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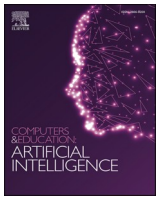

Future research recommendations for transforming higher education with generative AI

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A R T I C L E I N F O

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A B S T R A C T

Higher education is crucial for producing ethical citizens and professionals globally. The introduction of generative AI (GenAI), such as ChatGPT, has posed opportunities and challenges to the traditional model of education. However, the current conversations primarily focus on policy development and assessment, with limited research on the future of higher education. GenAI's impact on learning outcomes, pedagogy, and assessment is crucial for reforming and advancing the workforce. This qualitative study aims to investigate student perspectives on GenAI's impact on higher education. The study uses an initial conceptual framework driven by a systematic literature review to investigate the opportunities and challenges of AI in education. This framework serves as an initial data collection and analysis framework. A sample of 51 students from three research-intensive universities was selected for this study. Thematic analysis identified three themes and 10 subthemes. The findings suggest that future higher education should be transformed to train students to be future-ready for employment in a society powered by GenAI. They suggest new learning outcomes—skills in learning and teaching with GenAI, AI literacy—and emphasize the significance of interdisciplinarity and maker learning, with assessment focusing on in-class and hands-on activities. They recommend six future research directions – competence for future workforce and its self-assessment measures, AI literacy or competency measures, new literacies and their relationships, interdisciplinary teaching, Innovative pedagogies and their evaluation, new assessment and its acceptance.

1. Introduction

Generative AI (GenAI) is a type of artificial intelligence (AI) technology that can generate new and unique outputs (Peres et al., 2023). Some examples of these outputs include images, text, audios, videos, and 3D models. Because it is able to produce sophisticated and realistic content that resembles human ingenuity, GenAI is a useful tool for a wide range of industries, including education, entertainment, and product design (Castelli & Manzoni, 2022). Specifically, these industries can benefit from its use. Recent advancements in technology, such as Generative Pre-trained Transformer (GPT), have resulted in significant enhancements to these capabilities. These new developments have opened up new doors for the use of GenAI applications in higher education. Some examples of these applications include ChatGPT, Midjournery, and GitHub Copilot. These applications can be used to produce personalized learning, create or revise teaching materials, develop coding for research, and draft an email for responding to student inquiries (Chiu et al., 2023). As a result, GenAI has many potential applications across the board in the field of higher education. How will GenAI impact universities in the future? The fact that university educators have provided such a large number of immediate responses (such as discussions, seminars, and newspaper articles) to this question is evidence of the question's significance. The majority of the initial responses are connected to the worries that teachers have regarding the evaluation of their pupils; consequently, a great number of educational institutions have published their policies regarding the implementation of ChatGPT in the classroom setting. Educators who support the use of GenAI in the classroom have continued their conversation about the advantages and disadvantages that GenAI presents for use in higher education. However, neither the voices nor the perspectives of the students are included in most of these responses, e.g., Cooper (2023) and Peres et al. (2023). Students are the most important stakeholders in higher education; as a result, it is essential to involve students in research projects that seek to comprehend how GenAI will alter higher education.

Research into GenAI applications in higher education is ongoing.

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Many educators and policymakers are curious about what GenAI can and cannot do (Rahman & Watanobe, 2023). This paper used an initial conceptual framework consisting three domains for gathering and analyzing qualitative data in order to better understand how GenAI will transform universities in the future. The preliminary framework is based on a systematic literature review on AI in education conducted by Chiu et al. (2023) prior to the ChatGPT hot discussions. The review study provides an overview of AI-based tools such as adaptive learning systems, automated marking systems, and chatbots. For the purpose of determining how future universities in a society dominated by GenAI should be organized, there is a pressing need for additional empirical research involving student participation. Thus, this qualitative study examines GenAI's impact on higher education from student perspectives.

2. Conceptual framework

This study is to suggest how GenAI transform higher education. it should consider the four major educational domains – learning, teaching, assessment and administration. Therefore, the conceptual framework for this study was taken from an earlier systematics literature review on the opportunities and challenges bring to the four domains (Chiu, et al., 2023). The review study selected the 92 articles from 1418 articles in the four academic databases - ERIC, ProQuest, Web of Science, and SCOPUS. These articles were all published in the last decade (2012–2021). Matrix coding and content analysis were utilized in order

