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The future of teaching and learning in the context of emerging artificial intelligence technologies

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ABSTRACT

In the context of emerging artificial intelligence technologies (AI) such as AI-Bots (ChatGPT) and AI-Agents, it is imperative that adequate adjustment be made, and also seen to be made. However, this has to be done from an informed positions. There is no doubt that these disruptive technologies are changing the way we live, conduct our day-to-day businesses, teach, learn and conduct research. There are also emerging concerns that these dynamics may result in a paradigm shift from student-teacher relationship to student-AI-Tutor-based relationship within the academic circle. Besides, there are foreseeable dangers of compromising academic integrity through high-technology plagiarism and the potentials of students avoiding learning through AI deployment and utilisation in their academic pursuits. But something worth considering is how applying these tools in education will potentially change the entire classroom experience of students, their knowledge and skills outcomes that are relevant in this AI era. This position paper is an effort to put into context what the authors of this paper forecast as the future of teaching and learning in the context of these inevitable disruptions to education activities and its subsectors as we currently know it. The authors found it necessary to take these positions to help bring to fore some practical use cases of AI in education; recent developments and theoretical frameworks in literature, technical reports, as well as experts opinions that can help assuage stakeholder's concerns despite some obvious existing challenges. It is our view that this paper will be found useful by educators, stakeholders and administrators in the areas of curriculum design, classroom administration and entire academic planning and reviews.

1. Introduction

It is no longer up for debate that an emerging AI-centric society will be a deviation from norms - how we live, move, do business, and conduct our day-to-day life activities. In line with this, there are strong indications that AI will completely transform our

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workplace, skill demands, and businesses Robert and Meenakshi (2024). These anticipated changes are also expected to affect the existing teaching and learning environment Popenici (2023). Much more is the consideration that in no distant time, these dynamics will lead to a shift from student-teacher relationship to student-AI-enabled Personal Assistant relationship, that is the anticipated era of artificial general intelligence (AGI). Some of the evolving technologies that can lead to these shifts are AI-enabled chatbots (for example, ChatGPT, a Generative AI (GenAI) technology based on a large language model), personal agents, or personal digital-service provider (Gates, 2023c). These agents are a type of software tool that can respond and act on user instructions through everyday natural language and based on its knowledge of the user, can help to carry out virtually any activity in any area of life (Gates, 2023b). In education, there are fears about the dangers of compromising academic integrity (Cotton et al., 2023) through high-technology plagiarism and the potentials of students avoiding learning (Chomsky, 2023) through AI deployment and utilisation in their academic pursuits. More worrying are the potentials of changing the entire classroom experience for students; their knowledge and skills outcomes. Furthermore, Rosenblatt (2023) believes that having existing tools to detect text generated by AI is not enough to protect against the threats of academic integrity posed by AI.

In light of the above, there are some arguments on whether to ban the use of AI in the classroom or not, while the case where it was banned (Yang, 2023) has been lifted. Singer (2023) posits that its use and integration in classroom administration has been vocal (Roose, 2023; Rim, 2023; Brown, 2023; Duckworth & Ungar, 2023; Heaven, 2023) and overwhelming. Dowling and Lucey (2023); Thorp (2023) and Shields (2023) while arguing that AI tools have strong impacts on classroom administration, encouraged the use rather than the prohibition. Their reason is that the use of AI tools has been very helpful to students, ranging from getting started with an essay, writing an outline, and providing feedback on their work. Else (2023) in addition, said that AI tools have been helpful to students in generating ideas, organising their thoughts, writing an entire essay, as well as writing or debugging codes. One of the compelling voices in support of AI deployment in teaching and learning is that of the UK government (Edwards et al., 2025). The government has recently identified teachers as one of the groups that will start using AI for faster planning and record keeping in their recent plan to boost growth and deliver public services more efficiently using AI tools. This will in no small measure help in support of the deployment of existing government-developed AI teaching assistant that had been used by about 30,000 teachers in England at the moment.

In support of the above, Shields (2023) is of the opinion that, rather than banning AI tools in the classroom, teachers should design lessons around how the use of GenAIs can help with academic exercises such as essay writing. In addition, teachers should acknowledge the realities of the powers of GenAIs and focus on helping students through their use, which in turn will help revolutionise how they teach Agarwal and Vij (2024); Shamsuddinova et al. (2024). Dwivedi et al. (2023) added that due to the potentials offered by AIs, higher education teachers should focus on engaging deeply with these disruptive technologies, using them in creating state-of-the-art classroom experiences and research experimentation rather than avoiding or banning them. Gates (2023c) in furtherance of his support for the use of AI in education advised that the use of AI should be encouraged in classroom administration, as the tools can help students' writing and critical thinking alongside generating articles that the teacher and student can fact check. In addition, AIs can help students develop a study plan, point them to good resources, and test their knowledge. Heaven (2023) differs with Gates (2023c) by positing that although these AI tools may be helpful in providing students with quick answers to questions, they are devoid of the capacity to impact on them some essential academic and lifelong skillsets such as critical thinking and problem solving skills. Moreover, AI tools are deficient in being able to draw a student into a subject he/she is not already interested in.

In light of these points, the question is as follows: Should educators be gripped with fears or face the future by leaning on history and learning from previous disruptive technologies before AIs? Gates (2023c) argues that many of the issues that are raised in AI today have a historic precedent and there is no doubt that AIs will have big impacts on education (Dwivedi et al., 2023). He further opined that we could learn from history starting from the introduction of handheld electronic calculators, computers, etc. Furthermore, Gates (2023c) agrees that many teachers are concerned about the ways in which artificial intelligence will undermine their work with students, especially with the introduction of ChatGPT and other related prompt technologies. However, society has come to see how these technologies have changed how we query computers, write computer codes, write essays, assignments, and even academic articles.

The extent to which these disruptions by AIs will unfold remains very much unclear. Thus, exploring and holding a position based on perceived unfolding dynamics, especially as it affects teaching and learning, is the focus of this paper. The overall aim of this opinion paper is to situate the future of teaching and learning with regards to the rapid proliferation and roll-out of GenAIs and other AI related tools in education. The authors intend to do this by synthesising the existing literature, technical reports, practical use cases, recent developments, experts, and stakeholders' opinions.

The contributions of this paper include:

- Identify from the existing literature the level of GenAI applications in education.
- Providing some practical use case examples and safety measures on GenAIs in Higher Education.
- Providing information on precedence, the present, and the pedagogical adaptation to teaching and learning in the context of systemic changes.
- Deep dive into GenAIs in education: shortcomings, opportunities, threats, and recent developments.
- Providing through existing knowledge and opinions the present and future implications of use and non-use of these tools in education.
- Finally, we present the views and opinions of the authors in the context of this important ongoing academic discourse.

It is the authors' understanding and preliminary position that GenAIs have shown strong applications in education, as the

algorithms can be used by teachers and students as learning and communication support tools, research, and administrative assistance. They can also be used to create new and original content, such as images, computer codes, videos, and texts that cannot be easily differentiated from human-created content. But as a word of caution, the authors will advise against using GenAI tools outside one's domain of knowledge, as outputs need to be fact-checked for accuracy using expert knowledge. However, the coming era of AGIs is hypothetically believed to be a time when machines will have the ability to learn, think, and act in a way that is very close to that of humans. Thus, blurring the line between machine and human intelligence has very strong implications in education. For clarity, GenAI tools/Large Language Models (LLMs), AI/AI tools may be used interchangeably in this paper.

