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Reconceptualizing ChatGPT and generative AI as a student-driven innovation in higher education

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Abstract

Higher education is poised at the precipice of the changes and challenges brought about by ChatGPT. This paper addresses some of the most fundamental questions about the role, position, and implications of ChatGPT and generative artificial intelligence (AI) tools amidst the evolving landscape of higher education and modern society. By linking technological affordances with educational needs, we conceptualize ChatGPT as a student-driven innovation with rich potential to empower students and enhance their educational experiences and resources. However, this empowerment comes at a price. It requires collaborative efforts among the stakeholders to address the new and emerging challenges regarding student training, higher education curricula and assessment, and technology development and governance. It also implies new directions for educational research and theories.

Keywords: ChatGPT; generative AI; higher education; learning analytics; personalized learning; engineering education

1. Introduction

Since the launch of ChatGPT in December 2022, it has attracted wide attention and discussion in higher education. Conflicting voices about its impact and value have emerged from various perspectives. While some stakeholders emphasize the potential benefits of artificial intelligence (AI) tools for enhancing learning experiences, others raise concerns about their potential drawbacks and unintended consequences. Addressing these conflicting viewpoints requires a balanced understanding of technological affordances and educational needs. In this position paper, we adopt a bottom-up approach to conceptualize ChatGPT as a student-driven technology that could be leveraged as an enabler to support student learning and transform higher education. Considering ChatGPT's affordances, we further specify its impacts on and implications for student learning, higher education curricula and assessment, and technology development. We then conclude by discussing new directions for educational research and theory.

Nomenclature

AI	Artificial intelligence
GPT	Generative pre-trained transformer
LA	Learning analytics

2. ChatGPT as a student-driven education technology

Despite the wide discussion in higher education, ChatGPT is not an exclusive, domain-specific tool for education, but a general-purpose tool known as artificial general intelligence [1]. As a product, it is an AI chatbot that generates text-based responses to human inputs in natural language. ChatGPT has demonstrated significant progress over previous chatbots for its

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ability to engage in coherent, contextualized, and human-like conversations and to process various types of contents, such as essays and computer programs. At its core, it is a large language model built upon generative pre-trained transformer (GPT) models with a massive corpus of training data, intensive fine-tuning with human feedback, and powerful supercomputing infrastructures [2]. In the field of AI, ChatGPT represents a prime example of generative AI designed to generate new content rather than simply analyzing or manipulating existing data [3].

In comparison with existing learning technologies, ChatGPT has demonstrated unique features. Unlike many technologies, in which adoption has been largely driven by instructors (or developers and administrators), ChatGPT had a large and expanding user base before being adopted for educational uses. After its launch in December 2022, it gained 100 million users within the first two months, setting the record of the fastest-growing platform; now, it has 25 million daily visits [4]. The wide adoption of ChatGPT among higher education students has been widely reported in the news and referenced by educators and scholars [5]. Students' self-initiated adoption has made it almost impossible to ban or control it. Its rapid uptake rate among students has induced a student-driven education tool. The already massive user base has lowered the threshold of educational adoption while making the adoption self-sustained among students through peer networks. With this already familiar technology, students might feel more comfortable and confident.

The student-driven nature of ChatGPT is further reinforced by its user interface. As a chatbot, the interface of ChatGPT is a simple dialog format, with a text input area for users and a text output area from ChatGPT. The interface design ensures that the conversation is always initiated by users, and the direction of the conversation is primarily controlled by users. Students are then less likely to passively receive notifications or tasks pushed through predefined commands and are more likely to be empowered to decide the topic, path, and process of the conversation. However, such empowerment requires students to have a set of competencies to carry out and manage an inquiry because the quality of the ChatGPT output is largely influenced by students' inputs. This interface design centered around student inputs echoes the tenet of student-centered learning in higher education, in which students take a leading role in planning, organizing, and personalizing their learning process [6]. In this regard, ChatGPT has the potential to redefine the sources of power at play in educational processes, especially the roles and responsibilities of students.

Moreover, students are one of the most relevant stakeholders whose lives and futures will inevitably be shaped by ChatGPT and other technological advances. According to a BestCollege Survey, 61% of higher education students believed that ChatGPT and other AI tools would become the new norm in the long term [7]. As ChatGPT has been increasingly integrated into a wide range of fields and industries, the job market is constantly evolving, and many future careers will involve working with emerging AI tools [8]. As such, students should be equipped with the competencies needed to thrive in the workplace. Moreover, ensuring that all students have access to and can benefit from emerging technologies helps reduce inequalities in educational and professional opportunities while creating a more level playing field and promoting social equity.

