital technologies for knowledge and skills acquisition (Srivani et al., 2022). Education 4.0 (E4.0), a term coined and started by Gonzalez (2010) gradually turns in the way educational institutions operate due to technological progress while paying special attention to changes occurring around natural ecosystems as well. Education 4.0 is *"a technique of learning that is connected with the fourth industrial revolution and focuses on transforming the future of education through advanced technology and automation. Smart technology, artificial intelligence and robotics are part of this industrial revolution"* (Joshi, 2022). This innovative concept shall introduce new learning possibilities by aligning the technological developments with workforce training and for it to become real a strong academic-business environment is required (Ciolacu et al., 2017). However, systematic research regarding E4.0 only began to attract attention after publication year 2017 in this field. The first published works in this line appeared closely associated with the industrial to propose E4.0 as a solution for Industry 4.0 (I4.0) requirements pretending that way for society would also benefit from technological advances (Eichinger et al., 2017). This incorporation of the E4.0 concept has allowed teachers and students to take advantage of novel infrastructure, and advanced tools in higher education practices. Pedagogical practices, in this context, are evolving to innovate the training processes so that they can cater needs of a never-ending technological regime (Miranda et al., 2021). Therefore, in E4.0 it is argued that knowledge formations will move beyond pedagogy and andragogy to include a more holistic evolution wherein "heutagogy, peeragogy, and cybergogy" are integrated for systematization of such operations (Miranda et al., 2021).

E4.0 in Heutagogy, a humanist and constructivist approach to self-directed learning that focuses on the learner at the center of its process. The concept of peeragogy is not new but has been reconsidered with the advent of E4.0, indicating that learning falls within a collaborative framework through peer learning (Ouhrir, 2019). Technology developments, as well as the growth of every increasing opportunity for education provided by the internet through virtual spaces, facilitated and consolidation. Daud et al. (2019) define cybergogy as learning enabled by information and communication technologies, which are not bound by space and time. Technological enhancements along with these approaches also allow meeting contemporary demands and challenges largely related to programmatic development; as well as deploying processes within settings are imparted (Miranda et al., 2021). Now, teachers must work as facilitators for E4.0, and these projects must be based on the development of technology, new

styles of learning, and social dynamics or regional global so that they are used properly. With online teaching and learning procedures already in place, opportunities for learners to engage with appropriate conditions of educational institutions conducive towards their education-eliciting capabilities are enhanced — knowledge that the skills exposed here will come into play as they brace themselves against what lies ahead (Miranda et al., 2021). Hence, to materialize the visions of E4.0, both new educational frameworks and providers have to be designed and implemented in practice by institutions. E4.0 is majorly centered on four key components, i.e., "Competencies, Learning Methods, Information and Communication Technologies, and Infrastructure", which can deploy to multi-educational levels and different educational ambiences including formal and non-formal (Miranda et al., 2024). Furthermore, Table 1 offers a summary of key components of E4.0.

Table 1: Key Components of E4.0

S. No.	Key components of E4.0	Breakdown of key components	A brief description
I.	Competencies	• *Transversal (Soft):* Critical thinking, cooperation, collaboration, communication, creativity, and innovation (Miranda et al., 2024; Agyapong et al., 2018). • *Disciplinary (Hard):* Enhancing "functional, technical, and technological" knowledge along with effective workplace performance skills, the ability to "research, design, create and implement" new technologies, the application of new technologies and optimal practices to suggest technology-driven solutions (Ratnawat, 2018).	A major constraint that universities face in developing professional competencies is the challenge of getting their students to master handling real-world problems and situations where depth and practice matter most. Cultivating the most general competencies that they can apply at once in their personal, professional, and social life — this is how universities answer to question of what students get for studying on them (Brunel, 2014).
II.	Learning Methods	• *Modalities:* Face-to-face learning, online learning, and hybrid learning (Miranda et al., 2024). • *Methods:* Challenge-based learning, problem-based learning, and learning by doing (Miranda et al., 2024).	The concept by the advent of E.0 is designed to provide efficient, easily available, and flexible education programs where new ways evolve using technology while adopting traditional ideas/tactics/styles/pedagogical practices that are pervasive in higher education programming. These opportunities enable the demonstration of various teaching-learning strategies and ways to improve knowledge progression, and sharing information outside the department. In conversion, this has resulted in new prospective face-to-face delivery methods or a combination of remote and hybrid

			educational models (Miranda et al., 2024).
III.	Information and Communication Technologies (ICTs)	• *Technology-based:* Digital technologies, such as AI, Internet of Things (IoT), machine learning, cloud computing (Cheng et al., 2019), virtual images (Salinas-Navarro et al., 2019), etc. • *Tools/platform based:* Web conference technologies (Gegenfurtner et al., 2020), collaborative learning (Shurygin et al., 2020), mixed reality laboratories (Knox et al., 2019), educational robotics (Salas, 2019), intelligent tutoring systems (Boguski et al., 2019), Hologram-Teacher formats (Paredes et al., 2019), etc.	ICTs include tools that help to gather, communicate, or access information. ICTs have their applications in obvious areas, but they also lend themselves to innovative pedagogical approaches by enabling collaboration between student-student as well as teacher-student builds knowledge in real-time across continents. The use of ICTs is, however, not revolutionary in higher education per se — what is innovative about it instead lies in how its intended use brings value to existing ways we teach and learn (Miranda et al., 2024).
IV.	Infrastructure	• *Classroom level:* "Innovative furniture, connected tools, and other educational and didactic resources" (Miranda et al., 2024). Enhancing learning in libraries, learning commons, and collaborative spaces by modifying their lighting, color scheme, sound, and temperature (Han et al., 2019). • *Institutional level:* Technical and social systems that make up a campus, including a learning management system (LMS), and web-conferencing with this kind of ICTs services as a platform to be used. There are online libraries, instant messaging, and remote labs to name just a few of these that have become productive services (Miranda et al., 2024).	Proper infrastructures are laid to facilitate learning environments in E4.0 with a context that can meet the educational needs of students and address the current problems related to teaching and administration operations in education. Therefore, innovative virtual and physical environments are being created to tackle new needs and challenges (Miranda et al., 2024).

2.2. Education 5.0

Education 5.0 (E5.0) focuses on developing the adaptive, collaborative, and creative skills of a student through technology support. This concept builds upon the tenets of Education 4.0 — which set into motion a new era for education, focused on building technology-driven learning and skills as needed in the modern workforce, by focusing even more heavily on individualized learning processes through increased human/machine cooperation with educational systems that are designed to work within undefined futures (Judijanto et al., 2024). Education 5.0 "*refers to the fifth industrial revolution in education by leveraging digital technologies to eliminate barriers to learning, enhance learning methods, and promote overall well-being. The*

concept of Education 5.0 represents a new paradigm in the field of education, one that is focused on creating a learner-centric environment that leverages the latest technologies and teaching methods" (Ahmad et al., 2023). E5.0 aims to give students the required technical knowledge but also develop their critical thinking, adaptability, and innovation ability as change happens fast (Chankoson et al., 2022). E5.0 practices an all-encompassing pedagogical model that not only develops emotional and social skills but also prepares students for productive interactions with themselves and their environment (Chen, 2022).