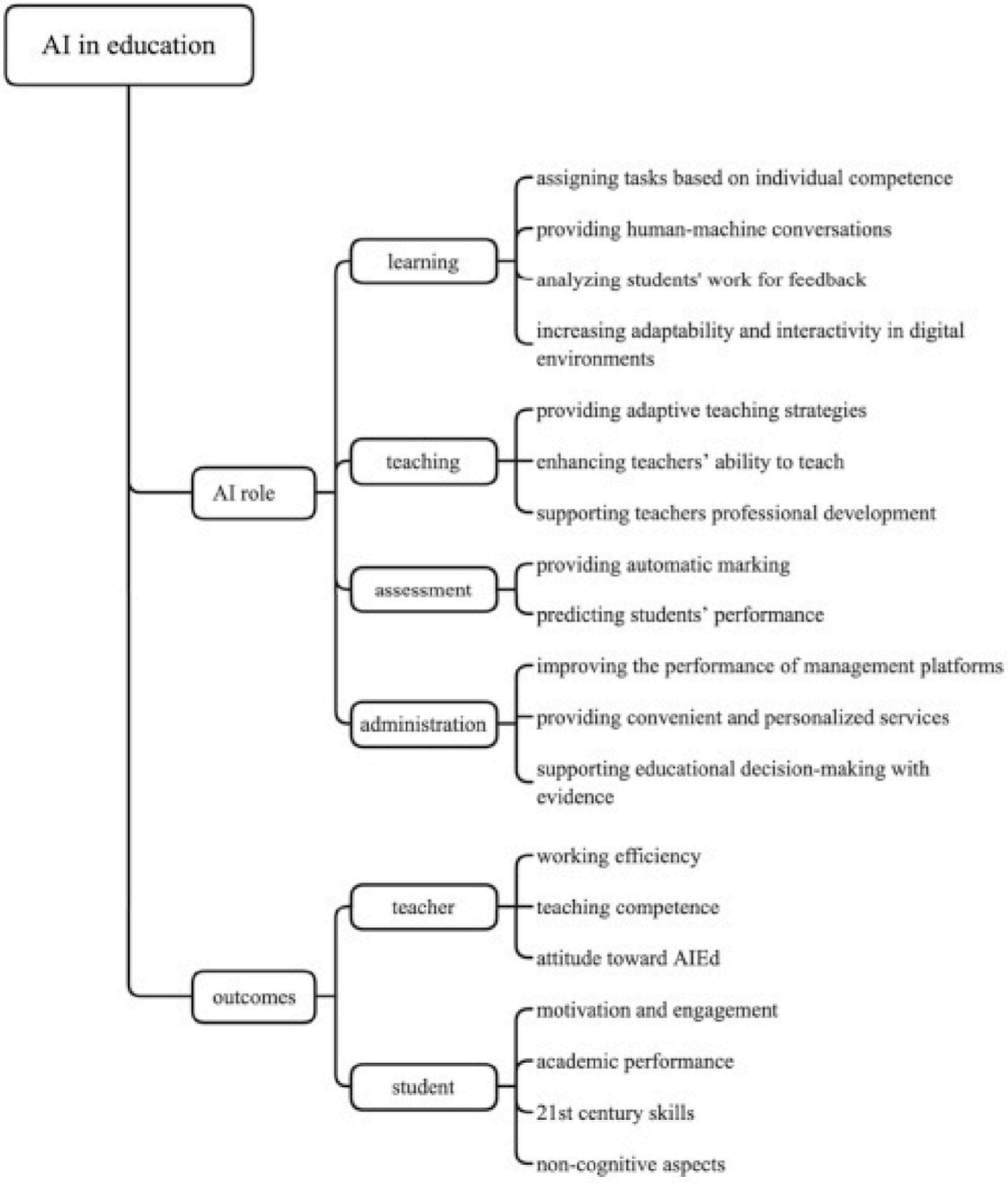

Fig. 1. The initial conceptual framework - The roles and outcomes of AI applications in education (Adapted from Chiu et al., 2023).

to investigate both the opportunities and challenges presented by AI in the educational setting. The review study identified thirteen roles for AI in education across four key educational domains: learning, teaching, assessment, and administration, see Fig. 1. Additionally, it identified seven major student and teacher learning outcomes, see Fig. 1. The purpose of this framework is to provide an initial framework for data collection and analysis.

This framework was created based on studies that used research designs such as system development and experiments. The advancement of GenAI, such as ChatGPT (a large language model) and Midjournery (a machine learning algorithm trained on a large amount of image data), is more likely to change the roles of AI in education, add new ones, and introduce new learning outcomes. The sections that follow describe the framework and speculate on the impact of GenAI on roles and learning outcomes.

2.1. Four key educational domains

The first domain is AI in learning, and its four roles were identified. (1) Assigning tasks based on individual competence: AI-based learning systems, such as intelligent laboratories and intelligent tutors, personalize student learning tasks by competence (Hirankerd & Kittisunthonphisarn, 2020; Munawar et al., 2018). Lack of learning resources is the biggest obstacle. The student's learning is passive and depends on the efficiency of systems. (2) Human-machine conversations: AI chatbots and interactive books that allow students to talk to machines about learning and help learners improve their communication skills through ongoing dialogue (Chew & Chua, 2020; Kim et al., 2021; Palasundram et al., 2019; Vazquez-Cano et al., 2021). These articles suggested that the way AI machines interact with students is limited. (3) Providing human-machine conversation: AI analyzes student work and learning processes to provide timely feedback (Fu et al., 2020; Porter & Grippa, 2020). For example, an AI notebook app provided writing feedback by recognizing and analyzing kindergarten students' handwriting (i.e., the shape, order, and direction of the segments) (Bonneton-Botte et al., 2020). (4) Increasing adaptability and interactivity in digital environments: AI technologies capture student learning data and enable interactions for more adaptive digital environments (Samarakou et al., 2015; Westera et al., 2020). They also revealed that the biggest challenge is finding a suitable evaluation method (Expectation 1). Moreover, the advancement in GenAI could possibly change or advance the roles and solve the challenges discussed in the reviewed articles. For example, GenAI can generate new content for student learning, make better conversations with students, and give students the answers to their questions or problems (feedback). However, new skills students need for using GenAI in their learning have been added, such as prompt skills, digital or AI literacy, and ethical knowledge (Expectation 2).

The second domain of AI in education has three roles. (1) Providing adaptive teaching strategies: AI systems using multimodal sensor data to determine the affective states of students and assist teachers in selecting the subject matter, instructional strategies, and communication techniques (Lampos et al., 2021; Luo, 2018). The research uncovered significant difficulties, such as inadequate evaluation techniques and efficient algorithms. (2) enhancing teachers' ability to teach: AI technology can quickly upload, assign, and distribute learning materials and tasks, as well as read aloud text-based problems in classes. They greatly simplify classroom administration for teachers (Jarke & Macgilchrist, 2021). Teachers might not, however, have complete faith in AI technology. (3) Supporting teacher professional development: Real-time classroom data can be analyzed by AI technologies to provide teachers with feedback or remarks. They can assess a teacher's behaviour, discourse, and questioning skills (Hu, 2021; Li & Su, 2020). The neutrality of AI evaluators lessens instructor resentment and promotes contemplation. The fact that so few studies have been done in this area suggests that the applications are still in their infancy (Expectation 3). As a result, the GenAI may persuade teachers to switch from adaptive teaching to learning approaches, but it has little effect on the final two roles.