The rest of the paper is organised as follows: Section 2 provides some existing literature in the public domain that focused on the subject matter under discussion, their outcomes, and areas of further studies. Section 3 was used by the authors to provide some practical use case examples of GenAIs in HE. Section 4 showed how learning theories and contemporary pedagogical approaches can help inform the deployment of educational AIs, while section 5 was used to provide information on the evolution of teaching and learning practices in the face of systemic changes to help lean on the precedence in the navigation of emerging disruptive technologies in education. Section 6 provided a detailed look at GenAI tools and their applications in education, as well as their limitations, opportunities, threats, recent developments, and varying opinions on their application and future of education. The paper summarised and made recommendations in section 7 and concluded in section 8.

2. Review of related works

Reading through section 1, it is clear that the authors of this paper are advocates of GenAI tools in teaching, learning, and research. It is also the authors' view that GenAI systems operate a shared responsibility model. Whereas it is the duty of the user to carefully guide GenAI tools with the right prompts for the expected outputs, it also lies on the user to fact check the outputs for accuracy before usage. So, the authors reiterate that it is not advisable to use GenAI tools outside one's domain of knowledge, as the issue of accuracy of results remains a challenge. On the basis of the above, this Section will be used to review existing knowledge, opinions, and advice in the literature on the use or otherwise of GenAI tools in teaching and learning.

Artificial intelligence systems are human-created computer models that can help solve a specific problem or provide a particular service. Gates (2023a) opined that AI-driven software in the next few years will help revolutionise teaching and learning practices. Dwivedi et al. (2023) in their recent opinion paper stated that the practice of teaching, learning and academic research will be transformed by these emerging dynamics Shodieva (2024). In line with these, O'Connor (2022), Ifenthaler et al. (2024) discussed the possibilities of having increased human-AI collaborations in higher education in the near future. Their opinions focus on advocating for change in existing academic policies to provide legal and policy frameworks for the development, testing, and application of these disruptive computational tools that have shown potential to improve student learning and experience Deguara (2024). The authors also noted that, although the use of AI technologies has shown numerous benefits, there are concerns with issues of biases (Chen et al., 2023; Hartmann et al., 2023; Popenici, 2023; Tariq, 2025); out-of-date training data; lack of transparency and credibility. Gates (2023c) shared some of these views and added hallucinations as part of the concerns. In AI systems, particularly GenAIs, hallucinations refer to the models' inability to understand the specifics of a user request, thereby resulting in an incorrect answer. Bias, on the other hand, happens because AI models have the chances of inheriting whatever prejudice baked into the datasets they were trained on. Some other concerns raised by Dwivedi et al. (2023) with regard to education (teaching and learning) in higher education (HE) include: the chances that its use could lead to superficial learning, lean abilities for critical thinking and creativity (O'Connor, 2022; Popenici, 2023), trust and transparency (Dowling & Lucey, 2023), privacy and security (Okonkwo & Ade-Ibijola, 2021a). Felten et al. (2023) listed teachers in schools and higher education as one of the most exposed to AI disruptions, which can lead to their profession being lost or degraded. This view was shared by the work of Popenici (2023). Popenici Popenici (2023) further argued that GenAI outputs are just texts with good grammar and syntax, but lacking in creativity, critical thinking, depth, and wisdom.

The need to provide a more personalised learning experience and engagement has been the major driving force in the use and application of AI technologies in education according to (Cunningham-Nelson et al. 2019; Mohammed et al. 2024; Francis et al. 2025 and Okonkwo & Ade-Ibijola 2021a). According to the authors, chatbots appear to be the main AI technologies that are used to achieve this personalised and engaging learning experience for students (Benotti et al., 2017). The reasons for this wider use and applications range from being able to provide a quick and instance response to users (Okonkwo & Ade-Ibijola, 2021a; Smutny & Schreiberova, 2020); respond to queries about course details and contents (Cunningham-Nelson et al., 2019); help students practice on their tests through questions and answers (Sinha et al., 2020). Gates (2023c) advised to use AI tools with caution as they are subject to biases and hallucinations, more cautiously when relying on them for routine frequently asked questions (FAQs) (Ranoliya et al., 2017) and so on. An example of a Chatbot widely used in Okonkwo and Ade-Ibijola (2021a) is ChatGPT (a GenAI tool). The use of this has shown from Okonkwo and Ade-Ibijola (2021a); Khanna et al. (2024) to be able to enhance student learning outcomes and experiences when deployed to answer their questions, navigate e-learning resources, curriculum participation, and instant feedback. Gates (2023a) agrees to the above, but added that AI technologies can only enhance learning and will never replace the classroom students-teacher relationship that fosters learning. However, it can help teachers with their routine administrative tasks, allowing them to engage more deeply on their classroom work (Hien et al., 2018; Röhrig and Heß, 2019). Some of these views were shared by the work of Mulaudzi (2024), who added that GenAIs for teaching and learning in higher education can lead to innovative teaching methods, personalised learning experiences, and improved student engagement. Beyond these, they have the ability to bring about improved administrative efficiency, and by addressing education inequalities, they can promote equity and inclusion Tariq (2025), Limba et al. (2024), but this can vary between institutions and disciplines.

The works of Shamsuddinova et al. (2024) explored the views and perceptions of educators about the impact of AI on teaching and

learning within the case study area. Their findings showed that although educators are open to the use and optimistic about the potential benefits for education, the lack of understanding and training Ojha (2024) in the use of these tools in classroom instruction and assessment remains a barrier to its utilisation. There are also fears about the impacts of what they identified as inhibiting factors such as sociocultural reservations, systematic resistance to change Dube and Setlalentoa (2024), lack of structured policies Agarwal and Vij (2024) and available resources within the study region. Hence, the study concluded that the need for structured policy frameworks and guidelines on the use of AI in education cannot be overemphasised as this will help in the integration and better understanding of how to mitigate against associated risks.

This study by Okonkwo and Ade-Ibijola (2021b) evaluated the ethical implications of Chatbots use and application in higher education. Based on their findings, the use of chatbots in higher education creates a digital gap, impacts user privacy, is not transparent, and has trust issues Rudolph et al. (2024). Furthermore, (O'Connor et al., 2023) said that GenAI tools cannot replace human interactions in learning, which they identified as part of their downside. The use of these tools in teaching and learning according to the authors has the potential to reduce learners' emotional intelligence; demeaning the necessary human social interaction that deepens learning and threatens the use of conventional classroom environment in teaching and learning. However, the authors agree that GenAI tools can help assess critical thinking ability of learners; help in language acquisition, and support digital literacy.

The literature above showed nearly the same views from various authors on the potentials, threats, opportunities, and challenges of using GenAI tools in teaching and learning. Although there are existing challenges and pitfalls regarding the use of these tools in HEIs, there are overwhelming views that these technologies are disruptive, have great impacts in education, and are coming to stay. One thing to note is that applications, user experiences, and usefulness vary between institutions and disciplines Mulaudzi (2024). The technologies are also a work in progress, and some GenAI tools are better than others. For example, a celebrated case of hallucination using Microsoft Co-Pilot Thorne (2024) has now been fixed. In addition, there are improvements in the newer versions of these tools that are being released, such as ChatGPTo1 Strawberry, which have been found to be better than previous versions with more functionalities such as self-prompting around the input prompt given, thus forcing GPT to explore more options related to the initial query and, in principle, reduces hallucinations.