The importance of the sustainability dimension has critically emerged around the world and education besides emotion is facing to encourage learners (improving their motivation) to help them become global problem-solvers (Judijanto et al., 2024). This educational pathway emphasizes the blend of fundamental, applied, and engineering knowledge to develop an innovative style, critical thinking as well and application ensuring for importunity atmosphere in learning which will help them incubate ideas that meet ethical entrepreneurs (Judijanto et al., 2024). The goal of E5.0 is to produce human resources that build future-ready capabilities and a sense of social conscience for the betterment of society (Dec et al., 2022). Five core principles of the E5.0 formulated as a guideline for improving teaching and training in students to meet future challenges included "collaboration, creativity, critical thinking, communication, and connectivity" (Duan and Zhao, 2023). According to Dupri et al. (2021), these concepts are geared towards integrating modern world-relevant life skills that will prepare learners for the new frontier of a vibrant, technology-driven environment. The purpose of integrating these five principles into the curriculum is to maximize academic knowledge and core skill development necessary for personal as well as professional success in the future, making E5.0 educational pedagogy a step ahead of our predecessors (Judijanto et al., 2024). This approach underpins the importance of personal connections, innovation, and critical thinking in a world where learning has become increasingly complex. Furthermore, to understand the principles of E5.0 in a better way, Table 2 offers a summary of key principles of E5.0.

Table 2: Key Principles of E5.0

S. No.	Key principles of E5.0	A brief description
I.	Collaboration	In E5.0, collaboration is at the center of a wide range of pedagogic strategies designed to promote learning as part of community effort. To solve complex problems in a digitalized world, both offline and online collaboration are vital (Dwivedi et al., 2023). Similarly, by developing them through class projects that require teamwork and utilizing the varied skills each team member possesses students learn how to work towards a common goal. Furthermore,

		entrepreneurship education teaches students empathy, and cooperation to develop solutions that bring long-term success in addition to being ready for the workforce of tomorrow (Garcia, 2020).
II.	Creativity	E5.0 helps students learn to think creatively by engaging them in learning activities designed for innovation and inquiry-based learning, where the course structure is flexible so it does not confine students' ideas (Gonçalves and Rua, 2022). The breeding of creativity is there to prepare students for the leaders of tomorrow, able to find new answers in an increasingly complex and interconnected world (González et al., 2022).
III.	Critical thinking	Critical thinking teaches students to assess data and parts of an argument in a structured, sensible way, which is an important concept in the digital age, given that students are bombarded with a myriad of information and must determine what constitutes truth and fact versus opinion as well as critical thinking compared to fallacy (Judijanto et al., 2024).
IV.	Communication	Communication supports the effective use of collaboration, creativity, and critical thinking. E5.0 helps to change and enhance student's communication skills related to the skills of language as well as the expression of complex concepts through multiple media. These skills are vital in everyday life and future work, which may involve collaboration in multi-cultural and interdisciplinary settings (Husaeni et al., 2024).
V.	Connectivity	Connectivity suggests that networking is an integral part of globalized modern society, where students need to be enabled to interact and become connected, both in terms of physical and digital presence. In such a way, E5.0 is concentrated on using technology to tie students with ideas, resources, society, and actual people outside the "traditional" classroom, which allows students to become more aware of the world and more engaged and competent as global citizens (Hwang and Tu, 2021), leading to understanding the advantages of diversity and the importance of cross-cultural cooperation to solve existent global problems (Ismaya et al., 2021).

3. Artificial intelligence in Education 4.0 and Education 5.0 towards Sustainable Development Goals across multiple stakeholders

This section discusses how AI is transforming E4.0 and E5.0 towards SDGs by enabling personalized, adaptive, and student-oriented learning experiences across multiple internal and external stakeholders. In doing so, the discussion is oriented to how AI acts as an enabler of digital transformation through the delivery of intelligent tutoring systems, automating administrative work, and delivering data-driven insights for teachers that help tailor their teaching methods accordingly in E4.0. Furthermore, how adaptive learning platforms and AI-based assessments provide a higher level of engagement and allow students to learn at their own pace. In addition, we discuss that in the transition towards E5.0, the emphasis becomes human-centric and value-driven, wherein AI enables lifelong learning as well as emotional intelligence and collaboration. Also, with the potential of AI, to provide educational value, improve operational efficiency, and create a more inclusive and equitable education system, AI enriches all of the stakeholders in the education ecosystem; students, educators, policymakers, and technology providers.

3.1. Stakeholders in the context of the education system

Stakeholder is a ponderous term and is taken with severe sincerity in the context of any education. Education cannot succeed without stakeholder's engagement in the process and the contribution they can make. In this context, stake means the education provided in an educational institution or tertiary education institution. It is defined as "A stakeholder is an individual that has an interest in or affected by an organization" (Bolling, 2024). The stakeholder groups in education include everyone who interacts with, affects, or is involved in the educational process. Educational institutions exist in a stakeholder environment comprised of both internal and external stakeholders.

3.1.1. Internal stakeholders

In the context of the present research we have adapted the classification for internal stakeholders given by González-Pérez and Ramírez-Montoya (2022), which considers three stakeholders under this, such as "students, teachers, and managers". Furthermore, the description of internal stakeholders is given in Table 3.

Table 3: Internal stakeholders

S. No.	Internal Stakeholders	Description of Stakeholders	Source (s)
I.	Students	Students are perhaps the most important group of stakeholders in education since they receive the learning. A good education prepares students with the knowledge and skills they need for a successful life. Furthermore, classrooms that were once set up for a teacher to be the center of attention may now need technical support to allow students, who are using their own devices and work on group projects independently.	Drew (2024), Akimov et al. (2023)
II.	Teachers (Educators)	The role of the teacher changes from simple lecturing to that of a guide, facilitator, or coach. The classrooms are turned into places for generating knowledge and ideas through the collection of one's experience in collaboration with discourse, where the instructor plays the role of facilitator. The suite of digital technologies affords educators to create more active, interactive, and adaptable learning resources in a variety of digital as well as multimedia formats that students can access online. Such adjustments equip teachers with the ability to tap into a wider variety of teaching methodologies that effectively enhance learning, making it easier and conducive to imparting more inclusive instruction.	Akimov et al. (2023)
III.	Managers	In this context, the people of administration, such as principals, associate principals, deans, and additional educational leaders are considered managers. They have a lot to do with the proper	Drew (2024)

	functioning of educational institutions and creating a good culture. They are often education professionals hired not for teaching but because of their wide experience and, therefore a valuable perspective on how educational institutions might improve. However, educational institution leaders often find themselves juggling the demands of multiple constituents and need to listen out for their input to make strategic decisions that will ensure educational institutions reflect community values.	

3.1.2. External stakeholders

In the context of the present research, we have adapted the classification for external stakeholders from the "Quintuple Helix Model" given by Carayannis et al. (2024, 2019), which considers four stakeholders under this, such as "government, industry, civil society, and environment". Furthermore, the description of external stakeholders is given in Table 4.