Third, two roles for AI in assessment were suggested. (1) providing automatic marking: Using AI grading systems was faster, more accurate, and more secure than teachers for both formative and summative feedback (Kumar & Boulanger, 2020). However, most of the automatic grading and marking was homogenous and applied to a few disciplines and domains, such as language learning, indicating that this AI application is still in development. It would be difficult to implement technology in real classrooms (Sun, 2021). (2) Predicting student performance: In online education, AI technologies appear to have helped predict student achievement and performance by analyzing students' participation in learning activities like discussion boards (Costa-Mendes et al., 2021; Yu, 2021). They may also predict online course performance. However, selecting data for student performance AI predictive models are difficult since the data are different from those utilized in traditional educational research (Costa-Mendes et al., 2021). Consequently, GenAI may add assessment roles without directly affecting these two roles. It can assist students in completing their work by drafting and outlining essays, retrieving content, getting new ideas, brainstorming, and confirming their solutions. Teachers are encouraged to alter the manner in which they assess student learning (Expectation 4).

The last domain is administration. Its three roles are (1) improving the performance of management platforms: these platforms were made more secure by incorporating facial authentication for examinations and portal management (Liu & Wu, 2019) and more efficient for administrators by assigning AI-enabled routines to tasks such as course scheduling and personnel data management (Li & Su, 2020). (2) providing convenient and personalized services: AI, such as activity recommendation systems, can make academic and non-academic recommendations, improving staff efficiency and quality (Crowe et al., 2017). (3) supporting educational decision-making with evidence: educational leaders have evidence from AI. Big data can help AI predict student dropouts, academic performance factors, and course selection (Cukurova et al., 2019). AI informs administrative and academic decisions. like other AI roles. But each of the three roles faces the same difficulties due to underdevelopment and understudying. Therefore, students in this study may be able to contribute to this role. This domain is not included in the conceptual framework.

2.2. Student learning outcomes

Four major learning outcomes were identified in the review literature. They are (1) motivation and engagement. Most of the studies used AI robots to motivate student engagement in various disciplines (Xia et al., 2022). Human-robot interactions made low-achieving pupils feel more secure and valuable, as well as less ashamed. (2) Academic performance: The majority of studies show significant increases in academic performance with the support of AI technologies (e.g., Khan et al., 2021). The research discovered that AI not only improved mainstream student performance but also that of students with special needs (Garg & Sharma, 2020). However, other studies imply that not all kids gain from AI technologies, with motivated and/or high-achieving students being the primary or sole beneficiaries (Bonneton-Botte et al., 2020). (3) 21st century skills: Real-time feedback platforms supported by AI have been demonstrated to produce sustainable growth in collaborative, communication, problem solving, creativity, and self-regulated learning skills (Porter & Grippa, 2020). These tools help students self-reflect and learn from their logical mistakes for self-regulated learning. They give students direct feedback and challenging problems to think more deeply. (4) non-cognitive aspects: the review has shown that AI not only boosts students' confidence in their ability to learn, but also reduces their anxiety about doing so (Kim et al., 2021). While some students benefited greatly from these learning tools, others experienced increased AI anxiety as a result of the technology's widespread use (Wood et al., 2021).

They were particularly concerned about their employment in the future. Therefore, GenAI is more effective than teachers at imparting knowledge to students. It will reorder the importance of learning outcomes, i.e., questioning or promoting skills become more important, and introduce new learning outcomes necessary for higher education, such as AI literacy (Expectation 5). Finally, the review study should pinpoint three outcomes of AI-related research on teacher education. Since this paper focused on students' voice, the framework did not address teachers' learning outcomes.

3. The present study and method

3.1. Research gap and goal

University leaders and educators have not previously been exposed to GenAI. The majority of the conversations taking place right now are driven by the opinions of experts and the experiences of educators, and they center on the process of policy development and assessment. There is a severe lack of research that is pertinent to the question of what the future of higher education should be like. Developing GenAI is emerging, interfering, and disruptive; as a result, opportunities to reform and advance our future higher education for the future workforce and learning are presented. The viewpoints of students are essential for making sense of the impact that GenAI will have on universities in the future with regard to learning, teaching, assessment, and administration. As a consequence of this, the purpose of this qualitative study is to investigate, from the point of view of students, how GenAI impacts our higher education. In light of this, the question is.

From the perspective of students, how do GenAI transform learning outcomes, pedagogies and assessment in higher education?

In order to extract concepts from the data, this study makes use of a hybrid deductive and inductive thematic analysis. This analysis summarizes key features across datasets by highlighting differences and similarities between them. By identifying themes that are associated with the conceptual framework, it provides assistance to researchers in the development of new themes. Researchers are able to produce well-organized and understandable findings using this method of analysis (Braun & Clarke, 2006), which is helpful for informing policies and pedagogies while working within the paradigm of participatory research (Chew & Chua, 2020).

3.2. Participants

The participants were undergraduate and postgraduate students. Participants from various backgrounds are probably going to have varying perspectives on how to use GenAI in education and how it will affect our future educational system. In order to select participants and gather various perspectives from 3 research intensive universities, purposeful sampling was used. Each university's 16–19 students contributed, making a total of 51 students who participated. Seven, Eight, Nine, and Nine are undergraduates in years 1, 2, 3, and 4, respectively; the remaining 17 are postgraduates. Ten of the participants major in social sciences, humanities, business, or science. Eleven of the participants major in engineering. Twenty-four of them were male and 27 were female. As a consequence of this, a sample size of 51 is adequate to produce codes for the purpose of thematic analysis.