In addition to the issue of hallucination, Michael Calvin Wood Wood (2024) as quoted in Stakelum (2024) has claimed to demonstrate the ability to achieve 100 % accuracy in certain types of AI tasks, particularly in question-answer scenarios through his work, Acurai. Acurai Wood and Forbes (2024) according to Michael Calvin Wood is the world's first AI that provides 100 % accurate, hallucination-free responses as made available to the public on July 23, 2024.

This study focuses on using the current available information and use cases, related theories, precedence, experiences, and recent developments to forecast the future of these powerful AI tools in teaching and learning.

3. Some practical uses of GenAI in HE: authors' use case examples

GenAI systems like ChatGPT, Copilot, Gemini, Claude, Grok, etc. are large language models (LLMs), which are deep learning neural networks. What LLMs offer to HE is really the same benefits they offer to everyone. In teaching and learning, we categorised the offerings into:

- **Learning Support:** Personalised tutoring, language learning, summarisation, and breaking down complex topics. **Practical examples:** LLMs were used in generating Python programming code for Data Science in a undergraduate class. The work involved giving plain English descriptions of complex programming code, which were used to analyse datasets in Data Science.
- The benefit of this is that even if the student does not know Python programming, LLMs can be used by the student to solve complex coding problems. This has been found to be an excellent way to learn the structures and form of the language by beginners.
- Another use case is where LLMs were used in breaking down complex papers in an MSc class. The application was found very useful by international students who struggled with the use of the English language. They used it to break down the content of a paper by asking a series of simple questions about the paper. Thus, making it easier for them to understand and build knowledge slowly.
- **Communication Support:** written communication, comprehension of communication, and simplification of language. **Practical Use Cases:** International students who struggle with the use of the English language have found the use of LLMs useful in translating between languages to clarify the meaning of written assignments/notes. They also used them in simplifying some concepts they found complex and confusing. Helping them to explain concepts step-by-step to improve comprehension, especially those switching programmes between their undergraduate and post-graduate studies.
- Another good use case is where a student with autism spectrum disorder (ASD) condition found the use of LLMs very useful in email communication: reading, understanding, composing, and replying to email communications. The student said that the use of LLMs in email communications has been a game changer.
- **Research Assistance:** Literature reviews, hypothesis generation, data synthesis, data analysis, rewriting of the manuscript, improved readability, transforming style and formatting. **Practical examples:** LLMs were used in data analysis, large-scale data handling, summarising large chunks of written data and performing analytics on datasets by undergraduate and post-graduate data science students.
- Some went further to using LLMs to generate potential research questions and hypotheses around a particular topic of their interest in research.
- **Administrative Use:** Streamlining student queries, automation of certain processes within schools. **Practical examples:** LLMs were used by some of the authors to automate repetitive tasks, such as questions frequently asked by students. This helped free up time for higher-value activities.

- Another use case is where students in Postgraduate Computer Science programme were asked to use it in analysing anonymised Personal Statements provided by prospective students. These were used to build profiles of the kind of students applying to our programmes, and helped in gaining insight into how well our course provisions matched their interests.

3.1. Some suggested safety measures on using LLMs in HE

UK Cabinet Minister, Pat McFadden in (Edwards et al., 2025) while acknowledging the significant strides of AI applications in teaching and health in the UK, added that AI is a developing technology with faults such as the recent call on Apple to withdraw a feature on its latest iPhone that generated inaccurate news alert using AI (Kleinman et al., 2025). McFadden advised that the use of AI tools has become a necessity but requires a mix of safety while maximising their opportunities. With some of these significant pitfalls evident on LLMs, one needs to worry about using the output from LLMs safely. Below are some of the safety measures recommended while using LLMs.

- One of the measures is to adopt a process that allows us to make use of the technology, but also to be totally sure of the output. For instance, avoid using LLMs to generate content outside of your own domain knowledge, as you may not be able to validate the outputs, and this is very risky.
- Planning the prompt in terms of input and output for the problem you are trying to solve will make better prompts with fewer hallucinations - using Case Diagrams or Data Flow Diagrams can provide enough detail to reduce likelihood of hallucinations.
- When interacting with LLMs, tell the LLM that it will be acting as a copyeditor/programmer/marketeer or whatever the task is at hand.
- When using LLMs for your domain work, consider that your role changes from being the primary source of knowledge to one of a supervisor checking and verifying the outputs.
- It is very important that users avoid providing Personally Identifiable Information (PII) in any LLM, as this could be used to train future versions of LLMs and may end up being publicly disclosed. Where possible, use a “no memory mode” in the LLM, this will mean that any prompts you write will not be remembered or used for future training.
- Furthermore, it is important for users to get acquainted with prompt engineering, plan input ahead before prompting LLMs.
- Whenever prompting LLMs, ask for the response to be explained step-by-step, as this can fundamentally change how the LLM responds to you and improves the detail of the response.
- Ask for levels of confidence in the answer expressed as a percentage, which will generally highlight any areas where the LLM is unsure of the answer and may indicate potential hallucinations.
- Also, ask LLM the following: to tell you how effective your prompt was in generating the output and to seek any areas of improvement from your input; to provide worked examples with the content produced; and for sources of knowledge used to generate the output.
- Finally, we advise that users avoid trying to get LLMs to “do the thinking” for you in the prompt. You need to tell LLM what you want, not ask it to solve a problem for you.

4. Learning theories and pedagogical strategies to inform the deployment of educational AI

Pedagogy as a concept, according to Loughran (2013), rather than being similar to teaching, is enmeshed in the relationship between teaching and learning. Loughran (2013), underscores the importance of understanding the relationship between teaching and learning, their recognition, and development in the educational enterprise. There is therefore a need to consider contemporary pedagogical approaches and strategies in order to appropriately underpin the pedagogical applications of educational AI. As Tang et al. (2023) highlights, there are concerns about the capabilities of educational theories, pedagogical approaches, and models in an AI-enabled learning environment. However, our understanding of AI in education is still in its infancy, and thus we are faced with several challenges of application and ethics Tahiru (2021).

Crucially, the world has witnessed the rapid development and deployment of GenAIs in day-to-day activities, so it is necessary to accelerate the development of modern pedagogical approaches, models, and methodologies that support a more intentional and considered application within teaching and learning. This is a direction already argued for in teaching and learning, particularly to close emerging human resource gaps (e.g., Gates, 2023c; Shields, 2023; Heaven, 2023; Zhang & Aslan, 2021). Although some (e.g., Kabudi et al., (2021) have begun collaborative work on AI-enabled adaptive systems, a knowledge gap exists regarding how to manage and implement these in educational settings, particularly in more authentic learning contexts (Bates et al., 2020 and Kabudi et al. 2021).

In the absence of this understanding, we argue that understanding of learning theories and pedagogical approaches can help educators design suitable learning environments that incorporate AI technologies. We believe that more considered applications of AI within educational contexts can facilitate more effective implementations, whilst also accounting for some of the present concerns and ethical challenges highlighted within the area. Thus, what follows is an introduction to several learning theories and their relevance (or not) to AI technologies in teaching and learning contexts. Some specific pedagogical strategies are also provided, with the aim of presenting example conceptualisations of how AI and pedagogy may be suitably put to use together by an educator.