Table 4: External stakeholders

S. No.	Internal Stakeholders	Description of Stakeholders	Source (s)
I.	Government	Government policies prioritize the creation of stringent requirements for curricular alignment and implementation measures to ensure educational access and equity among all students. While still a critical influence on the promotion of new teaching and assessment methodologies, they do so with less effect to support personalized learning.	PwC (2024)
II.	Industry	Industries/ business communities have a stake in making sure students are receiving good educations that will get them ready for jobs. The objective is to arm future graduates with the knowledge so they do not be condemned as valueless by society. So educational institution funding comes, in part from the business and industry community that donates much of its financing for educational institutions. Many companies also partner with educational institutions to offer internships and full-time employment options for students. Moreover, the sector can work with boards of education to update current educational institutions' curricula and allow students internships–and apprenticeship opportunities so that they do not steer into an illusionary dreamland.	Drew (2024), PwC (2024)
III.	Civil society	Good education directly serves the civil society/local community, which will benefit in this context from having educated residents. An educated public is going to be more likely to find jobs, make higher salaries, and need less help from the government. In addition, an educated body of citizens is more likely to take part in and help shape public behaviors as they emerge within their society. An educated society propels community success, prepares for today's challenges and tomorrow's happenings as well provides a higher standard of living.	Drew (2024)

IV.	Environment	Here the natural environment encourages creativity, each expression justifying its dependence on ecology, environmental sustainability, and climatic effects. The natural world is also increasingly proving to be a subsystem for knowledge and innovation models, which are situating "nature" as an essential part of the process—a co-equal component—of how we think up new ideas. Next, the environment is considered an even more critical driver of creativity than academics themselves in combination with business enterprise that includes government and society as well. On the other hand, they can enable the environmental limitations by pushing sustainable development forward into new technologies, etc. That model for innovation calls for a truly inclusive and pro-equity approach to innovate, meaning that it creates just enough environmental sustainability in every part of the knowledge society, so there will be a sustainable future.	Carayannis et al. (2018), Carayannis et al. (2019)

3.2. Reshaping Education 4.0 using Artificial intelligence towards Sustainable Development Goals across multiple stakeholders

AI is at the foundation of the E4.0 framework due to its ability to analyze huge sets of data leading up to adaptive learning systems that are bound by it (Santos et al., 2024). Silveira and Vieira Junior (2019) and Figueiredo et al. (2023) suggest that these systems are more than just analytic and they will adapt the training process based on the performance and learning profile of each student. Also, AI in education presents a unique opportunity to personalize content, resources, and instructional strategies like never before. The personalization is done with a detailed evaluation of what makes each student special in terms of characteristics, abilities, and desired outcomes.

3.2.1. Internal stakeholders perspective

Core components of E4.0 like competencies, learning methods, ICTs, and infrastructure are fundamentally transformed by AI technologies that interact with internal stakeholders directly, such as students as well as indirectly addressing the demands of teachers and administrators. In this way, machine learning (ML) offers personalized educational learning, where based on student performance data, ML can personalize content and paths for students—which allows them to cultivate competencies such as problem-solving ability and critical thinking (SDG 4) (Elhussein et al., 2024). This personalization ensures that students, who otherwise might be just going through the motions of instruction and hence cover less than they possibly could or learn it with far more struggle than is necessary (SDG 4).

In addition to this, integrating Natural Language Processing (NLP) could make the learning experience more enriching. It would enable interactive systems where students can talk in their natural language with educational platforms (SDG 4) (Alqahtani et al., 2023). This enables chatbots, which can question (answer), explain, and guide on complex topics leading to deepening comprehension and retention (Ashwini et al., 2022). Furthermore, reinforcement learning (RL) can create adaptive learning environments where students work on the computer using algorithms that learn from student interactions and outcomes to provide immediate feedback along with customized challenges, leading to greater engagement in doing their best around a subject (SDG 4) (Sutton, 2018). Instant feedback on written and visual submissions can support students to iterate and improve their work through this data (Matellio, 2024). On the administrator side, computer vision tools can evaluate classroom-specific data such as engagement ratio and participation rate to get a comprehensive analysis of what may need work on in individual instructional practices (SDG 4) (Matellio, 2024).

As the underlying technology for much of what drives AI applications in education, artificial neural networks (ANNs) analyze data and apply algorithms to help predict outcomes (Zawacki-Richter et al., 2019). Further, it could guide strategic decisions at the institutional level, leading to the agency that addresses students most likely to struggle in a class or cohort (SDG 4 and SDG 9) (Zawacki-Richter et al., 2019). This will allow universities, colleges, and other educational institutions to target resources appropriately, implementing interventions that can increase student success (SDG 16 and SDG 17). From enrollment processes to data management, Furthermore, by analyzing student emotions and level of engagement, emotional AI provides a crucial insight into the realm of educational experience (Ho et al., 2024). Identifying when a student is failing or checked out allows educators to step in and address the issue, fostering a more nurturing learning environment (SDG4 and SDG 16). Such emotional awareness helps students feel emotionally connected, driven, and essentially a sense of belonging benefiting academic performance (Ho et al., 2024).

In addition, immersive learning solutions incorporating Augmented Reality (AR) and Virtual Reality (VR), blur the distinction between theory-based learning — that we are all used to in classrooms today, on-screen tutorials, etc (Kamińska et al., 2023). Using this technology students are more engaged in learning difficult concepts like realistic historical simulation and virtual science laboratories (SDG 4). Experiential learning, something that traditional methods cannot achieve is provided through AR and VR to further uplift the students' understanding as well as prepare them for real-life challenges (SDG 9 and SDG 16) (Kamińska et al., 2023).

Overall, the role of AI technologies in E4.0 has led to a fluid and flexible educational ecosystem. These innovations meet the distinctive needs of students, teachers, and administrators in a rapidly globalizing world where allowing everyone to learn more effectively is crucial to achieving better educational outcomes now while also helping learners be prepared for whatever comes their way tomorrow.

3.2.2. External stakeholders perspective

In the context of E4.0, AI technologies play an important role in revolutionizing key skills and learning processes as well as infrastructure development across education sectors from all stakeholders including governments, industries, civil society, and environments. In doing so, ML and ANNs make personalized learning possible by analyzing massive amounts of data from students. They can pinpoint specific learning styles, strengths, and weaknesses to allow educators to provide adaptive educational content and interventions that respond directly to individual learners (SDG 4 and SDG 10) (Zawacki-Richter et al., 2019). In addition to driving engagement higher, this personalized approach helps with retention and keeps students participating longer while also maximizing the learning outcomes (SDG 4) (Lin et al., 2023). Furthermore, NLP assists in establishing improved communication and interaction among learners as well as the learning resources (Alqahtani et al., 2023). With conversational interfaces and intelligent tutoring systems, NLP assists students in more intuitively accessing information while aiding language learning across a range of linguistic contexts (SDG 4, SDG 5, and SDG 10) (Alqahtani et al., 2023). In addition, Emotional AI that determines students' emotions by studying facial expressions and tone of voice contributes to designing empathetic environments for education (SDG 4, SDG 5, and SDG 10) (Singh et al., 2022). Understanding these emotions can help educators adjust their teaching approaches to ensure better motivation with much more efficient learning (SDG 4) (Singh et al., 2022). Also, RL can be used to create learning systems that change themselves based on how students interact with the system (Sutton, 2018).