3.3. Research procedure

The data was collected after a 3-h workshop on GenAI in education was given to all the participants. This was set up so that the participants would be prepared to discuss the influence of GenAI applications like ChatGPT, Midjourney, and GitHub Copilot on their learning. They were told to think about the future of universities and how to improve the system of higher education with using GenAI. We used an online questionnaire to collect all the participants' ideas and concerns about the integration of GenAI applications into their coursework, projects, and research before the interview. It was estimated that the questionnaire would take 30–60 min to complete. Other than demographic data, the questionnaire has five major questions: How did you use ChatGPT to support their learning and competence? What difficulties do you have when using AI in learning? What assignment will enable you to learn more? What are the skills you need for your future careers? What does a future university look like? Twelve focus groups were facilitated and audio recorded by the team consisted of a project leader and two research assistants (mean duration: 92 min). There were four or five participants in the group. The project leader read the questionnaire results in advance of the focus groups in order to think of pertinent follow-up questions to ask. The participants were given the opportunity to share their thoughts on the roles and learning outcomes described in the conceptual framework during the focus groups, and the project leader posed the predetermined questions to further elucidate the discussions. The questions include "How do GenAI tools change the way you learn? What do you expect to learn from your program? What new literacies do you want learn? What challenges do you have/expect when you learn with GenAI? What learning tasks do you prefer ? How can instructors effectively assess your learning?"

To ensure the truthfulness, credibility, and trustworthiness, this study used thematic analysis in four phases, guided by theoretical constructs (Braun & Clarke, 2006).

Phase 1: Got acquainted with the data and generating preliminary codes under the (sub)themes outlined in the conceptual framework. One of the research assistants read and reread the transcripts line by line, annotating them with codes that described significant content.
Phase 2: Add new and revise existing (sub)themes. The other research assistant thoroughly examined all annotated transcripts to identify any discrepancies in interpretations and codes. Any interpretation disagreements were handled by the project leader as a go-between. The team analyzed the codes to generate the themes and subthemes.
Phase 3: Examine the (sub)themes. Some existing themes may be combined or divided into subthemes by the team. This process was repeated until the team was satisfied with the final thematic map.
Phase 4: The team defined and named elements that provided a thorough understanding of the (sub)themes, as well as their importance.

4. Results and discussions

The analyses focused on the three major themes of learning outcomes, pedagogies, and assessments to identify the potential changes required for higher education when GenAI is implemented. The inter-reliability of the analyses is 0.79. Table 1 shows the results of thematics analysis.

4.1. Theme 1. student learning outcomes

In this theme, a few existing student learning outcomes were emphasized, and some of them were removed from research. And some new outcomes are suggested to be added in the future of universities. The followings explain the subthemes.

Subtheme 1.1. Learning and working with GenAI: All of the participants were concerned that using ChatGPT would have an impact on their performance in the written exams. Using ChatGPT encourages students to summarize rather than remember facts or knowledge. The knowledge serves very important roles in integrating cognitive processes that are critical for the development of students' understanding (Chiu & Mok, 2017). This may be explained by cognitive theories, which holds that filtering and selecting information is essential for cognitive development (Mayer, 2019). This suggests that the students may not be cognitively engaged in learning or using ChatGPT. Students will be

Table 1
The results of thematic analyses.

Themes	Subthemes	Examples of excerpts in the focus group
1. Learning outcomes	1.1. Learning and working with GenAI	*We need to learn with ChatGPT for social science.* *I want to learn how to analyze my data collected in my research project.* *In the future, we need to work with ChatGPT. It will be good that I can learn how to work with ChatGPT"*
	1.2. Interpersonal communication skills	*We should have good skills to interact with others in blended and face-to-face environments.* *We should develop the interpersonal communication skills that ChatGPT cannot do in universities.*
	1.3. AI literacy	I want to learn more about GenAI and how they train their models. I don't know much about the ethical principles of AI. Are there any courses related to AI I can take?
	1.4. Adaptability	To learn with GenAI, I will change my approach. To benefit yourself from learning with GenAI, it is more about understanding when to modify my approach. The focus of future research should investigate ways of developing resiliency and self-confidence by assisting students in embracing their shortcomings, rising to meet new challenges, and gaining knowledge from a variety of sources.
2. Pedagogies	2.1. Prerequisite knowledge	I want to know if the outputs are correct, but I don't have the knowledge to evaluate them. I need a solid grounding in research methodology in order to evaluate the efficacy of the study design.
	2.2. Maker learning	I believe I want to create a model to communicate my essay's concepts (non-engineering students) I can create multimedia artifacts despite my lack of skill" Now I'm able to do it with ChatGPT.
	2.3. Interdisciplinary learning	ChatGPT provides ideas from other disciplines. Using ChatGPT, I can approach a problem from the perspective of other disciplines.
3. Assessment	3.1. In-class activities	Exams are necessary, but we need more than that in assessment. We need to use assessment to understand the abilities I will need for future professions. Assessment should occur in classrooms or lectures.
	3.2. A collection of artifacts	We might generate a sequence of objects for assessment. Assignments should be in the form of a project or campaign, such as designing, developing, and promoting a product. I am able to make a poster using GenAI (I am unable to draw it before).
	3.3. Originality	Perhaps we might regard all tasks as empirical research. We could test the ideas or solutions given by ChatGPT.

required to interact and work with GenAI (personal assistants) in the future. These findings imply that learning and working with GenAI should be the learning outcomes for new students in future higher education (Expectation 2 and 5). The following excerpts are examples of the students' expressions or feedback: "We need to learn with ChatGPT for social science.", "I want to learn how to analyze my data collected in my research project". and "In the future, we need to work with ChatGPT. It will be good that I can learn how to work with ChatGPT.".

Subtheme 1.2. Interpersonal communication skills: what ChatGPT could do is more cognitive aspects; the students expressed that the skills that ChatGPT cannot achieve are more important for the future of work; these skills include skills in interpersonal communication in blended, digital, and face-to-face environments. They are all in agreement that the classrooms of the future should provide them with more opportunities to develop these skills in preparation for the jobs of the future (Bowles & Kruger, 2023). This is supported by the study of Bonfield et al. (2020) that suggesting interpersonal coomunication skills becomes more important in digital world (Expectation 2 and 5). The following excerpts are examples of the students' expressions or feedback: "We should have good skills to interact with others in blended and face-to-face environments." and "We should develop the interpersonal communication skills that ChatGPT cannot do in universities."