4.1. Learning theories and their relevance to educational AI

Theories of learning have developed significantly in the last century, with understandings of how learning happens moving relatively frequently. Beginning with earlier conceptualisations of behaviourism, the following passage introduces and discusses theories of cognitivism, constructionism, constructivism, and social constructivism in relation to educational AI.

- **Behaviourism:** Behaviourism (Pavlov, 2010; Skinner, 1988; Thorndike, 2017) centres on the idea that environmental interaction of learners impact on their behaviours (Anastasie & Cyprien, 2021). This implies that learning occurs as action changes. For instance, the use of repetition and training can turn certain behaviours into habit (Bloomfield, 1976), thus making evaluation or assessment focused on observed behaviour (Ibrahimu, 2022). It is associated with both rewards and negative sanctions for learning or lack of learning (Nath, 2013a,b). Whilst the theory of behaviourism has not recently been more widely advocated as a suitable lens with which to view learning, it can be considered in relation to the development of educational AI systems that provide immediate feedback for students. This is particularly relevant with AI triggers and progress tracking on student learning activities. It can also be effective in the development of digital rewards systems to encourage learning for students.
- **Cognitivism:** Cognitivism focuses on how the human mind receives, processes, and organises information as well as stores, and retrieves it. Changes in understanding over time is the main stay of cognitivism according to (Hanfstingl et al., 2019). Principally associated with the work of (Piaget, 1976), cognitivism highlights that life-long constructive processing leads to knowledge development through the organisation, structuring, and restructuring of experiences in the light of existing schemes of thought. Cognitivist theory has the potential of being effectively applied to educational AI systems, particularly in the design of information processing models, such as mirroring how humans process, store and retrieve information. Cognitivism also advocates the breaking down complex topics into more manageable chunks, a task that educational AI can perform through task-setting and triggers. However, cognitivism has been criticised for presenting a somewhat incomplete view of learning, particularly in relation to the social, cultural, and historical underpinnings of learning (see Vygotsky & Cole 1978). As such, we present cognitivism with a note of caution, that educators must consider how they are implicated within the learning process, above and beyond the content of a curriculum alone.
- **Constructionism:** Constructionism (e.g., Papert (1991) builds on Piaget (1976) notions of cognitivism. The emphasis of the theory is on the efficacy of learning through the creation and actively constructing knowledge rather than just passively receiving information. Central to the idea that learners have the ability to make or construct their own knowledge based on experience. It makes a case for the toleration of technology in learning by pioneering the use of computers as learning tools. Thus, digital tools have the potential to enable students to test ideas in more concrete ways. Beyond mere imagination, digital tools and educational AI can allow students to construct and make things of personal value, thereby testing their concrete capabilities. Such a process lends itself to (Papert, 1991) theory of constructionism, where learners produce learning artefacts, externalisations of their knowledge.
- **Constructivism:** Constructivism focuses on the idea that learners have the capability of making or constructing their own knowledge based on experience (Alismaiel et al., 2022). The theory implies that for learning to take place, new learning experiences must take into consideration human factors that can influence how learners assimilate new knowledge to their existing knowledge constructs. For instance, notions of cultural-historical theory (see Vygotsky & Cole 1978), highlight the need for an educator to take account of the prior knowledge and lived experience of a learner, in order to facilitate appropriate connections between current and new knowledge. It is important to note here that, whilst a more complete view than cognitivism, later conceptualisations of constructivism (i.e., social constructivism) are more widely advocated for in educational research.
- **Social Constructivism:** This differs from constructivism as conceived by (Piaget, 1976) as it adds that learning is a collaborative effort. Vygotsky and Cole (1978) and Vygotsky (1986) views centred on the role of teachers in facilitating learning rather than learning as a seamless and environmental phenomenon. These arguments implicate the role of a More Knowledgeable Other (Vygotsky & Cole, 1978), and therefore advocate that learning must take place within social contexts. It is therefore, incumbent on an educator to make effective use of technology within teaching. Thus, it is critical for educators to understand their intentional use of digital tools and GenAI. Recent understandings of digital learning and alike often advocate social constructivist learning (e.g., Fawns, 2022).
- **Liberationism:** Arguing that learning should be democratic in nature, Freire (1972) proposed that student voice in teaching and learning should be incorporated as a matter of essence. The theory proposes that learners are able to make choices about their education, in terms of how they engage with their learning, but also in terms of what they engage with. Freire's work developed educationalists' ideas of transparency, ethics, and educational virtues within their curricula. As such, he has promoted human values of openness, humility, tolerance, attentiveness, rigour, and commitment. With respect to educational AI, we argue that educators must take great care with how they suggest (or even permit) students engage with it. For instance, educational AI that is embedded within a Virtual Learning Environment (VLE) to unlock learning opportunities as a student progresses may seem liberating to an individual at first, particularly if perceived as a reward for their engagement. However, this liberation is illusionary, as the AI actually limits a student's choice of what they can engage with. Some GenAI tools, on the other hand, may allow students to discover concepts outside of the defined curriculum, offering a level of empowerment. Great care must be taken here, however, as pure liberation may also lead to engagement with irrelevant or contradictory concepts. Thus, Vygotsky and Cole (1978) notion of a more knowledgeable other rears its head. Educators must first, therefore, understand the inherent boundaries placed on learners as a result of their predefined curriculum. Consequently, they must secondly consider their role in the development of critical thinking and critical consciousness in relation to the educational AI use of their students.

In thinking of the above theories, we recommend that educators adopt a knowledge-based attitude. That is, we argue that each of these theories has relevance to the teaching and learning realities of the readers, and also to their implementation of educational AI. This is not to say that one-size-fits-all, however, hence the provision of a more detailed chronology of learning theory for the reader.

4.2. Pedagogical strategies and educational AI

- **Scaffolding:** Derived originally in the work of Wood, Bruner, and Ross Wood et al. (1976), the word scaffolding is offered as a metaphor for learning. Wood et al. (1976) described a process in which a teacher, or more knowledgeable other Vygotsky and Cole (1978), provides temporary support to help a learner learn new skills and develop new concepts. In light of this, it should be noted that the links between scaffolding and social constructivism are particularly explicit, so we reiterate the need for educators to understand how their knowledge supports a learner. The metaphor suggests the provision of support through instruction, motivation, appropriate selection of learning activities, and feedback, which are then gradually removed as the learner becomes more competent and autonomous. Scaffolds can be put in place by a teacher in order to bring a learner into their Zone of Proximal Development (ZPD) (Vygotsky and Cole, 1978). This process involves the role of assessment, where a teacher must assess what a learner can or cannot do independently before providing an appropriate level of challenge or support. Useful scaffolding techniques may involve breaking down complex tasks into step-by-step processes; separating bigger concepts into manageable chunks; using hints, prompts, and templates; or modelling desired results for a learner to imitate.
- **Adaptive Learning:** Adaptive learning theory, as introduced by Rachmad (2022), uses technology, methodologies, and data to create personalised learning experiences that are dynamic in relation to each student's performance, needs, pace, learning patterns, and preferences. The theory provides guidelines for creating a flexible, dynamic, and responsive learning environment tailored to individual needs. It can be used to personalise learning in which the instructor continuously collects student data on performance, behaviours, and analyses these data to understand where the student needs support, and applies appropriate measures to help improve the student's learning experience. Theoretically speaking, it is understandable that one may consider this as cognitivist practice, particularly if these actions are automated or driven by educational AI. However, any integration of human intervention should be considered as a social-constructivist approach. Here, the integration (or interplay) of human and educational AI becomes particularly apparent. In practice, adaptive learning can be applied by the instructor using different types of assessment, and then from the data make informed decisions on appropriate learning pathways for a student. Such a learning pathway be to break down the indicative learning contents into more manageable chunks or using different methods in representing information such as text, video, audio, graphs, interactive elements, etc.