In summary, ChatGPT can be seen as a student-driven technology with the potential for innovating teaching, learning, and assessment practices in higher education. Simply banning or controlling it would be counterproductive. Efforts should be focused on leveraging it for educational benefits and preparing students for coming changes and challenges.

3. ChatGPT as an enabler in higher education

Determining how the education potential of ChatGPT could be unleashed requires an understanding of its technological affordances and the needs, interests, and perspectives of key stakeholders in higher education. Overall, we believe that ChatGPT is a potent enabler for enhancing education quality and transforming higher education. Particularly, as shown in Figure 1, the technological architecture of ChatGPT and other GPT models can be leveraged to enhance learning analytic techniques, generate customized scaffoldings, facilitate idea formation, and eventually expand educational access and resources for social justice.

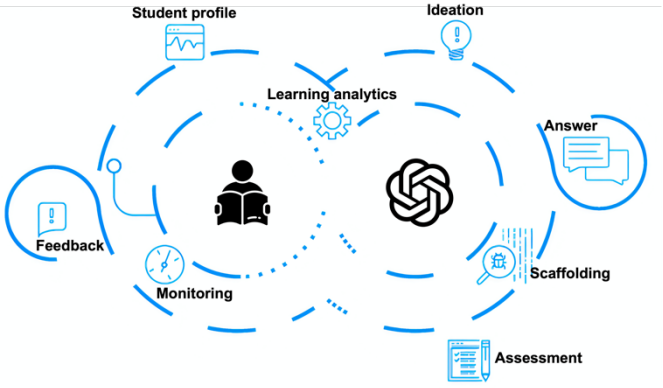

Fig. 1. ChatGPT as an enabler in higher education.

3.1. Learning analytics for personalized learning

At its most basic level, GPT is a natural language processing model that is good at analyzing and understanding natural language. Its strength in processing text-based data offers the potential to mine qualitative educational records and complement existing learning analytics (LA) techniques. Language, in oral and written forms, is widely seen as the primary medium for educational processes; students' language, as an externalization of their thoughts, constitutes a critical source of evidence for diagnosing, measuring, and assessing student learning [9]. However, qualitative records may not be well-utilized in LA systems due to technological limitations. These systems often rely on questionnaires, quizzes, and self-generated metrics, such as the number of page views or clicks and log history, to capture student learning data [10]. In this regard, GPT models can complement quantitative metrics in existing LA systems with qualitative, text-based analyses for greater analytical capability and a comprehensive understanding of student learning.

The enhanced LA technique thus supports better personalized learning. Specifically, the integration of GPT models can significantly enrich the source and variety of data for analyses, allowing for simultaneous and automated formative assessments to uncover students' thoughts and progress that are embedded in qualitative records. The analytical results can be used to develop more comprehensive profiles of students, including multifaceted metrics of students' preferences, engagement, and performance [11]. Based on these enriched student profiles, customized instructions, resources, and tasks can be tailored to support their self-paced and personalized learning. Moreover, enhanced LA techniques can also empower instructors to monitor the learning pace and progress of students and provide support and interventions in a timely manner.

3.2. Real-time assistance for customized scaffolding and feedback

Another affordance of ChatGPT is context awareness, as it can reference recent texts and contexts provided by users when generating responses. This capacity allows ChatGPT to gain a contextual understanding of student input and better identify individual learners' needs, goals, and areas of difficulty. Given this potential, ChatGPT may be leveraged as real-time assistance that provides personalized support to students in a more coherent and sensitive way. This real-time assistance can not only generate targeted explanations but also provide customized scaffolding to address the learning difficulties and struggles of individual learners. ChatGPT's capacity to process texts in various styles and genres enables it to tailor the language, examples, and explanation strategies to meet the needs of individual learners.

Instant feedback is another potential benefit of ChatGPT as a learning aid. By processing students' inputs, it can provide immediate responses to and guidance on their inquiries. Instant feedback enables students to learn and make progress at their own pace and on their own schedules rather than waiting for an instructor's availability. This is particularly supportive for students in large classes. With this immediate feedback, students can clarify their confusion and resolve misconceptions in real time as well as apply new understandings to subsequent tasks. Therefore, the immediate feedback of ChatGPT is likely to enhance student learning engagement and increase the efficiency of education.