Policies that support digital literacy and make access to technology more equal for all students can be implemented by governments (Kerv, 2024). Governments can develop educational infrastructure and make classrooms more inclusive by investing in assets such as high-speed internet and digital devices (SDG 4 and SDG 9) (Kerv, 2024). Also, effective training programs should be prepared for educators in these technologies to allow them to apply AI efficiently to their teaching (SDG 9) (Elhussein et al., 2024). Industries need to collaborate

with educational institutions for a skilled workforce that imparts the competencies needed in a digital economy (SDG 4 and SDG 17) (OECD, 2019). This can take shape as internships, mentorship programs, or co-developed curricula that reflect in-demand job market needs (SDG 17). Colleges need to watch out with whom they associate and develop deeper partnerships that can shore up their pipeline, by helping provide more potential applicants who already have received some hands-on experience (Elhussein et al., 2024). To make sure that communities not reached benefit from AI-powered learning resources, civil society organizations could influence inclusive education practices (SDG 4). Through increasing awareness and resources for historically underserved communities, these structural organizations are positioned to level the playing field of educational opportunity across all learners (SDG 5 and SDG 10) (Elhussein et al., 2024). They can also be an important force in driving community engagement and emulation, guaranteeing that local voices have the chance to weigh in on how we develop our educational policies and practices (Zawacki-Richter et al., 2019). Furthermore, Table 5 offers a comprehensive overview of how AI plays a significant role in E4.0 across multiple stakeholders.

3.3. Reshaping Education 5.0 using Artificial intelligence towards Sustainable Development Goals across multiple stakeholders

3.3.1. Internal stakeholders perspective

At the cutting edge of this transformation stand, ML tailors educational experiences by shifting through large volumes of student data to offer customized learning paths. Creating this level of personalization nurtures critical thinking by offering students problems that are habituated to their abilities and passions (Di Battista et al., 2023). Moreover, NLP is an important aspect of communication continuity among students and educators. NLP is also a key component for true dialogue-based learning through intelligent tutoring systems and chatbots providing real-time feedback and guidance (Alqahtani et al., 2023). Such technology fosters better collaboration as it removes the barrier of distance for students and increases strengthening student cohesion. NLP helps create an engaging learning environment where students can discuss and exchange ideas which builds up collaborative critical thinking (SDG 4) (Alqahtani et al., 2023).

Using practical cases in the educational space benefits from RL as they provide opportunities for students to try things out and learn from their mistakes, i.e. experimentation in virtual environments (SDG 4) (Sutton, 2018). This technology lends itself to a situation

where students try multiple solutions and strategies on any given problem. The freedom of error that RL gives fosters creativity, and innovation which are the two extremes necessary to adjust dynamically in this world (Sutton, 2018). It fosters a growth mindset, where students are prepared to tackle obstacles and understand that setbacks can lead to positive growth (SDG 4). Educational settings are increasingly becoming blended with computer vision technologies like facial recognition and gesture analysis to ascertain student engagement in class (SDG 5 and SDG 10) (Matellio, 2024). They provide educators with real-time classroom dynamics that adjust, depending on how students respond and are engaged with what is presented. The result is an immediate feedback loop that seeks to enrich teaching practices with the ability for educators to adapt to various learning capacities, all aimed at creating a better overall experience (SDG 4) (Matellio, 2024).

Table 5: Comprehensive overview of AI role in E4.0 across multiple internal and external stakeholders towards different SDGs

E4.0 core components	Internal stakeholders			External stakeholders			
	Students	**Teachers**	**Managers**	**Government**	**Industry**	**Civil society**	**Environment**
Competencies	AI tools can create tailored learning pathways that foster essential skills like critical thinking, innovation, and digital literacy (SDG 4).	AI-driven analytics can help teachers identify the areas where a particular student scores well and in what they lag, therefore facilitating personalized instruction and support (SDG 4).	AI tools can be employed by administration to recognize the trends that appear which will help them determine the right strategy for their institution (SDG 16).	Governments can use AI tools to analyze labor market trends and skills gaps, thus ensuring educational curricula are aligned with industry demand (SDG 9).	AI-driven analytics can be used to know about the specific skills required in industries making it easy to prepare students for certain roles (SDG 16).	AI tools can help identify skills gaps in marginalized populations and advance inclusive education ensuring continuous skill enhancement (SDG 4).	AI tools can facilitate the embedding of sustainability competencies in educational programs by providing simulation capacities that serve students to be prepared for global challenges (SDG 13).
Learning methods	Students can use gamification and AI Chatbots to create lively learning spaces that better engage, motivate, and maintain them (SDG 4).	Using AI, educators can learn new methods such as flipped classrooms and blended learning techniques among others that allow them to innovate in their teaching (SDG 4).	Administration can access AI tools to scrutinize student success and participation data, which they can use to optimize teaching methodologies for the better across their institution (SDG 4).	AI can help governments put the onus on individual student learning styles and paces, to ensure that all students reach their full potential (SDG 5 & SDG 10).	Creating immersive learning experiences with AI tools can offer real-world experience to students and can be hands-on (SDG 4).	Cloud-based collaborative learning platforms, powered by AI can connect students with mentors and other learners around the world to create community togetherness and fosters diversity (SDG 4 & SDG 17).	AI can support project-based learning, which increasingly revolves around environmental contributions and solutions to contemporary problems (SDG 4, SDG 13, & SDG 16).
Information and communication technologies (ICTs)	AI tools can facilitate convenient communication between	AI tools can assist educators in completing the most routine, administrative	AI tools in resource allocation help administration directly use	The government can build AI-based smart platforms that consolidate the	Collaborating with educational institutions, tech companies can develop AI-	AI tools can be used to figure out what obstacles actually lie before accessing ICTs and address	AI tools can help to be aware of the importance of ICT on sustainability where students can learn how

	students and educators through intelligent platforms running inquiries handling and tutoring sessions (SDG 4, SDG 5 & SDG 10).	tasks so they have more time available for personalized student interaction (SDG 4).	technology and optimal places to put the resources needed by institutions as they evolve (SDG 4 & SDG 16).	tools and resources needed to ensure students and teachers have support for effective learning (SDG 5 & SDG 10).	powered platforms for smoother communication and interaction between students, teachers, and parents (SDG 4 & SDG 17).	them properly so that nobody gets left behind when it comes to changing the way we do education (SDG 4).	technology can lessen environmental footprints and implement it practically (SDG 12 & SDG 13).
Infrastructure	Physical and virtual learning environments can be improved by AI that facilitates the use of space, ensuring classroom layouts are optimal and digital libraries are easily available (SDG 9).	AI-enabled infrastructure designed for educators including interactive whiteboards and collaborative tools to enable group work and real-time feedback etc (SDG 4).	Administration can utilize AI for proper infrastructure monitoring and management by efficiently utilizing the resources while early resolving maintenance concerns (SDG 9).	Governments can leverage AI-powered smart technologies to use resources more effectively, secure buildings, and create adaptive learning environments (SDG 9).	The collaboration of education institutions with technology companies can help in creating contemporary infrastructure like smart classes which could entail intelligent tutor systems and learning analytics (SDG 9 & SDG 17).	Communities can demand education in facilities related to AI that are accessible to everyone which can help identify overlooked areas and advocate for funding to meet the special needs of those communities (SDG 10).	AI can be used for energy efficiency and resources to develop sustainable educational infrastructures that are environmentally friendly (SDG 9, SDG 12, & SDG 13).