Although GenAI is still in the early stages of adoption, its accessibility is undeniably poised to shape pedagogical discussions in these areas in the future. Table 1 outlines how GenAI can contribute and influence these educational approaches.

5. Teaching and learning in the context of systemic changes

This section is a summary of how teaching and learning approaches have been transformed in the context of systemic changes. Examples of such a pandemic are the recent COVID-19 pandemic, during and after the pandemic era. The section will provide information on the lessons learned and potentials of leveraging these in dealing with the issue of AI (GenAIs and anticipated AGIs) in teaching and learning.

- **Virtual Learning and Teaching**: Virtual learning and teaching (VLT) refers to a learning environment where teacher and student interact through a technological mediated space. It involves the deployment of course contents through application software; while teaching instruction and discussion take place using multimedia resources, the Internet, videoconferencing, and so on (Dung, 2020; Bri et al., 2009; Mueller & Strohmeier, 2011). Though popularised during the COVID-19 pandemic, a major benefit of this approach is that is has shown to be adaptable and personalised, which can enhance academic performance (Mai, 2023; Reginald, 2023). However, VLT may unintentionally lead to a heightened sense of isolation among learners, a condition that is potentially intensified by the physical separation and the lack of immediate, tangible visual and verbal feedback. The isolation might result in increased

Table 1
Contemporary pedagogical approaches and suitability in educational AI.

Pedagogical Model	Discussion
Behaviourism	Generative AI can provide immediate feedback, triggers, and progress tracking for students. It could also facilitate digital reward systems to encourage learning through reinforcement.
Constructivism	Technology-driven learning aligns with constructivist theories, making educational AI useful for personalized and adaptive learning experiences that build on prior knowledge.
Social Constructivism	Educational AI can facilitate collaborative learning by incorporating social elements, supporting peer interactions, and enabling role-based knowledge sharing through intelligent tutoring systems, as well as acting as an artificial more knowledgeable other.
Cognitivism	AI can model cognitive processes, helping students by breaking down complex topics into manageable chunks, supporting schema development, and enhancing metacognition.
Liberationism	AI can empower students by giving them control over their learning path, supporting democratic and inclusive education, and fostering critical consciousness through ethical AI applications.

anxiety and apathy about engaging in online classes, negatively impacting higher education sustainability (Tennakoon et al., 2023). It is therefore critical to identify the VLT communication barriers that may cause some students to become disengaged when deploying VLT technologies, especially the international students (Crawford-Ferre & Wiest, 2012). While existing studies have confirmed that online discussions facilitate knowledge construction and learning engagement (Liu et al., 2023), it also appears that there may be some face-to-face interactions that might influence students' online interactions. Crawford-Ferre and Wiest (2012) discovered that the lack of visual cues in asynchronous and synchronous discussions caused problems for international students participating in an online Master of Business Administration programme.

- Although VLT approaches have shown promise in improving the performance of learners, there is a clear research gap about how well they work in promoting student interactive behaviour and engagement. The components that make VLT platforms interesting are not adequately stated in the literature. A comprehensive understanding of these properties is paramount for creating and preserving the strong sense of community in virtual learning spaces. This knowledge is essential for fostering a learning environment that is not only intellectually stimulating but also emotionally supportive. Furthermore, research needs to examine into how virtual environments can emulate the shared experiences and relationships of a traditional classroom in order to preserve the feeling of community within VLT. This includes the development of shared goals, the fostering of mutual support networks, and the encouragement of a culture of collaboration.
- **Blended Teaching and Learning**: The approach as defined by Garrison and Kanuka (2004) is the combination of online (virtual) with face-to-face (in-person) learning. Their position pre-COVID was that the use of this approach in teaching and learning will be an effective low-risk strategy that will aid universities in meeting the demand of teaching and learning in the context of technological advancements or what the authors of this paper refer to as systemic change driven by advanced level technologies and tools.
- Furthermore, Barber (2022) defined Blended learning as the combination of in-person delivery and that of delivery in a digital environment. The authors posit that Blended learning should be carried out through a well thought out plan. It is important that any such plan focuses on determining the level of online activity requisite for students' learning and supplementing that with face-to-face activity. In some instances, it uses the online materials to support students' learning, while that of traditional for a follow-up of the online activities.
- Though the position of Garrison and Kanuka (2004) did not foresee the implications of teaching and learning in a post-COVID era, it became a much-adopted approach. The approach became necessary in closing the transitory gap between COVID era where virtual learning was predominant as a result of difficulties of in-person classroom setting and pre-COVID, a return to normal in-person traditional classroom setting.
- **Flipped Teaching and Learning**: While Bishop and Verleger (2013) described flipped classrooms as an approach that combines asynchronous video-based lectures with problem-based learning (PBL), this definition does not fully capture the broader scope of flipped teaching. The flipped model extends beyond video-based instruction and PBL, incorporating various pedagogical methods to enhance student engagement. As stated in the article, "the method encourages the use of multiple teaching and learning approaches" meaning that flipped learning is adaptable and not limited to a single instructional format. It fosters active learning environments that prioritise student engagement and skill development over traditional teacher-centered instruction (Rahman et al., 2019). Additionally, flipped learning aligns well with the technological advancements of the 21st century, making it a relevant and effective strategy in modern education Rahman et al. (2020), Rahman et al. (2019), Bredow et al. (2021).

5.1. Adapting existing methods in AI era

Zhao and Watterston (2021) identified potential three changes to teaching and learning in a post-COVID era (otherwise known as era of AI), such as having a developmental, personalised and evolving curriculum and student-centred pedagogy, that is enquiry-based, authentic and purposeful. They also identified education delivery that focuses on the use of synchronous and asynchronous teaching and learning environments. The latter has been supported by the works of Imran et al. (2023), Singh et al. (2021), Saboowala and Manghirmalani-Mishra (2020), Pellegrini et al. (2020), and Guppy et al. (2022), where it was considered a blended/hybrid learning system.

Although researchers have shown concerns about the capabilities of contemporary education theories, pedagogical approaches and models in an AI-enabled learning environments (Tang et al., 2023). Gates (2023c) argues on leaning on historical precedent, insights from the works of Zhao and Watterston (2021) and that of many experts can be leveraged in overcoming the emerging challenges posed by disruptive GenAIs in teaching and learning.