3.3. Ideation facilitator

As a large language model, ChatGPT is trained on massive data from various sources, such as scientific journals, news articles, and books, on which it synthesizes and learns a wealth of knowledge. Considering its massive training data and knowledge base, ChatGPT may be adopted as an ideation facilitator to generate ideas, provide suggestions, and aid in brainstorming on given topics or prompts. With this affordance, students can explore different perspectives, identify potential solutions, and think about various possibilities. In addition to direct facilitation, ChatGPT can retrieve and generate a wide range of stories, cases, and examples from its database, which may inspire new ideas or spark creative thinking among students.

As an ideation facilitator, ChatGPT can support students' divergent thinking by generating multiple ideas or solution paths rather than converging on a single answer. Its extensive database enables it to offer diverse viewpoints and insights, allowing students to expand their range of perspectives and think outside the box. The unexpected or unconventional perspectives offered by ChatGPT may stimulate students' curiosity and creativity, encourage them to question their assumptions and biases, and help them forge more creative and novel approaches to problem solving. However, rather than a think tank of novel and original ideas itself, ChatGPT is more like a suggestion box, with ideas and opinions collected from various sources. That being said, the quality of ChatGPT's output is constrained by the data it has been trained on, and ChatGPT lacks originality, human intuition, and critical thinking when generating ideas. Under these circumstances, ChatGPT outputs can serve as a vehicle to aid and inspire idea formation, but students will need to deploy their own expertise and judgment to evaluate the outputs and construct novel and original ideas.

3.4. Enhancing educational access for social justice

Given the above affordances and benefits, ChatGPT can potentially enhance educational access and resources and contribute to social justice in general. Within higher education institutions, ChatGPT can support instructors and complement teacher–student interactions, especially for large classes in which it is challenging for instructors to provide individualized attention and support to students. It can serve as a supplementary resource to answer students' questions, provide explanations, and offer additional learning opportunities tailored to students' needs. In a more general sense, AI tools can help reduce the cost of education by automating certain tasks and offering more efficient learning experiences. Lower costs can make higher education more affordable for students from low-income backgrounds or those who struggle to meet the financial demands of traditional programs. As such, ChatGPT has the potential to make educational opportunities accessible to a diverse range of learners, including those who may face barriers due to geographical location, socioeconomic status, disability, or other factors.

4. Learning to learn with AI

Although ChatGPT has rich potential, this potential will not be actualized naturally or automatically. Higher education stakeholders need to be prepared for informed and responsible adaptation of ChatGPT. We argue that this preparation can start by shifting our perspective on and approach to AI. This shift in perspective is rooted in the interactive and adaptive relationship between humans and AI; that is, AI is no longer a passive, static tool that is simply manipulated by students but an active participant that significantly shapes students' learning experience. The changing role and position of AI implies new directions for research and theories.

4.1. Shifting from learning via AI to learning with AI

Human adoption of and adaptation to ChatGPT indicates a shift in conceptualizing the human–technology relationship when researching education technology. During its initial stage, research on education technology focused on observing changes in teaching and learning by comparing face-to-face and online or hybrid settings [12]. As technology became more interactive and powerful, however, the focus shifted toward understanding the role and affordances of technology in promoting meaningful learning as well as studying our interactions with the technologies themselves. More recently, due to the advent of AI and personized algorithms, an emerging theme is overcoming the traditional one-size-fits-all approach and adapting to the needs of individual learners [13]. This theme is also reinforced by mobile and social media, as teenagers and young adults have changed their behaviors, habits, and practices to accommodate and take advantage of technology [14]. Empirical evidence shows a tendency to treat AI as if it is an autonomous social actor [15].

This evolving research agenda implies a transition from technology-based learning to learning with technology. As for ChatGPT, learning with AI has become more salient than ever, especially considering the significant role of prompts in eliciting quality outputs from ChatGPT. Prompts refer to the input text or message provided by the user in ChatGPT, and they act as a cue or instructions to guide the model to generate responses. That is, the quality of ChatGPT's output is largely influenced by the quality of students' prompts. As such, to unleash the full capability of ChatGPT, students need to understand how to write effective prompts and adapt their prompting practices in alignment with the working mechanisms of GPT models. In this process, human–AI interactions are no longer one-way interactions from questions to answers but a negotiation process in which both parties (humans and AI) constantly observe each other's output and adjust their input accordingly. In this regard, ChatGPT and AI-driven tools have transcended their traditional role as mere instruments and evolved into active participants that co-shape educational experiences with students.