RPA takes the day-to-day out of grading, scheduling, and much more leaving teachers with time to maximize student engagement and personalized instruction (Grunwald et al., 2024). Infusing an empathy-led learning approach, Emotional AI provides the tool with which educators may better understand their student's emotions and levels of engagement (SDG 4) (Ho et al., 2024). Emotional AI offers insight into student wellness and engagement by using emotional cues like facial expressions and voice tone (Singh et al., 2022). These technologies take students through a jarring visual experience that dissects complex methodologies and reconceptualizes traditional learning into fun-filled exploration (Kamińska et al., 2023). AR and VR enable learners who come from all types of backgrounds to design together, collaborate on projects across physical space and time, as well share understandings using new pathways (SDG 5 and SDG 10) (Satpathy et al., 2023).

Overall, using AI technologies in E5.0 is a major change in previous technological and forced approaches as regards E4.0. Highlighting the need for individualization, emotional intelligence, and socializing educational processes (Cherewick et al., 2021) within E5.0 fosters a more flexible and democratic environment of education (SDG 4).

3.3.2. External stakeholders perspective

E5.0 is a fundamental change in learning paradigms with many AI technologies that help stakeholders such as government, industry, civil society, and the environment to develop core competencies of working with one another in new ways to build new skills like collaboration/creativity/critical thinking/communication/connectivity (Duan and Zhao, 2023). Such an approach aims for a more seamless and agile educational system that empowers learners to meet the challenges of modern-day life (Rane et al., 2024). AI-based learning platforms ensure better collaboration as they allow real-time interaction between students, teachers, and even industry professionals (SDG 17) (Ellikkal and Rajamohan, 2024). One possible example includes students from different regions, working together to create solutions for local ecosystems. In this regard, an AI-driven project management tool could help organize these students to work together efficiently, share necessary resources needed for the campaign, and have guidance from dedicated mentors (SDG 12, SDG 13, and SDG 17) (Tominc and Rožman, 2023), especially in government, and civil society organizations. Such initiatives promote community and a sense of shared intention as well as give students access to multiple viewpoints, practices, and collaborative experiences (SDG 17) (Rane et al., 2024).

Furthermore, creativity is promoted by establishing advanced AI algorithms that can give individual feedback about each project to the students (Rane et al., 2024). An AI art generator may put students to work on digital artwork while providing in-the-moment feedback and suggestions in the industry-relevant language (SDG 4, SDG 5, and SDG 10) (Interaction Design Foundation, 2023). AI chatbots and virtual assistants help students and educators find resources, connect with experts in different fields, etc., streamlining one of the key components of effective education, which is communication (SDG 4 and SDG 17) (Alqahtani et al., 2023). AI allows students to communicate with business professionals in the industry through arranged engagement, establishing mentorship relationships along real-time feedback on projects (SDG 17) (Natasha, n.d.). For example, a student working on a tech solution for environmental monitoring could easily reach out to a scientist or a policymaker using an AI-enabled platform. This cultivates a vibrant dialogue and exchange of ideas, which stimulates learning and creates an open culture (SDG 9).

Moreover, civil society organizations assist in understanding community needs and encouraging curricular formations for social responsibility and environmental stewardship (SDG 12, SDG 13, and SDG 16) (Sanchez, 2021). Not only does this enhance the educational process, but it also cultivates a shared sense of responsibility among all stakeholders (SDG 10). Overall, AI deployed in E5.0 contributes to an integrated learning environment that nurtures creativity, collaboration, and critical engagement (Elhussein et al., 2024). In summary, deploying AI to strengthen collaboration, creativity, networked knowledge, and critical thinking enables academic institutions to train external stakeholders not just in their academic work but also in becoming informed citizens as well as responsible members of society (SDG 9, SDG 12, SDG 13, SDG 16, and SDG 17). Such a holistic approach is the way to go not just for the learners but for society as well, ensuring that we support our future community members in weaving a tapestry of sustainability, equity, and inventiveness (SDG 12 and SDG 13). Furthermore, Table 6 offers a comprehensive overview of how AI plays a significant role in E5.0 across multiple stakeholders.

Table 6: Comprehensive overview of AI role in E5.0 across multiple internal and external stakeholders towards different SDGs

E5.0 basic principles	Internal stakeholders			External stakeholders			
	Students	**Teachers**	**Managers**	**Government**	**Industry**	**Civil society**	**Environment**
Collaboration	AI-powered collaborative platforms offer sharing resources among students to manage projects efficiently along with peer-to-peer learning (SDG 4).	Adaptive learning platforms can suggest teachers form diverse groups and plan different activities for a collaborative experience (SDG 5 & SDG 10).	AI analytics can be used by the administration to identify better collaboration for students and allocate the resources accordingly for better outcomes (SDG 17).	Policymakers can access the information shared among all the stakeholders to identify the best practices to prioritize and support the initiatives (SDG 17).	Businesses can collaborate with students and other stakeholders based on their skills and competencies to improve project-based learning (SDG 17).	AI can identify areas where there are gaps in educational access and resources, and civil society can use it to organize together against these disparities so that all students have an equal opportunity (SDG 5 & SDG 10).	AI tools can help the collaboration among students for local sustainability projects and it will help them to be aware and prepare for real environmental challenges (SDG 12, SDG 13 & SDG 17).
Creativity	Generative AI tools can help to create projects with feedback in real-time (SDG 4).	Teachers can use generative AI tools to design creative assignments (SDG 4).	Administration can integrate generative AI tools into the curriculum along with training of teachers for better implementation (SDG 4 & SDG 17).	The government can support AI-driven educational platforms among students to foster creative learning (SDG 4).	Businesses can collaborate with institutions to offer immersive platforms to develop innovative solutions for problems (SDG 9 & SDG 17).	AI tools can be used to analyze societal needs and offer creative solutions for societal issues (SDG 9).	AI can be used to facilitate design challenges to encourage innovative solutions for environmental issues (SDG 9 & SDG 13).
Critical thinking	AI-driven simulation ambience can promote critical thinking among students by offering an immersive experience rather than an	Teachers can use adaptive testing platforms to adjust the difficulty level of questions to improve critical thinking among students (SDG 4).	The administration can employ AI analytics to assess critical thinking activities and pinpoint areas for enhancement	AI tools can be used to analyze educational data to identify the critical thinking abilities of students and support the initiatives	Businesses can offer simulation-based ambience using AI tools to foster decision-making and critical thinking skills (SDG 4 & SDG 17).	AI platforms can facilitate discussions related to societal issues and community problems, leading to fostering critical thinking skills for solutions (SDG 9).	AI can help students analyze environmental data for sustainability issues and foster critical thinking to deal with ecological challenges (SDG 9, SDG 12, & SDG 13).