Section 3 has practical use cases from the authors' experiences on how GenAIs can be used effectively in teaching and learning in the areas of providing students with communication and learning supports, as well as research and administrative assistance for both staff and students. In addition to these use case examples, 4 provides information on how learning theories and contemporary pedagogical frameworks can be adapted in educational AI systems. For instance, Cognitivism theory can be effectively used in the design of AI-based information processing model that can mirror how human process; store and retrieve information, as well as breaking down complex topics into manageable chunks. It can also be used to design AI systems that can track students' cognitive load and adjust content delivery accordingly. Cognitive theory can also be leveraged in building pattern recognition algorithms that are capable of identifying students' learning strategies and adapting instruction given to the student in line with the pattern as identified.

6. Generative artificial intelligence technologies in the context of teaching and learning

This section will focus on emerging AI technologies applied in teaching and learning, their limitations, opportunities, and threats, some recent developments, and the opinions of experts and authors on their application and future of education.

6.1. Emerging AI technologies in teaching and learning)

- **ChatGPT**: The Centre for Teaching and Learning at the University of Oxford (CTL, 2023) opined that ChatGPT is one of the many tools expected to change the landscape of teaching and learning in the coming years. It is not just a chatbot, but also a useful tool that will have a strong impact on teaching and learning in the coming years. There are many known and yet to be known potentials of ChatGPT in education, which have been widely discussed in 1 and 2 above.
- **Intelligent AI-Agents**: These agents or tutors, as suggested by Zhang and Aslan (2021) have the capacity of providing customised, timely, and appropriate materials, as well as guidance and feedback to learners. Can also act as personal-digital-service providers (Gates, 2023c); and will be the next software system platform like today's Windows, Linux, Android and iOS (Gates, 2023b). According to McCarthy et al. (2018) have been shown to promote independent learning, but have failed to improve student academic performance. Other AI tools that educators can look out for in the coming years as Zhang and Aslan (2021) posit include, Expert Systems, Machine Learning-powered tools, Personalised learning systems or environments, and Visualisations and virtual learning environments.

6.2. Limitations of GenAIs and prompt technologies in education

This section highlights the limitations of GenAIs in education and the importance of critical evaluation and validation processes to mitigate risks and ensure the accuracy and reliability of AI-generated content. The authors believe that trust in AI systems should be balanced with a commitment to thorough validation and verification practices. These, in no doubt, will help to uphold educational standards, as well as promote effective learning outcomes. The following are some of the existing shortcomings in AI tools in education.

1. **Risks arising from GenAIs**: GenAI tools while in their nascent stages pose numerous risks that warrant careful consideration, such as the ability to promote independent learning but fail to improve student academic performance. This domain is rapidly evolving with technological advances that continue to shape the landscape of GenAI providers, capabilities, and accuracy levels Stakelum (2024). Inaccuracies stemming from GenAIs collectively termed as hallucinations result in outputs that are often nonsensical; inaccurate, or entirely unrelated to the user's prompt.
2. **Hallucinations**: These refer to instances where the output deviates significantly from the intended prompt, resulting in inaccurate answers or reasoning (IBM, 2024). For example, research on the limitations of ChatGPT for code production revealed instances where the model provided incorrect answers (Thorne, 2023), particularly in scenarios involving uncertainty. Although subsequent updates may improve model performance, other GenAIs may still exhibit hallucinations, especially in tasks involving logic and mathematics (Plevris et al., 2023; Davis, 2024; Frieder et al., 2024; Shakarian et al., 2023).
3. **Prompt Engineering, Validation, and Verification**: Prompt engineering plays a crucial role in ensuring accurate output from GenAIs. Incomplete or ambiguous prompts increase the likelihood of hallucinations (Plevris et al., 2023; Thorne, 2023; Wan et al., 2024), leading to errors in the generated artefacts. Validation and verification are essential processes to confirm that the output aligns with the prompt and accurately reflects real-world scenarios. However, users may overlook these steps due to misplaced trust in the AI system's capabilities, contributing to the persistence of inaccuracies.
4. **Magical Thinking and Reification in AI**: Magical thinking (Morris, 2023; Shakarian et al., 2023) and reification Croll (2018)) pose significant risks in the context of GenAIs for education. Students may attribute unwarranted properties to AI systems, such as infallibility or wisdom, leading to misplaced trust and lack of validation and verification. Reification further exacerbates these issues by transforming abstract AI systems into unquestionable truths, regardless of their actual performance. Such tendencies contribute to inflated expectations and perceptions of AI capabilities, increasing the risk of reliance on inaccurate outputs. One such approach to reduce the impact of these factors is to instill critical thinking skills in students (Sternberg & Halpern, 2020) when using GenAIs and provide them with mechanisms such as triangulation (Greyson, 2018) to validate and verify the result of GenAIs.

6.3. AI technologies in teaching and learning: opportunities and threats

Every system that improves on the existing method (innovation) will inevitably lead to skill gaps, system and technical obsolescence, as well as human and skill redundancies (Anyanwu, 2024). One of such inevitable changes has been brought about by GenAI technologies. Whether these technologies will shape our era is no longer up for debate, the question is how best humanity can fully utilise the revolutionary power of AI by making it human-centric. Doing these requires a deliberate retooling of our contemporary teaching and learning practices, research and knowledge development, ethics, policies, and regulatory frameworks.

Dwivedi et al. (2023) are of the view that the concept of mindfulness in information technology is key to how critical it is for instructors and teachers to focus their mindset on experience and experimentation during systemic change. IT Mindfulness according to Thatcher et al. (2018) has four aspects namely: 1) awareness of distinction, 2) awareness of multiple perspectives, 3) openness to novelty, and 4) orientation in the present. Imbibing these constructs will help teachers engage with students on how best to explore and experiment with new technology tools. In line with the above, Dwivedi et al. (2023) posit that inviting students to apply IT mindfulness

will be necessary as it relates to GenAIs in their work and practices.

On the basis of these, the authors of this paper present herein what they think will be the changes that GenAI technologies will bring in teaching and learning practices as presently practiced in the next Section - Summary and Recommendations.

6.4. Some recent developments underscoring the potentials of GenAIs in education

In addition to the new development as reported in 2 on the claim by Michael Calvin Wood (Wood, 2024) as quoted in (Stakelum, 2024) that Acurai has demonstrated the ability to achieve 100 % accuracy in certain types of AI tasks, particularly in question-answer scenarios. This subsection brings to fore some other similar development that have potentials of putting to rest most of the concerns raised by stakeholders on the application of GenAIs in education - covering ethics and bias in AI, assistive technologies, adaptive and personalised learning, document analysis for researchers, and critical thinking AI support systems.

Ethics and bias In AIs: The work of (Team et al., 2024b) claimed to have developed a model known as Gemma models that can be used in dealing with ethics and bias issues in AIs. These models, as claimed, can be used in creating AI applications that provide transparent insights into decision-making processes, as well as detecting and mitigating biases during model inference.

Assistive technologies: In Qwen 2 Model Series, (Yang et al., 2024) claimed to have developed models that can be used in the creation of AI tools in assistive technologies. For instance, a tool for the visually impaired that can interprete and describe images in real time. Other tech-assistance that can be developed using the nodel include: advanced language translation paired with visual context, as well as visual assistants with features that can understand and respond to multimodal queries.

Adaptive and personalised learning: MixR A7B as developed by (Jiang et al., 2024) has shown to possess the ability to be used in the creation of AI systems that can adapt to individual user preferences in real time. They can also be used to build educational tools that can be tailored to student needs.