4.2. Learning to learn with AI

For students, learning with AI is a learning task in itself. Students often experience a learning curve as they gain more proficiency and efficiency with technological tools over time [16]. From our preliminary observations, students' learning curve with ChatGPT can be represented in two interdependent dimensions, as shown in Figure 2. Learning to use ChatGPT, as represented by the red line, refers to general methods for operating the tool. As the user interface is straightforward and intuitive, it is generally not difficult for most students. However, learning to learn with ChatGPT implies more effort beyond operations, as it requires students to frame appropriate prompts and questioning strategies and to understand the capacity and limitations of this AI tool. Most likely, this is not a linear process but an iterative and recursive one in which students explore, experiment with, and identity effective (or not) strategies that can elicit desired outputs and fulfill their personal goals. This process might not be smooth but full of setbacks and stagnation, as students need to test worst or best practices for interacting with GPT models, adjust their expectations of the level of assistance from ChatGPT, and improve their own capacity as self-regulated and self-motivated learners.

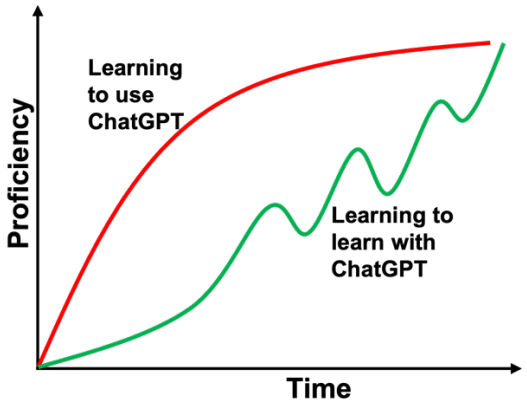

Fig. 2. Students' learning curve with ChatGPT.

The mutually adaptive relationship between humans and AI implies that more research is needed to investigate the processes and patterns of student–AI interactions. As AI tools are increasingly integrated into students' everyday lives, it is especially crucial to gain more insight into how students interact with AI and their interactional styles, patterns, and preferences. This research can provide valuable insight into students' behaviors, cognitive processes, and emotions when interacting with AI, greatly enhancing the knowledge and theory of learning sciences and technology. Moreover, interdisciplinary research collaboration between learning scientists, computer scientists, psychologists, and other experts is needed. Such interdisciplinary research can further advance the theoretical knowledge and empirical foundations in this field and inform the design and development of AI-driven educational systems.

5. Changing expectations of students' skillsets and competencies

Against the multifaceted and cumulative impacts of ChatGPT, students are positioned at the frontier of coping with changes and challenges. On the one hand, the student-driven nature of ChatGPT expects students to take a leading, autonomous role in actively managing their learning and inquiries with AI. On the other hand, students who lack the relevant competencies to manage their learning with AI are likely to be disempowered by the technology's adoption. The double-edged effect of ChatGPT has led to the proposal of new expectations and requirements for students' competencies to survive and thrive in this rapidly evolving educational and social landscape.

5.1. AI literacy

To prepare themselves for ChatGPT and other AI tools, students, even those not majoring in computer sciences or AI,

need certain competencies with AI. AI literacy is not merely about how to compose effective prompts; it encompasses the knowledge and skills needed to effectively engage with AI systems; critically evaluate their outputs; and navigate the ethical, social, and practical implications of their use [17]. Familiarity with the fundamental concepts and mechanisms of AI, such as how AI models like ChatGPT are trained, will enable students to better interpret the outputs from generative AI tools and engage with the tools in an informed and productive way. Students also need technical and problem-solving skills to effectively interact with AI and develop AI systems for real-world problems. In particular, students need to develop an ethical awareness of issues related to data privacy, algorithm fairness, transparency, and accountability. They should learn to use AI responsibly by considering the ethical implications of their actions when interacting with AI. With such preparation, students will be more likely to make informed and responsible decisions when using and developing AI systems in their studies, workplaces, and everyday lives.