	imaginary experience (SDG 9).		(SDG 4 & SDG 9).	fostering it (SDG 4).			
Communication	Language processing AI tools can help students improve their skills so that they can articulate ideas with more clarity (SDG 4).	Teachers can use AI to help with communication, by looking at how students are interacting and who is not participating effectively which will reduce another level of barrier using running dialogues (SDG 4).	Administration can use AI platforms to communicate with all the stakeholders, which will establish a more cohesive educational environment (SDG 4, SDG 5, & SDG 10).	AI-driven platforms can be used by governments to broadcast their educational policies, announcements, and updates efficiently for easy understanding of both educators as well as students and parents (SDG 4 & SDG 16).	Industries can use AI platforms to establish communication among students, educators, and institutions, and guide them to foster the skills needed for the job market (SDG 4).	AI can be used to develop communication training programs targeting marginalized groups and offer resources that give focus to public speaking, writing, and digital communication which helps them feel self-assured (SDG 4).	Using AI to analyze social media and community data would provide the opportunity to develop communication strategies reflecting tailored messaging in environmental education campaigns that resonate with different audiences (SDG 12 & SDG 13).
Connectivity	AI tools can help students connect with peer networks, which offer a wide range of knowledge and learning experiences (SDG 4 & SDG 17).	Teachers can use AI tools to connect with fellow teachers to share resources and best practices (SDG 4 & SDG 16).	Administration can use AI tools to establish a network of alumni for sharing joint initiatives and broader objectives (SDG 4 & SDG 17).	Governments can use AI to analyze data and offer a comprehensive picture of the education sector including policy-making and promoting connectivity among institutions (SDG 4 & SDG 17).	Industries can use AI to create platforms connecting students to internships, mentorships, and jobs, providing real-world experience that demonstrates the relevance of education (SDG 4 & SDG 16).	AI tools can assist the civil society with identifying and matching volunteers to educational initiatives, which strengthens support networks that enhance a student learning environment SDG 4 & SDG 16).	AI can connect educational institutions with organizations, helping policies that will promote sustainability by informing students about such initiatives SDG 4, SDG 12, SDG 13, SDG 16, & SDG 17).

4. Discussion

In this article, we look into the paradigm growth of AITs for E4.0 and E5.0 towards SDGs and explore their impact on various stakeholders and the future of innovation in education. The research addresses the three research questions by looking into the integration of AITs in E4.0 and E5.0 towards SDGs, and how they impact the internal and external stakeholders. Furthermore, we provide insights from a future perspective informed by the literature that might help improve the education literature.

Furthermore, this section discusses how we addressed the individual research questions as follows:

RQ1: How are AI technologies shaping Education 4.0 and Education 5.0 towards different SDGs?

AI has played a significant role in the transformation of both E4.0 and E5.0 towards SDGs. In E4.0, AI undergirds data-driven, adaptive, and thoughtful learning systems. The impact of AI such as ML, NLP, and RL helps to personalize the content and delivery of that educational material (Lin et al., 2023). Using these technologies, a significant amount of data from students is analyzed in such a way that feedback can be provided immediately; individualized learning experiences can be offered through enhanced media and content; and key skills such as problem-solving or critical thinking are developed (SDG 4) (Silveira & Vieira Junior, 2019). For example, AI-powered tools for students such as intelligent tutoring systems and immersive learning technologies (AR/VR) facilitate active learning and experiential learning experiences to internalize complex subjects more easily (SDG 4) (Figueiredo et al., 2023).

E5.0 is more human-centric, holistic education blending collaboration, creativity, critical thinking, communication, and connectivity (Duan and Zhao, 2023). AI remains important but, instead of increasing education efficiency, co-creation with students leads to more agile and individualized educational experiences (SDG 4 and SDG 17) (Rane et al., 2024). In E5.0, AI tools like NLP and emotional AI help to develop empathy and a better quality of conversation not only between students but also with employees such as teachers and administration which will directly lead to more inclusive learning environments that address the emotional perspective of students (SDG 4, SDG 5, SDG 9, and SDG 10) (Singh et al., 2022). RL enables experimentation and nurtures creativity so that students are prepared to meet the new-age dynamic world.

RQ2: What is the impact of reshaped Education 4.0 and Education 5.0 from AI technologies on different stakeholders?

The influence of AI in reshaping E4.0 and E5.0 from AI technologies is reflected in the context of internal and external stakeholders. In particular, personalized AI-driven platforms for students and educators that align their competencies with those required by the industry can help internal stakeholders to develop in a contextually reinforced and independent manner (SDG 9, SDG 16, and SDG 17) (Ellikkal and Rajamohan, 2024). For classroom educators, AI can be employed to facilitate timely teaching and learning though analysing student learning and performances while creating individual and personalized learning experiences. AI also help to reduce the time gap between the period of assessment and tutors' response by providing real-time feedback. Real-time feedback helps students to learn from their mistakes in no time rather than waiting to receive feedback after hours or days. Furthermore, AI can also be employed in automating grading, student performance tracking, and classroom management; this will allow educators to be free from the unproductive part of dealing with administrative issues (SDG 9) (Grunwald et al., 2024), while emotional AI can enable educators to track the engagement and emotional condition of students and act as supporters, this will have an explicit impact on educational achievement since a supportive and caring classroom environment makes the most difference to the student's learning (SDG 4, SDG 5, and SDG 10) (Ellikkal and Rajamohan, 2024). For external stakeholders, E4.0 and E5.0 are the means how to achieve social and economic aims. From the perspective of the government, AI can be employed to develop the educational infrastructure, information systems, and policies to promote digital literacy and fair access to education (SDG 9, SDG 16, and SDG 17). For civil society, AI can be used to ensure that the needs of the community are being met in more inclusive ways to enhance access to education (SDG 4, SDG 5, and SDG 10) (Sanchez, 2021).

Furthermore, to offer a more comprehensive overlook for addressing *RQ1* and *RQ2,* we have developed on 'next-gen quality learning' framework which is based on the literature insights while conducting the research. Figure 1 depicts the next-gen quality learning framework which comprehensively illustrates how AIT is reshaping the E4.0 and E5.0 towards SDGs across multiple internal and external stakeholders.