Subtheme 1.3. AI literacy: As the students were unaware of how the GenAI application actually works and how the data is processed, they had the impression that they were learning with a black box. According to the findings of the analyses, the students were aware of the benefits of GenAI; however, they were not aware of certain risks and threats associated with ethical concerns (Klimova et al., 2023). Two of these major risks are privacy and transparency, or the lack of them. These risks should be carefully evaluated by conceptual as well as empirical studies, which will clearly delineate where the potential threats could be located (Expectation 1). It is essential for the students to have an understanding of how GenAI applications function. These indicate that every student ought to have a solid understanding of what AI is. All students in higher education should be required to acquire new literacies, including AI, data, computational, algorithm, digital, and media literacy (Expectation 2 and 5). This is in line with the worldwide initiatives for AI education being undertaken by AII (Chiu, 2021; Chiu et al., 2022). The following excerpts are examples of the students' expressions or feedback: "I want to learn more about GenAI and how they train their models.", "I don't know much about the ethical principles of AI." and "Are there any courses related to AI I can take?"

Subtheme 1.4. Adaptability skills: the students expressed that they are expected to learn with a variety of new technologies including GenAI applications or AI systems that are emerging. They have to get up to speed on all of the most recent technological developments. These indicate that it is very important for students to have adaptability skills because they assist students in dealing with new scenarios and situations (Expectation 2 and 5; Bonfield et al., 2020). The students commented, "To learn with GenAI, I will change my approach." and "To benefit yourself from learning with GenAI, it is more about understanding when to modify my approach." The focus of future research should investigate ways of developing resiliency and self-confidence by assisting students in embracing their shortcomings, rising to meet new challenges, and gaining knowledge from a variety of sources.

Aside from the suggested subthemes, the analyses revealed research directions for GenAI in education. According to the findings, all of the participants said they used ChatGPT for learning and were very interested in using GenAI for their studies if their universities permitted it. They used ChatGPT to gather information for their courses and write an article or piece of work. They discovered ChatGPT to be extremely useful and were eager to put it to use. This is consistent with research indicating that user intention to use technology is influenced by self-efficacy (de Andrés-Sánchez & Gené-Albesa, 2023). ChatGPT is a large language model that better understands learners' prompts. Students believe that because ChatGPT is easy to use and learn with, they will do better in non-exam assessments. This, however, differs significantly from previous research into how to motivate students to learn using AI systems. Students appear to prefer GenAI applications due to their more user-friendly human-computer interaction. Future studies should go beyond motivation with GenAI.

4.2. Theme 2. pedagogy

This theme pedagogy integrated the themes learning and teaching. According to the findings of the analyses, GenAI maximizes all of the opportunities discussed in the proposed framework. Since GenAI is more advanced than other AI technologies, it provides better personalized learning, more effective conversation and interaction, and feedback. It also has the potential to improve teacher teaching. The analyses also suggest that the introduction of GenAI in higher education would alter pedagogies by shifting the emphasis from transfer knowledge to processing knowledge, and from disciplinary learning to interdisciplinary learning (Expectation 3). These result in the three subthemes listed below.

Subtheme 2.1. Prerequisite knowledge: Ninety percent of the students agreed that solid disciplinary knowledge is required to assess ChatGPT's outputs. This agrees with the majority of ChatGPT-related conversations about the value of analytical thinking and reasoning (Kasneci et al., 2023). The ability to evaluate disciplinary content from GenAI critically will be an essential skill for students to have in the future university classroom. In other words, students who lack in-depth disciplinary knowledge are more receptive to the information generated by GenAI, while students with in-depth knowledge will benefit from ChatGPT's emphasis on deep, cyclical thought. This suggests that students' prior knowledge in the subject area is a significant factor in how well they learn with ChatGPT, which is explained by studies on learner expertise. The students' excerpts include, "I want to know if the outputs are correct, but I don't have the knowledge to evaluate them." and "I need a solid grounding in research methodology in order to evaluate the efficacy of the study design."

Subtheme 2.2. Marker learning: all the students stated that they are confident enough to complete any written homework with the help of ChatGPT. They anticipated that more activities would be "hands-on", involving students in their learning by encouraging a personal link between concepts in courses and their application in real-life circumstances (Expectation 3; Burke, 2015). Teachers can combine GenAI tasks with activities. Students could use GenAI to develop something in a course. This GenAI echoes the makerspace or maker movement's advocacy. The focus group snippets include "I believe I want to create a 3D model to communicate my essay's concepts (non-engineering students)" and "I cannot create multimedia artifacts despite my lack of skill, Now I am able to do it with ChatGPT."

Subtheme 2.3. Interdisciplinary teaching: According to this subtheme, GenAI actively promotes the use of interdisciplinary approaches in the classroom. GenAI applications offers students with responses based on the analysis of data obtained from a variety of sources in response to their multidisciplinary queries (Knight et al., 2013). This suggests that solutions may be derived from a variety of fields or points of view. The promotion of real-world challenges or real-life learning in courses is consistent with the increasing number of interdisciplinary programs (Knight et al., 2013). Students are required to integrate knowledge from several fields into their approach to solving challenges. The GenAI outputs inspires students to cross subject borders and provide more integrated solutions. This implies that higher education should have a more positive outlook on transdisciplinary education by highlighting its value (Expectation 3). "ChatGPT provides ideas from other disciplines." and "Using ChatGPT, I can approach a problem from the perspective of other disciplines." are excerpts from the focus group.

4.3. Theme 3. assessment

The appearance of ChatGPT urges higher education educators to rethink assessment, since GenAI applications may quickly finish assignments such as essay, report, research proposal, and lesson plans for students. Instructors were unable to determine if the assignments were original student work. Some instructors thought GenAI was a threat to the assessment. Previous research in the proposed framework of this study focused on auto-making and assessment, which relieved instructors' grading workload. Therefore, GenAI add a new aspect on assessment (Expectation 4). In the focus group, the students suggested what assessment should be for higher education in the future as they believe the assessment should prepare them for the future workforce, see the following three subthemes.