5.2. Learning how to learn

The personalized learning experiences enabled by ChatGPT highlight the significance of learning how to learn, as AI tools are meant to facilitate student learning, not replace human efforts. Learning how to learn is concerned with students' development as effective and efficient learners who can take charge of their own learning and maximize the educational benefits of ChatGPT. It involves self-understanding about one's own learning preferences and habits as well as metacognitive and self-regulation skills to manage one's learning process [18]. By self-regulating the learning process, students can avoid over-reliance on AI-generated answers and maintain a balance between independent problem solving and seeking AI assistance. Self-assessment skills are simultaneously important, as students need to regularly evaluate their progress, reflect on their interactions with ChatGPT, and identify any gaps in their knowledge. By learning how to learn, students can grow into more self-directed and resilient learners who are capable of harnessing the potential of AI technologies while maintaining their autonomy and critical thinking.

5.3. Critical thinking and epistemic agency

The most critical pitfall of ChatGPT is that it sometimes produces confident but irrelevant or inaccurate responses—a phenomenon known as AI hallucination. Students need to critically assess ChatGPT outputs using their knowledge, expertise, judgement, and creativity. Critical thinking helps students question and evaluate the validity of AI-generated content, ensuring the accuracy of information for decision making [19]. Moreover, due to the data training mechanism, GPT models can inadvertently reproduce or perpetuate biases embedded in historical training data. With a critical and discerning mindset, students can recognize potential biases in AI-generated content and avoid incorporating biased information into their work or decision-making processes.

Beyond critical thinking, ChatGPT pushes the expectations of student development to the level of epistemic agency. Epistemic agency refers to an individual's ability to actively and purposefully engage in the processes of knowledge construction, inquiry, and learning [20]. When using ChatGPT to search for information and generate ideas, students should be encouraged to autonomously question, analyze, and critique AI-generated content rather than consuming information passively. In this regard, epistemic agency can help students become more autonomous and responsible learners. In a world where information is readily available, students need to develop the ability to navigate vast amounts of data; discern the accuracy and relevance of generated contents; and, most importantly, develop their own criteria for information verification. By exercising their epistemic agency, students can effectively filter and synthesize information from ChatGPT and generative AI tools while recognizing its limitations and potential biases.

5.4. Adaptability and continuous learning

Adaptability and continuous learning are crucial skills for this generation of students, as the AI landscape is rapidly evolving and advancing. By staying flexible and committed to continuous learning, students can keep up with the latest developments and maximize the benefits of AI technologies in their studies and future careers. The job market especially is being increasingly influenced by AI and automation, and the ability to adapt and learn new skills will be essential for students' future success and employability. As such, it is important to instill a growth mindset in students so that they view learning as a lifelong process, embrace challenges and uncertainties, and take actions for continuous learning and growth. Meanwhile, ChatGPT and other AI tools can be harnessed to bolster individuals' life-long learning and perpetual development upon their graduation from higher education institutions. By cultivating adaptability and a proclivity for continuous learning, students can seamlessly transition into an ever-evolving professional landscape in which AI-driven technologies play an increasingly integral role across diverse industries and sectors.

6. Addressing challenges through collaborative endeavors

As the nexus between AI and education continues to expand, it is incumbent upon academic institutions, educators, and policymakers to foster collaboration, devise comprehensive efforts, and address potential risks and unintended consequences. As the ethical concerns of ChatGPT have continued to grow, higher education institutions have a responsibility to ensure accountability, transparency, and supervision in the development and deployment of AI systems.

6.1. Plagiarism detection and new protocols for AI usage

The advent of ChatGPT and generative AI tools has significant implications for academic integrity in HE [21]. AI tools like ChatGPT can generate high-quality content quickly, which may tempt students to plagiarize or cheat on

assignments, papers, and exams. Such practices undermine the learning process and erode academic integrity, potentially leading to a decline in academic standards. Plagiarism detection software must advance to effectively identify instances of plagiarism, academic dishonesty, or unauthorized use of intellectual property in written work. However, plagiarism detection tools alone cannot solve the issue of academic dishonesty. Educators, institutions, and students must work together to foster a culture of integrity and ethical responsibility that discourages plagiarism and promotes genuine learning.

Additionally, over-reliance on AI in ideation and writing can hinder students from engaging deeply with the subject matter and exercising their own thinking and problem-solving abilities. Students may become accustomed to seeking quick answers from AI systems instead of working through challenges independently or collaboratively, which will eventually lead to the erosion of creativity and originality. To mitigate these potential risks, clear policies and guidance should be developed to guide the adoption of ChatGPT and generative AI tools in courses and programs. These policies should provide a framework specifying the acceptable and unacceptable uses of AI tools as well as the protocols for reporting AI usage in a transparent and accountable manner.