Document analysis and research: Gemini 1.5 by Google DeepMind (Team et al., 2024a) is an AI tool suitable for analysing large documents, such as books, articles or legal texts. This tool can be used to summarize large and voluminous documents by providing specific information (text extraction) and insights, which makes it very useful for researchers and legal professionals.

Critical thinking AI tutors: Orca LLM as developed by (Mitra et al., 2023) focuses on improving the reasoning capabilities of learners as claimed. The LLM can be used in the development of AI systems that teach critical thinking to students by walking them step-by-step through logical problems. They can also be used in creating AI tools that can assist students in decision making by logically evaluating trade-offs as well as games or apps that solve riddles or logical challenges.

6.5. Expert opinions on GenAIs in teaching and learning

In view of emerging changes and the need for adaptation in teaching and learning, United States Department of Education in (Department of Education, U., 2023) provided areas that need urgent attention and policy change. Changes that focus on using automation to advance the achievement of expected learning outcomes while protecting human decision making and judgement. Furthermore, there is a need to understand the quality of data used in AI models by interrogating them. Doing this, they argued, will help ensure a fair and unbiased decision-making process for AI models. In addition, educators should take appropriate steps in examining how AI technologies provide for equity and take steps in safeguarding this by limiting AI systems that undermine equity, as well as providing for human checks and balance on these emerging systems.

However, experts from UNESCO (Sabzalieva & Valentini, 2023) support the use and integration of GenAIs in higher education institutions (HEI), but advised that it be used with care and creativity. The advice focused on how HEIs could connect the use of these tools with the expected learning outcomes of programme Modules; conduct a review of all forms of assessments and evaluations in line with this inevitable change, as well as review and update policies relating to academic integrity and honesty in relation to GenAIs and other AI tools (Torres, 2023).

In support of this, UNESCO suggested that HEIs build the capacity and competencies of their staff members to understand and manage GenAIs. This new knowledge could lead to the introduction of new programmes and indicative course content focusing on GenAIs and other emerging AGI tools. That there is also need to revamp existing programmes and modules in a way to proactively articulate and incorporate the teaching of core AI competencies, skills, literacy,and ethics besides providing peer support and mentoring among staff and faculty members.

In contrast, the Center for Teaching and Learning at the University of Oxford CTL (2023) provided four lessons on the opportunities and challenges of GenAIs, which are: the challenge of academic integrity is real with the emergence of GenAIs, but neither new nor unique from precedence. That the tools are useful for educators, though at an early stage of exploration in terms of teaching and learning. Finally, GenAIs are just one of the many tools expected to change the landscape of teaching and learning in the coming years.

Below are a summary of some existing expert opinions on the impacts of GenAI tools in teaching and learning practices.

- Assessments need to be diverse, where some are classed as Human - describing a situation where the assignment is carried out without any AI input except for grammar and spellchecking; AI-Acknowledged, where the student is allowed to use AI tools as part of the study and in preparing initial guidance on the assignment; and AI-embedded, where the student is permitted to use AI tool as an integral and expected part of the assessment. These have become necessary because these tools are likely to be used in the future workplace, which could enhance students' employability prospects (CTL, 2023).

- With regard to pedagogical research, human creativity is now more than ever needed to explore how teaching, learning, and assessment can be enhanced using GenAIs. Also, on how best to employ AI tools in all aspects of the process (Sabzalieva & Valentini, 2023; Department of Education, U., 2023).
- A human-AI collaboration in higher education is now in the foreseeable future. Hence, more funding, along with policy changes, is needed to ensure that we can develop, test, and apply these sophisticated computational tools to further student learning (Sabzalieva & Valentini, 2023; Department of Education, U., 2023).

6.6. *Authors' opinions on GenAIs in teaching and learning*

Gleaning from the existing literature, technical reports, recent developments, expert advise and opinions on the impacts of GenAIs in education, the authors will want to state as thus:

- Fully human-centred classroom administration will be gradually integrated with that of AI assistance leading to some levels of automation, but the extent of integration/automation will vary across nations, institutions, disciplines, and programmes. That is to say, there will be a gradual increment on the percentage of human-AI classroom integration based on improvements, understanding and adaptations.
- Generative AI has the capacity to support pedagogy in a way that can may develop concept of an 'AI integrated classroom'. The level and type of adoption however will vary greatly by level of study, as well as the subjects being studied. These emerging dynamics and considerations of use could result in a paradigm shift from student-teacher relationship to student-AI-Tutor-based relationship within academic circles, especially to help support students with scaffolding their own development. This will be likely driven largely by AI-Agents and the increasing accessibility of generative AI through large language models.
- These Agents will have the capacities of offering personalised learning and communication supports; self-paced teaching and learning - tutoring, assessment, and feedback; research and administrative assistance. In the nearest future, the right to formal education will increase the existing requirements associated with digital competence to have a greater focus on AI literacy, as knowledge related to AI will become that of international importance and of high-skill demand.
- When we begin to see the development of systems that are close to general artificial intelligence, machines will have a greater capacity to mimic the ability to learn, think, and act in a way that is very close to that of humans. Thus blurring the line between machine and human intelligence, and likely once again calling into question the role this technology will play in formal education.
- There is a capacity for improved generative AI to support a rise in of asynchronous learning. As with other areas, the capacity for this development will largely be factored around the level of the technology, as well as the level and subject of learning taking place. In the light of the above, the concept of asynchronous learning through opencourseware and social media may begin to be popular. What these imply is that formal educational institutions may have to resort to the use of opencoursewares, social media platforms in advertising their programmes, drive for formal education and learning McNamara (2023).
- Gates (2023b) posits that AI-based personal assistants (Agents) will be the next software system platform like today's Windows, Linux, Android and iOS. The authors share in this opinion and believe that the potentials of having AI-based personal tutors are not far fetched. An AI-powered personal tutor that can tailor individual learning needs, provide curriculum, instruct and measure learning based on the knowledge of the user. A view also shared by (Javaid et al., 2023), and include the ability to create individual educational resources and contents in line with the student's interests, learning pace and goals. There is no doubt that this trends may change the traditional learning environment, but with appropriate laws and regulations, adequate measures will be put in place to mitigate risks that may accrue as a result of this disruption. The precedence to this exist in the way digital currency is being developed by different national banks in the light of the disruptive non-regulated cryptocurrencies.
- Emerging disruptive GenAI technologies will lead to the development of agents in the nearer future (Gates, 2023c). These agents will act as personal-digital-service providers and will in no doubt revolutionise learning. Take for instance, if someone could have AI-agent to write computer codes and deploy it, prepare presentations, write articles, help the individual pass examinations (Else, 2023), the quest for teacher-student traditional learning system may be affected. It is therefore necessary for educators and relevant stakeholders to start rethinking the concept of teaching and learning, the curriculum design and deployment in the context of these emerging realities.
- In the coming years, emerging skill gaps in AI industries will lead to the need for dynamic (yearly changing) curriculum in teaching and learning. Thus, making the concept of virtual University a needed alternative to provide the urgent training and skill demands and this will be driven by the big technology industries. The traditional HEIs will be made to adopt two main modes of learning environments - Virtual and Hybrid. While the virtual learning environment will be run on a dynamic curriculum, the hybrid will be an intermediary between dynamic and non-dynamically tailored curriculum in teaching and learning.