Subtheme 3.1. In-class activities: Current course grades are mainly dependent on summative assessment, such as written assignments and exams. This kind of assessment may not meet the demands of university students (Expectation 4). Using a written assignment as an assessment for student learning outcomes may not be acceptable since the assignment might be primarily created by GenAI. Examinations may test students' disciplinary knowledge; however, what learning goals should be established by higher education institutions if GenAI can supply students with disciplinary knowledge? Eighty percent of students in the focus group agreed that assessment should prepare them for future careers. Students said that classroom activities should be utilized to evaluate the abilities and information they need for their jobs (Bowles & Kruger, 2023). They proposed that the classroom activities acted as formative evaluation. During class, students may share or exhibit their learning process, use GenAI to answer challenges posed by professors, and participate in discussions. They also could receive timely feedback from instructors, peers and ChatGPT Accordingly, the assessment activities should be individualized and student-centered. The excerpts include "Exams are necessary, but we need more than that in assessment.", "We need to use assessment to understand the abilities I will need for future professions." and "assessment should occur in classrooms or lectures.".

Subtheme 3.2. A collection of artifacts: The benefits of GenAI should be used in assessment (Expectation 4). GenAI may assist students in creating something they were previously incapable of. For instance, GenAI can assist students who lack coding skills in developing computer applications. GenAI can do the impossible. It might assist students in producing artifacts. Moreover, current assignments and exams are tailored to accomplish course learning outcomes. They often examine the outcomes individually. In the focus group, students suggested that a collection of artifacts may be used for overall assessment. For instance, students may be required to write an essay and produce a video to describe and explain their digital solutions to a given issue. They must also develop solutions (Burke, 2015). They are cohesive and comprise a body of work that resembles a campaign for a job. In other making learning and design thinking is embedded in the whole course (Chiu et al., 2021). According to the students in the focus group, "We might generate a sequence of objects for assessment.", "Assignments should be in the form of a project or campaign, such as designing, developing, and promoting a product." and "I am able to make a poster using GenAI (I am unable to draw it before)".

Subtheme 3.3. Originality: Because no present technology can tell whether a piece of work was generated by AI, the assessment should emphasize the relevance of student work originality. Even plagiarism software, e.g., Turnitin, does not accurately reveal originality. According to the findings, the assessment for future higher education should require students to (i) collect and analyze various sorts of evidence to support their ideas, and (ii) develop and interpret empirical findings or new materials for their solutions. Students may receive feedback on their work from peers or users. The excerpts include "Perhaps we might regard all tasks as empirical research." and "We could test the ideas or solutions given by ChatGPT."

5. Implications

This qualitative study intended to investigate how GenAI affects higher education from the perspective of students. These findings imply that students' perceptions of learning, pedagogies and assessment for future institutions have changed as a result of GenAI. Prior research on AI in education has centered on the design and development of effectives learning environments, as well as the use of experimental and

correlational research to comprehend the factors influencing student academic performance and motivations (Chiu et al., 2023). The AI applications or systems are not completely accessible to university instructors and students. Instructors and students could believe AI has no relevance to their learning and teaching until they experience ChatGPT and other GenAI apps. GenAI and its applications are disruptive because students have easy access to them. They address the challenges identified in prior studies and optimizes the opportunities of AI in education (Chiu et al., 2023). Consequently, GenAI is prepared to encourage institutions to transform for the future of education. This study offers four practical implications and three policy ones for the field of higher education, and made six recommendations for further study of GenAI's potential in research.

5.1. Implications for practices

New learning outcomes: future higher education institutions should better prepare for the future workforce. The findings propose new learning outcomes, and emphasize some existing learning outcomes. The new outcomes include skills in learning and working with GenAI (subtheme 1.1.), AI literacy (subtheme 1.3.), and an interdisciplinary learning mentality (subtheme 2.3.). First, GenAI is being integrated into workplace applications such as email providers, report generators, graphics creators and editors, 3D models, productivity tools, and coding programs. Future employees are bringing their AI skills to work as new hires, accelerating more utilization in the future. Furthermore, young employees are more inclined than their elders to use GenAI at work. As a result, it is critical to train students to use GenAI for lifelong learning and employment (Chiu et al., 2023). Second, another new outcome that students should have been AI literacy. Students that understand AI can work with GenAI while knowing its capabilities and risks (e.g., ethical and moral issues). They become more responsible and responsible GenAI users and learners. Other than AI literacy, this study suggests that higher education institutions can improve students' digital and media literacy to enable them deal with future difficulties and make decisions about the use of GenAI. The final new result is an interdisciplinary learning mentality. Traditionally, university courses are single-disciplinary in nature; nevertheless, students should be prepared to learn in an interdisciplinary domain in order to tackle complex real-life challenges using GenAI (Knight et al., 2013). Furthermore, in a GenAI-powered society, the other two existing learning outcomes that should be addressed are interpersonal communication skills and adaptability (subtheme 1.2. and 1.4.). They are frequently developed in whole university initiatives, making them less essential from student perspectives. Future institutions should make course or program learning outcomes more explicit (Bonfield et al., 2020; Bowles & Kruger, 2023).

Innovative learning approaches: although higher institutions have actively encouraged blended learning and makerspaces in order to make learning more student-centered (Chiu et al., 2021), lectures remain the bulk of knowledge delivery modes, which may be supplanted in future GenAI applications. The findings support the use of activity- and evaluation-based approaches in classrooms (subthemes 2.2. and 3.2.). It is suggested that design thinking be used in the classroom to boost the originality and relevance of student work (subtheme 3.3.; Chiu et al., 2021). Moreover, this study also shows that rather than being a threat to teachers, GenAI could be viewed as a learning agency, a student learning partner, and a teaching assistant (Chiu et al., 2023). Maker learning should be incorporated into the majority of courses (Burke, 2015), as metaverse environments give everyone with their own maker space.