6.2. Promoting assessment literacy among instructors

To maintain academic integrity, teachers will need to adapt their assessment methods and design appropriate assessment tasks accordingly. This requirement for teachers highlights the necessity of continuous professional development to improve their assessment literacy. Assessment literacy refers to the knowledge and skills teachers possess regarding the design, implementation, interpretation, and use of assessments to evaluate student learning [22]. With the emergence of AI tools, teachers must adapt their assessment designs to focus on critical thinking, problem solving, and creativity rather than simply memorizing, recalling, and applying content knowledge. This requires an understanding of how to create valid, reliable, and relevant assessment tasks that provide explicit evidence about student development and performance while minimizing the chances of using AI-generated content dishonestly. Another aspect of assessment literacy is teaching students about the importance of academic integrity and ethical behavior in terms of ChatGPT and generative AI tools. To effectively communicate the consequences of academic dishonesty to students, teachers must first be equipped with the knowledge and skills to do so.

6.3. Fine-tuning ChatGPT for domain-specific AI tools

So far, GPT models have been developed for general purposes with training data from diverse sources, and their performance may vary depending on the specific domain or topic. Their accuracy and depth of knowledge are subject to the quality and breadth of the training data they have been exposed to. As such, they may not always be as proficient or accurate in highly specialized or niche domains compared to a dedicated domain-specific AI tool. To address this issue, extensive efforts are needed to fine-tune GPT models for domain-specific use in educational contexts. Fine-tuning involves training the pre-trained model on a smaller dataset that is specific to an educational field or subject matter. This process helps the language model become more proficient, knowledgeable, and sensitive in a specific domain while improving its performance and relevance for the target subjects, students, and learning environments.

As for ChatGPT, the conversation style and strategies should also be redesigned in alignment with educational values and purposes. The current communication between ChatGPT and users is primarily represented in an ask-and-answer flow in which ChatGPT directly delivers answers in a way that satisfies users. This communicative style may be problematic for education, as learning is mostly an iterative and recursive process of sense making and meaning making by students. This process can be full of exploration, confusion, and frustration, in which students make mistakes and then learn from those mistakes. Such exploratory processes are necessary for students to foster authentic, in-depth engagement with the subject matter and to construct their understanding of the intended knowledge. Therefore, a specifically tailored communicative style is needed to align ChatGPT with educational values and purposes. The communicative style can reference teachers' effective discursive strategies, such as modelling, scaffolding, and encouragement [23], to create a supportive and non-judgmental learning environment for student exploration and meaning making.

6.4. Shifting the educational focus from the known to the unknown

Existing education practices often focus on equipping students with established knowledge and skills while leaving them less prepared to deal with unknowns and uncertainties in the real world. This educational model is greatly challenged by ChatGPT and large language models that can easily retrieve information and cope with standardized assessments from massive training data. As such, more emphasis should be placed on students' competencies and preparation for the complexity and ambiguity of the real world. This requires comprehensive curricula and pedagogical changes that not only impart subject-specific expertise but also cultivate whole-person development. The cultivation of certain personality traits, such as grit, perseverance, and resistance, should be especially prioritized. These attributes serve as indispensable components of a well-rounded person, fostering students' capacity to adapt and persist in the face of unforeseen challenges.

To this end, comprehensive curricula and pedagogical changes are needed to equip students with the aforementioned competencies. Specifically, authentic, interdisciplinary approaches to education should be championed to help students synthesize training across diverse domains. Experiential and project-based learning opportunities can be integrated into the educational framework to contextualize student development in real-world contexts. Moreover, joint efforts between academic institutions and external organizations, such as businesses, non-profit organizations, and governmental

agencies, can provide students with opportunities for internships, externships, or service-learning projects. External organizations can also offer mentorship programs or workshops, connecting students with professionals who can act as role models. These experiences can expose students to diverse perspectives and cultivate their personal and professional competencies, thus preparing students for an increasingly complex and uncertain world.