7. Summary and recommendations

This section provides what the authors can glean from the provisions of this paper alongside reasonable recommendations for all education stakeholder as derived from the relevant literature, recent developments, theoretical frameworks and opinions.

7.1. *Summary*

The transformative effects of GenAIs in education cannot be overemphasised and are here to stay. Therefore, acquiring the

necessary knowledge and upskilling in this domain has become a necessity for teachers and learners. Although there are some obvious challenges and concerns about GenAIs' adoption in education, but going by recent developments, better understanding, emerging AI policy frameworks, and expected regulations, the adoption in education will surge over the years. As adoption increases leading to mixed mode classroom administration, teachers, educators, and stakeholders would have to grapple with the issues of ethics, privacy, student assessments, academic integrity, and true measurement of learning. Although the use of research would lead to a reduction in some of these challenges and concerns, some emerging issues may require reasonable and thoughtful adaptations but not compromise. We can take a cue from the emergence of virtual Viva Voce after the COVID-19 pandemic as an alternative to face-to-face Viva Voce before COVID-19 as a result of social distancing and total lockdown of movements around the world.

7.2. Recommendations

The following are the authors' recommendations as derived from the contents of this manuscript.

- Educators are encouraged to review existing teaching and learning curricula in line with the contemporary issues posed by AI and its constituent technologies. Developing AI-infused programmes is a necessary step in curriculum development.
- There is an emerging need for AI technologies (e.g., ChatGPT) to be discussed in relation to learning and teaching activities. These discussions should focus on how it works, principles, ethics, capabilities, applications, and weaknesses. In doing so, we suggest that learning can be enhanced in the modern era, leading to the development of new skillsets by learners. Conversations on how AI technologies can be abused or reduced should also be discussed. Such conversations may facilitate the development of employability skills of learners (O'Connor, 2022).
- As some of the concerns of emerging educational AI systems are - what are the best ways of measuring learning as the current assessment systems have been found inadequate in the face of current realities and the risk that though the systems have shown to promote independent learning, but failed to improve student academic performance. Therefore, it is necessary to focus the emerging education curriculum on understanding how AI systems work, their developments, and their management in different HEI programmes. Adding to knowledge should therefore be seen as the ability to use the tools in creating novel or modifying existing knowledge.
- It is obvious that in the coming years, AI technologies will take up many available routine and lower level technical jobs. Doing this will redefine the expected learning outcomes, skillset demands in the labour market by employers. Therefore, knowing how to interpret AI results; deciphering AI bias from the outputs; understanding of AI hallucinations; defining manageable organisational risk appetite; de-risking AI agents and bots prior to deployment; AI risk level management in different workspaces will be required in many sector of human endeavours. So, we urge employers of labour in education to consider training and retraining of their employees in AI for efficient service deliveries.
- Critical thinking has always been a measure of students' progress and independence in learning. It is necessary as it equips students with the ability to manage their own learning by being able to independently analyse, synthesise, evaluate, and form logical conclusions from their vast array of available information. It also provides them with sense of creativity and curiosity, self-assertion and reflection, problem solving, innovation, and 'I can do spirit.' Thus, strengthening the prospects of their career. In the context of generative AI-Bots and Agents, teaching critical thinking using AI-Bots and Agents may be challenging, as abuse is seemingly inevitable. So serious tinkering, field experience, and experimentation using diverse methods and adaptive pedagogy may be needed.

8. Conclusion and future works

Humanity over the years has been fraught with dynamics leading to systemic changes in day-to-day life activities, including how businesses and education are conducted. In recent time, the COVID-19 pandemic is a perfect example of such systemic change. The pandemic threw the world into some level of chaos, but in a short period of time, the concept of remote work and virtual learning was introduced to adapt to the realities on the ground. The present post-COVID-19 era has seen the introduction of hybrid work pattern and blended learning, a combination of work from home, virtual learning, and traditional face-to-face learning environment. Since November 2022, the world has been witnessing another systemic change led by the emergence of GenAI tools, for instance, ChatGPT as introduced by OpenAI. There is no doubt that this is fast leading to an inevitable systemic change in all facets of human endeavours including education. As the focus of this paper is to take position on foreseeable impacts of these emerging disruptive technologies in relation to teaching and learning, this study has been able to x-ray deeply into the available literature, technical reports, authors' practice examples, expert opinions and guidelines in the use and utilisation of generative AI tools in education.

The material provided above includes information on the present level of applications of GenAI tools in education. Understanding how issues of systemic change affect teaching and learning has been handled in the past through pedagogical adaptation, giving credence that the emergent GenAIs will not be different. Furthermore, the knowledge on the existing shortcoming of GenAIs in education is a pointer that AIs will not completely replace humans in teaching and learning, as there will always be a place for human supervision of AI tools and the need for social interactions that deepen learning. In general, there is strong advocacy for the use of GenAIs in education by experts and stakeholders with thoughtful application, caution about adaptation, and implementations.

Despite this information, there is no doubt that quite a good number of educational institutions, especially HEIs, will remain very cautious, aloof, and hesitant about the use and integration of these tools in teaching and learning. Some of these instances may arise from the lack of policy directions, attendant costs, capacities, manpower, and technical know-how on how to integrate these tools and

still provide education that meets the expected learning outcomes as stipulated in existing programmes. However, with existing and compelling arguments on the integration of these tools in teaching and learning, there will be a balance, as these opinions are overwhelming.

Returning to the aim of the paper, the authors have attempted to provide valuable information on some practical uses of GenAIs in HE. To achieve this, we have provided case examples alongside theoretical frameworks for educational AI. In doing so, we note how contemporary pedagogical approaches can inform the use of educational AI, particularly leaning on how our understanding of teaching and learning has evolved over time (e.g., from behaviourist to more constructivist lenses).

This paper, to our knowledge, has provided the necessary information and opinions from experts and educators on GenAIs in education. It is our firm belief that the information and recommendations made herein will be useful to education stakeholders, administrators, and government agencies in making informed decisions, policies, and regulations on the way forward in the context of emerging disruptive artificial intelligence technologies in education.

8.1. Future works

In the near future, some of the authors aim to start incorporating GenAI tools on a large scale into their learning materials in line with Adaptive Learning Theory. This will be used in conducting internal action research with the informed consent of their students. The results will determine appropriate funding needed to take the research forward within the wider University community. The authors have become a team of researchers working on the use of generative AIs in education by starting with a survey on staff usage of the tools in teaching and learning, research, and development. This will be followed by that of the students. The authors understand that these ongoing efforts will help provide empirical evidence that will lead to responsible and safe use of GenAIs in education.

Authors and abbreviations

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CRediT authorship contribution statement

Elochukwu Ukwandu: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization. **Bola Omisade:** Writing – original draft, Formal analysis, Conceptualization. **Karl Jones:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Simon Thorne:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Formal analysis. **Mike Castle:** Writing – review & editing, Writing – original draft, Supervision, Investigation, Conceptualization.

Contributions

Conceptualisation and formal analysis: E.U.; investigation: E.U. and K.J.; methodology: E.U., and K.J.; validation, E.U., B.O., K.J., and S.T.; writing—original draft preparation, E.U., B.O., and S.T.; and writing—review and editing, E.U., K.J. and S.T. All authors have read and agreed to the published version of the manuscript.

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The authors have read and approved for this paper to be submitted for publication and hence declare that they have no competing interests.

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