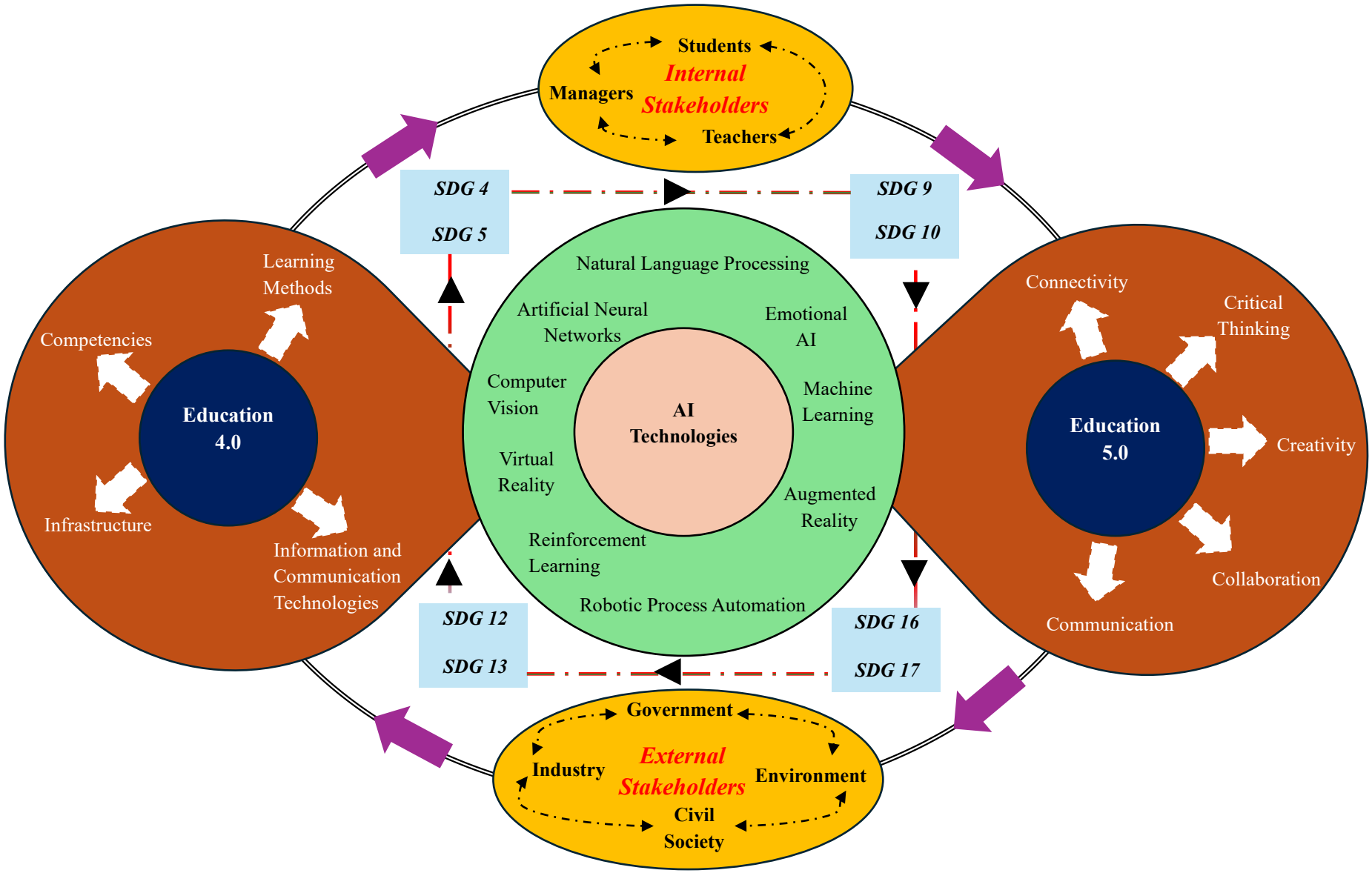

Figure 1: Next-gen quality learning framework

RQ3: What future insights can be taken from the literature for the betterment of educational innovation?

To address the *RQ3*, authors have done multiple brainstorming sessions, and come up with some open research questions (ORQs), which offer futuristic insights for other researchers regarding how this research can enable the different UN sustainable development goals (SDGs). As achieving UN SDGs is a major concern for educational institutes, we have looked into it from the futuristics perspective, and proposed ORQs in this direction as follows:

From the internal stakeholder perspective:

ORQ1: What role do AI-powered adaptive learning platforms play in increasing access to underserved communities while promoting equity and inclusion in learning outcomes? **[SDG 4: Quality education]**

ORQ2: What ethical challenges are associated with Emotional AI in the classroom to measure student engagement and emotion, and how can these challenges be mitigated in practice/development considering privacy issues and fairness? **[SDG 10: Reduced inequalities]**

ORQ3: How can NLP systems be employed to overcome linguistic barriers in education, promoting multilingualism and linguistic diversity? **[SDG 4: Quality education]**

ORQ4: How can leveraging AI-powered immersive technologies (AR/VR) disrupt the classification of learning to be which is participative and experiential from past classroom activities, while paying attention to environmental footprint tracking? **[SDG 13: Climate action]**

ORQ5: How can we use ML algorithms for personalized content creation to further inclusive and differentiated instruction in the education of students with special needs? **[SDG 10: Reduced inequalities]**

ORQ6: What role can AI-driven educational systems play in fostering social and emotional learning (SEL) in students, promoting empathy, collaboration, and social responsibility? **[SDG 16: Peace, justice and strong institutions]**

ORQ7: How can AITs guarantee the inclusiveness of assessment methods to reduce biases based on gender, race, and socioeconomic status in educational contexts? **[SDG 5: Gender equality]**

ORQ8: How does AI-enabled automation affect administrative functions in education institutions, and how can they improve resource efficiency? **[SDG 9: Industry, innovation and infrastructure]**

From the external stakeholder perspective:

ORQ9: How AI-based adaptive learning systems can embed sustainability themes, such as climate change education or environmental justice, into curricula and mobilize student engagement? **[SDG 13: Climate action]**

ORQ10: How can governments work alongside AI education systems to guarantee the receiving of equal access to technology and infrastructure, particularly in rural and marginalized areas? **[SDG 10: Reduced inequalities]**

ORQ11: How could civil society organizations take advantage of AI-based education platforms to raise awareness of sustainable development to shape curricula in an inclusive and environment-friendly manner? **[SDG 4: Quality education & SDG 13: Climate action]**

ORQ12: How AI technologies can potentially help universities and colleges facilitate multidisciplinary collaboration, and allow students to address global environmental and social issues? **[SDG 17: Partnerships for the goals]**

ORQ13: How can individuals and policymakers intervene so that the digital divide in education is not widened by AI-powered technologies and ensures they get to all students? **[SDG 10: Reduced inequalities]**

***ORQ14*:** How can AI-powered learning platforms be designed to promote cross-cultural collaboration and global citizenship including awareness regarding SDGs? **[SDG 4: Quality education & SDG 17: Partnerships for the goals]**

ORQ15: How can education policy-making be optimized by governments through the use of AI and big data analytics to ensure national resources are allocated in a way that supports not only the SDGs but also equitable access to quality education? **[SDG 4: Quality education & SDG 16: Peace, justice and strong institutions]**

ORQ16: What will be the environmental effects of the widespread use of AI in educational institutions, and what Solutions can Indeed Eco-Friendly AI solutions contribute to energy consumption reduction and sustainable campus conduct? **[SDG 12: Responsible consumption and production]**

ORQ17: How can mentorship platforms powered by AI enable students from under-represented backgrounds to connect with high-achieving professionals across various sectors that are crucial for achieving the SDGs?? **[SDG 10: Reduced inequalities]**

4.1. Theoretical implications

The theoretical implications of this article provide an understanding of AIT at the forefront of reshaping E4.0 and E5.0 and in line with the Sustainable Development Goals (SDGs). The research demonstrates the capacity for AI-driven systems to create, promote and enhance educational outcomes, support critical skills in stakeholders, and generate inclusivity between diverse stakeholders by showing how AIT help form personalized and adaptive learning environments. The shift from E4.0 to E5.0 highlights the current directions for education by placing stakeholders at the center, prioritizing collaboration and emotional intelligence over configurational designs, reflecting a paradigm shift towards a multi-faceted understanding of what success in education looks like beyond efficiency. In addition, the article proposes a 'next-gen quality learning' framework which is developed as a conceptual lens through which to work systematically and integrate human-AI collaboration into education systems, in turn, which may serve as a roadmap for future research, practice and evidence-based focus to help educate individuals as both members of society and communities. The theoretical implications of the present research encourage further studies about the ethical, social and economic dimensions of the role of AI in different education contexts, highlighting the need for a sustainable equilibrium between profit and sound development. The article also contributes to the discourse of human-centred and holistic education in E5.0 which expands the boundaries of classic education theories toward responding to functionalism but with a focus on co-creation, emotional intelligence, and empathy through AI. In addition, the perspectives on AI's potential to enhance administrative efficiency and support collaborative, dynamic learning environments add to our theoretical understanding of how technology transforms education governance and stakeholder relationships, providing a multidimensional perspective of how to achieve SDGs.