7. A closing and an opening

It is arguable that we are at the dawn of greater changes. As ChatGPT and generative AI tools have continued to advance and diffuse, the impact of these technologies is multifaceted and far reaching, with implications yet to be fully understood. It is hoped that this article will spark further conversation and exchange on the topics discussed. As we continue to grapple with the rapid development of these technologies, it is critical that we remain open and adaptive to new ideas and perspectives as well as steadfast in our commitment to creating a better future for all.

References

[1] Bubeck S, Chandrasekaran V, Eldan R, Gehrke J, Horvitz E, Kamar E, Lee P, Lee YT, Li Y, Lundberg S. Sparks of artificial general intelligence: Early experiments with GPT-4. arXiv preprint arXiv:2303.12712. 2023.

[2] Floridi L, Chiriatti M., 2020. GPT-3: Its nature, scope, limits, and consequences. Minds and Machines 30(4):681-94.

[3] van Dis, Eva AM, et al. "ChatGPT: five priorities for research." Nature 614.7947 (2023): 224-226.

[4] Similarweb. ChatGPT topped 1 billion visits in February. 2023. Retrieved March 1 from https://www.similarweb.com/blog/insights/ai-news/chatgpt-1-billion/

[5] Huang K. Alarmed by AI chatbots, universities start revamping how they teach. New York Times. 2023. Retrived March 1 from https://www.nytimes.com/2023/01/16/technology/chatgpt-artificial-intelligence-universities.html.

[6] Lee, Eunbae, and Michael J. Hannafin. "A design framework for enhancing engagement in student-centered learning: Own it, learn it, and share it." Educational technology research and development 64 (2016): 707-734.

[7] Welding L. Half of college students say using AI on schoolwork is cheating or plagiarism. 2023. Retrieved March 25 from https://www.bestcolleges.com/research/college-students-ai-tools-survey/

[8] Eloundou, Tyna, et al. "Gpts are gpts: An early look at the labor market impact potential of large language models." arXiv preprint arXiv:2303.10130 (2023).

[9] Vygotsky, Lev Semenovich, and Michael Cole. Mind in society: Development of higher psychological processes. Harvard university press, 1978.

[10] Viberg, Olga, et al. "The current landscape of learning analytics in higher education." Computers in human behavior 89 (2018): 98-110.

[11] Fong, Ricci Wai-tsz, et al. "Digital teaching portfolio in higher education: Examining colleagues' perceptions to inform implementation strategies." The Internet and Higher Education 20 (2014): 60-68.

[12] Paechter, Manuela, and Brigitte Maier. "Online or face-to-face? Students' experiences and preferences in e-learning." The internet and higher education 13.4 (2010): 292-297.

[13] Bulger, Monica. "Personalized learning: The conversations we're not having." Data and Society 22.1 (2016): 1-29.

[14] Madden, Mary, et al. "Teens, social media, and privacy." Pew Research Center 21.1055 (2013): 2-86.

[15] Sundar, S. Shyam. "Rise of machine agency: A framework for studying the psychology of human–AI interaction (HAII)." Journal of Computer-Mediated Communication 25.1 (2020): 74-88.

[16] Dai, Yun, Stephen Lu, and Ang Liu. "Student pathways to understanding the global virtual teams: an ethnographic study." Interactive Learning Environments 27.1 (2019): 3-14.

[17] Long D, Magerko B. "What is AI literacy? Competencies and design considerations." Conference on human factors in computing systems (CHI) (2020), Honolulu, HI, USA

[18] Wang, Chih-Hsuan, David M. Shannon, and Margaret E. Ross. "Students' characteristics, self-regulated learning, technology self-efficacy, and course outcomes in online learning." Distance Education 34.3 (2013): 302-323.

[19] Spector, Jonathan Michael, and Shanshan Ma. "Inquiry and critical thinking skills for the next generation: from artificial intelligence back to human intelligence." Smart Learning Environments 6.1 (2019): 1-11.

[20] Elgin, Catherine Z. "Epistemic agency." Theory and research in education 11.2 (2013): 135-152.

[21] Rudolph, Jürgen, Samson Tan, and Shannon Tan. "ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?." Journal of Applied Learning and Teaching 6.1 (2023).

[22] Chan, Cecilia KY, and Lillian YY Luk. "A four-dimensional framework for teacher assessment literacy in holistic competencies." Assessment & Evaluation in Higher Education 47.5 (2022): 755-769.

[23] Green, Judith L. "Exploring classroom discourse: Linguistic perspectives on teaching - learning processes." Educational Psychologist 18.3 (1983): 180-199.