Assessment approaches: the findings advise instructors to give more weight on assessing in-class activities and hands-on artifacts rather than essays or tests (subtheme 3.1. and 3.2.). The assessment should be aligned with the learning outcomes for the future workforce driven by GenAI (See subthemes 1.1. and 1.3.), and learning approaches (see the second practical implications). Furthermore, originality should be emphasized in the assessment rubrics (see subtheme 3.3.).

Prerequisite knowledge: the findings show that AI literacy and disciplinary knowledge are crucial for learning with GenAI (subtheme 2.1.). Before beginning to learn with GenAI, instructors may need to supply students with basic information that masters students' critical thinking skills. These skills involve AI literacy as well as understanding of the discipline field. This study suggest that instructors should plan each session carefully to make sure that students with the above traits have a better chance of learning with GenAI.

5.2. Implication for policy development

Assessment policy: the findings suggest that new dimensions and approaches to assessment will be required for future higher education (Themes 1 and 3). Currently, course grading, i.e., student performance assessments, has traditionally relied mainly on final activities such as essays, projects, tests, or exams. Essays and projects could be completed with the assistance of GenAI, and cognitive learning as measured by exams or tests may become less relevant in the future workforce. Instead of making recommendations, institutions should develop guidelines and policies that highlight the competence required for the future workforce, and in-class and hands-on activities outlined in this study. To understand the impact of GenAI on assessment, AI and GenAI should be embedded in teacher professional development programs in universities. In other words, AI literacy is suggested for both students and teachers. Moreover, students' competences for future jobs (21st century skills) are often measured by a questionnaire at the end of the term or year. Institutions should use objective measures to develop a competence assessment platform that allows students to test their competence at any time.

Interdisciplinary programme: Although interdisciplinary research has been promoted, interdisciplinary education research is not connected with the research aspect. Interdisciplinary educational programs allow for the synthesis of ideas and characteristics from several fields, address students' individual peculiarities, and aid in the development of transferrable skills. Students in GenAI-powered institutions could readily access information or knowledge from other disciplines. This study encourages educational institutions to use GenAI to build and develop more multidisciplinary educational programs (subtheme 2.2., 2.3., and 3.2.).

Foundation activities: historically, prerequisite knowledge has appeared on the program level - prerequisite courses in higher education. Some advanced courses require students to have completed some introductory courses before enrolling in them. However, this study suggests new prerequisite knowledge, such as AI, media and digital literacy, and fundamental disciplinary knowledge. This study suggests two more levels, in addition to the course level, to establish students' prerequisite knowledge for learning. First, at the institutional level, AI, media, and information literacy workshops or courses (see the fourth practical implication) should be provided to students who learn with ChatGPT. For this, the institution could create a self-directed learning platform. Second, at the course level, instructors are advised to teach the foundation knowledge prior to studying with ChatGPT, as critical thinking abilities requires disciplinary knowledge.

5.3. Future research direction

This study offers the following five recommendations for future research direction.

- Competence for future workforce and its self-assessment measures: GenAI has impact on the competence needs for future workforce. According to the findings, Learning and working with GenAI (subtheme 1.1), Interpersonal communication skills (subtheme 1.2), Adaptability skills (subtheme 1.4) were three major outcomes the participants mentioned. We also suggest interacting and working with GenAI, factchecking, entrepreneurship and creativity skills are

another three major outcomes the students should have for further workforce (Chiu, 2023; Weng et al., 2022). Moreover, most assessments of the competencies required for future workforce in higher education are not accessible to students. This study suggests that educational research should investigate to develop self-self-assessment tasks using scenarios or cases. Students can regularly assess their competence required for future workforce that is drive by GenAI.

- AI literacy or competency measures: Measuring AI literacy is in its infancy and requires additional study (subtheme 1.3). Most of the current study used self-reported questionnaires to assess student AI literacy (Laupichler et al., 2023). However, self-reported measures do not reflect the actual performance (Tempelaar et al., 2020). Objective measures should be used to measure student AI literary. Moreover, more studies are required in the area of AI literacy assessment, especially in the subfields of AI ethics and machine learning. Students can understand how AI work (i.e., machine learning), and ethics.
- New literacies and their relationships: Researchers have been motivated by GenAI to consider what digital literacy means in an age of algorithms and automation (Wood et al., 2021). AI, media, data information, computational and algorithm literacies are more likely to be significant consequences for higher education (theme 1; subtheme 2.1). These literacies and AI literacy have distinct definitions that are not mutually exclusive. Future studies should be conducted how to foster these literacies, and how they relate to one another.
- Interdisciplinary teaching: GenAI pushes for more interdisciplinary teaching, so more innovative approaches to course and programme designs are needed (subtheme 2.3). This study recommend that future research propose and assess new benchmarks and curricular frameworks for multidisciplinary or interdisciplinary teaching or programmes.
- Innovative pedagogies and their evaluation: ChatGPT is still new to higher education and make impact on pedagogies and instructional designs (theme 2; subtheme 2.3). Currently, many educators used their expertise and experience to suggest how to teach or learn with GenAI. The suggestions are subjective. This study suggests future research should focus on using empirical design to examine the effectiveness of innovative pedagogies on student cognitive (e.g., knowledge and skills) and non-cognitive learning outcomes (e.g., motivation and engagement). We also suggest future studies should investigate how the different literacies: AI, digital, data, information, computational, algorithm literacies affect the use of GenAI in learning (Xia, et al., 2023).
- New assessment and its acceptance: GenAI enables students to generate written essay easily for their assignment. This easy based task may become less effective or useful. Our findings suggest assessment how use In-class activities (subtheme 3.1), a collection of artifacts (subtheme 3.2), and originality (subtheme 3.3) to design the tasks. These are some ideas driven by the students. This area is still new; how to design effective assessment remains unclear. Moreover, innovative assessment is related both teaching and learning, and may cause unacceptance issue. Therefore, we suggest more studies should investigate how to design effective GenAI assessment empirically, and examine teacher and student acceptance to the assessment approaches.