4.2. Managerial implications

The integration of AIT in E4.0 and E5.0 poses important managerial implications for educational institutions that desire to align with SDGs. For example, using AI-driven tools to develop personalized learning experiences for diverse students, enhances engagement and educational outcomes (Lin et al., 2023). But this method not only develops vital skills like

critical thinking and emotional intelligence but also prepares students for a quickly changing job landscape. For instance, with the use of data analytics, Khan Academy creates individualised learning plans for each student (SchoolAnalytix, n.d.). These plans include adaptive practice problems, instructional videos, and real-time feedback that is specific to each student's needs (SchoolAnalytix, n.d.). Furthermore, educators can use AI automation for administrative workloads to concentrate on supportive and inclusive learning environments that promote student success (Grunwald et al., 2024). Embracing AI can enable stakeholders in education, like governments and civil society, to create equitable educational policies and infrastructure, ultimately ensuring access to quality education (Sanchez, 2021). For instance, in Estonia, AI-based digital learning platforms have democratized access to education, while supporting initiatives for lifelong learning (E-Estonia, 2024). They demonstrate the potential of AI to bridge the educational gap, promote inclusivity, and equip societies with the rapidly evolving skills required for a sustainable future, reinforcing the role of management in facilitating collaboration between government, industry and academia to fully promote the use of E4.0 and E5.0 innovations. In addition, AIT can increase the accessibility of learning to all learners including students with disability. AI facilities such as chatbots, automatic machine translations speech generation and recognitions can help to facilitate communication in the process of learning and enhance the participation of disabled students particularly those with visual and hearing impairment.

5. Conclusion and limitations

The article offers a collective opinion on the application of AI in reshaping E4.0 and E5.0 towards SDGs which shows the transformative power of contemporary technologies with various education stakeholders. AI provides tools to strengthen agile learning environments, increase collaborative learning opportunities, and enhance administrative efficiencies. AI-powered solutions in E4.0 harness the power of AI by using AI-enabled systems to customize learning material, maximize administrative productivity, and offer instant feedback, thereby allowing educators to concentrate on developing students and enabling personalized learning journeys. However, E5.0 focuses more on collective emotional capabilities, collaborative spirit, and ingenuity to offer full human-centred educational experiences. Thus, AI not only improves the learning outcomes but also enables students with the skills they require to succeed in an ever-evolving and fast-paced world. Whether it is their integration with immersive learning solutions such as AR, VR, or emotional AI and intelligent tutoring systems that creates a wholesome ecosystem to prepare students for the future challenges of life, or collaborative

frameworks at the external stakeholder level that bring together possible steps to align education-industry-government efforts and a close student-stakeholder collaboration indeed support its way towards our future. The advancement of AI in education is no longer simply an enhancement in the process of technology, but a transition to a new reality, where education becomes more diverse and adaptable to SDGs and directly meets future global challenges. With its ability to link various domains and encourage an interdisciplinary mindset, AI prepares them to be the informed, empathetic, perpetrator of positive change who can thrive against future unknowns.

While AI seems to have multiple competitive benefits in learning, it has a few limitations. The integration of AIT into E4.0 and E5.0 raises several ethical concerns and issues, especially in areas such as data privacy and equity. With AI systems relying heavily on large-scale data collection to customize and innovate learning environments, the risk of misuse or data breach is a major concern. Educational institutions are required to enact strong data governance policies to ensure the proper treatment of sensitive information and student rights protection. Best practices in data collection, storage, and use need to be followed for building trust with students and parents. Additionally, the issue of equitable access to AI tools is another concern. However, the digital divide could widen if AI in education favors students who contribute the most data or resources. The same educational risks apply to students from lower socio-economic backgrounds, who may not have the same access to tools to enable remote learning and keep up with their peers, risking lagging. Thus, if policymakers and educators are both enable to create and grow AI-driven resources, and technology developers are directed towards this passion, coupled with research and development of it, there is potential for equitable access to learning resources. Moreover, the intellectual use of AI in education should involve understanding the ethical repercussions of using decision-making programs. Using AI extensively to evaluate student performance or to help steer educational trajectories is also troubling given the risk of biased algorithms.

When the data on which they are trained is biased against certain demographics, AI systems may perpetuate these discrepancies, resulting in biased treatment of some students. Therefore, there is a constant need to monitor and improve AI systems to minimize these risks. Furthermore, as E5.0 prioritizes a more human-centred approach to learning, it is imperative to weave emotional intelligence into AI solutions. By understanding how emotional AI can support educators in this regard, the outcome of students taking guidance to become independent and responsible thinkers is achievable. But it also makes us wonder where AI

should sit in the emotional space, and whether we are becoming over-reliant on technology in spaces that should be populated by human connection. AI indeed can provide personalization in learning but finding the right balance between automation and human involvement (teacher) is a challenge as well. While the role of educators may change, human interaction is still imperative to nurture emotional and intellectual growth and too much reliance on AI might emanate setbacks from this perspective. Finally, the cost of introducing AI tools can be prohibitive for many educational institutions (especially in developing countries), and the requirement for continuous improvements and training puts a burden on scarce resources. Thus, although AI holds exciting prospects for the future of education, we must remain mindful of its limitations and ethical concerns to ensure it ultimately serves as a vehicle for all learners. Considering these challenges, stakeholders need to work together to create ethical frameworks that guide the use of AI in the educational process. This should include frameworks that are not just focused on technology for the sake of technology but also on fairness, accountability and transparency. In this way, we can ensure that AI is a tool of empowerment, expanding educational opportunities for all students and complementing SDGs for inclusion and equity in education. So, the ultimate successful implementation of AI in E4.0 and E5.0 fundamentally depends on our collective ability to engage with these ethical imperatives in a thoughtful, collaborative manner, ultimately fostering an educational paradigm that is creative and just.

The article is based on the literature instead of empirical data or field studies. As a result, it fails to generate actual evidence for how AI can make a difference in E4.0 and E5.0 towards SDGs. Therefore, it would have been nice to see some primary research conducted — like a survey or interviews with key stakeholders — that validates these findings. The article intends to examine the implications of AI for various stakeholders—including students, teachers, managers, industry, and government—but will likely not provide a full analysis of how each group uniquely confronts different challenges and opportunities. The status quo remains largely theoretical, in that it proposes general principles of how AI technologies are used without taking into consideration regional or institutional differences that may affect their use and implementation. While the article briefly addresses some ethical aspects surrounding AI, it would benefit from a deeper analysis of important issues such as data privacy and algorithmic bias, which could lead to their exclusion from use in conceptions that benefit certain groups of students but disadvantage others. It would require an analysis of how these ethical concerns might be different with respect to the educational systems and stakeholders involved.

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