6. Conclusions and limitations

It is essential to pay attention to the opinions of students in order to fill in the gaps left by the fact that most of the conversations pertaining to this topic take place between instructors or researchers. This study could be one of the first empirical studies to use student voice to suggest how GenAI transform higher education. Overall, the students are motivated by the prospect of future employment and desire to develop the skills required for GenAI-powered jobs. The findings give an overview of three areas: learning outcomes, pedagogy, and assessment. There are three key limitations to this study: First, this study was conducted in an eastern cultural region; students in the western region may view it differently. Future research should include comparative studies to better understand how GenAI affects higher education. Second, instructors are stakeholders and may have different views; therefore, future studies should collect instructors' views. Last, while GenAI is a new technology, not all participants have extensive experience learning and teaching with it. They may change their minds after GenAI is fully integrated into schools.

Ethical statements

This study got ethical clearance from the Chinese University of Hong Kong, and all the procedures were performed in compliance with relevant laws and institutional guidelines. Informed consent from all the participants was obtained. The participants understood their right to access and delete parts of the data, and the corresponding author anonymized the data and stored it in secured places.

CRediT authorship contribution statement

Thomas K.F. Chiu: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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References

de Andrés-Sánchez, J., & Gené-Albesa, J. (2023). Assessing attitude and behavioral intention toward chatbots in an insurance setting: A mixed method approach. *International Journal of Human-Computer Interaction*, 1–16. https://doi.org/10.1080/10447318.2023.2227833

Bonfield, C. A., Salter, M., Longmuir, A., Benson, M., & Adachi, C. (2020). Transformation or evolution?: Education 4.0, teaching and learning in the digital age. *Higher education pedagogies, 5*(1), 223–246. https://doi.org/10.1080/23752696.2020.1816847

Bonneton-Botte, N., Fleury, S., Girard, N., Le Magadou, M., Cherbonnier, A., Renault, M., Anquetil, E., & Jamet, E. (2020). Can tablet apps support the learning of handwriting? An investigation of learning outcomes in kindergarten classroom. *Computers & Education, 151*. https://doi.org/10.1016/j.compedu.2020.103831

Bowles, D. C., & Kruger, J. S. (2023). Generating employable, intelligent graduates in a world with generative AI: Thoughts for educators. *Pedagogy in Health Promotion, 9*(2), 75–77. https://doi.org/10.1177/237337992311751

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Burke, P. J. (2015). Re/imagining higher education pedagogies: Gender, emotion and difference. *Teaching in Higher Education, 20*(4), 388–401. https://doi.org/10.1080/13562517.2015.1020782

Castelli, M., & Manzoni, L. (2022). Generative models in artificial intelligence and their applications. *Applied Sciences, 12*(9), 4127. https://doi.org/10.3390/app12094127

Chew, E., & Chua, X. N. (2020). Robotic Chinese language tutor: Personalising progress assessment and feedback or taking over your job? *On the Horizon, 28*(3), 113–124. https://doi.org/10.1108/OTH-04-2020-0015

Chiu, T. K. F. (2021). A holistic approach to Artificial Intelligence (AI) curriculum for K-12 schools. *TechTrends, 65*, 796–807. https://doi.org/10.1007/s11528-021-00637-1

Chiu, T. K. F. (2023). The impact of generative AI (GenAI) on practices, policies and research direction in education: A case of ChatGPT and Midjourney. *Interactive Learning Environments*. https://doi.org/10.1080/10494820.2023.2253861

Chiu, T. K. F., Chai, C. S., Williams, J., & Lin, T. J. (2021). Teacher professional development on Self-determination Theory-based design thinking in STEM education. *Educational Technology & Society, 24*(4), 153–165. https://www.jstor.org/stable/48629252.

Chiu, T. K. F., Meng, H., Chai, C. S., King, I., Wong, S., & Yeung, Y. (2022). Creation and evaluation of a pre-tertiary Artificial Intelligence (AI) curriculum. *IEEE Transactions on Education, 65*(1), 30–39. https://doi.org/10.1109/TE.2021.3085878

Chiu, T. K. F., & Mok, I. A. C. (2017). Learner expertise and mathematics different order thinking skills in multimedia learning. *Computers & Education, 107*, 147–164. https://doi.org/10.1016/j.compedu.2017.01.008

Chiu, T. K. F., Xia, Q., Zhou, X.-Y., Chai, C. S., & Cheng, M.-T. (2023). *Systematic literature review on opportunities, challenges, and future research recommendations of artificial intelligence in education*. Computer & Education: Artificial Intelligence, Article 100118. https://doi.org/10.1016/j.caeai.2022.100118

Cooper, G. (2023). Examining science education in ChatGPT: An exploratory study of generative artificial intelligence. *Journal of Science Education and Technology, 32*(3), 444–452. https://doi.org/10.1007/s10956-023-10039-y, 32.

Costa-Mendes, R., Oliveira, T., Castelli, M., & Cruz-Jesus, F. (2021). A machine learning approximation of the 2015 Portuguese high school student grades: A hybrid approach. *Education and Information Technologies, 26*(2), 1527–1547. https://doi.org/10.1007/s10639-020-10316-y

Crowe, D., LaPierre, M., & Kebritchi, M. (2017). Knowledge based artificial augmentation intelligence technology: Next step in academic instructional tools for distance learning. *TechTrends: Linking Research and Practice to Improve Learning, 61*(5), 494–506. https://doi.org/10.1007/s11528-017-0210-4

Cukurova, M., Kent, C., & Luckin, R. (2019). Artificial intelligence and multimodal data in the service of human decision-making: A case study in debate tutoring. *British Journal of Educational Technology, 50*(6), 3032–3046. https://doi.org/10.1111/bjet.12829

Fu, S., Gu, H., & Yang, B. (2020). The affordances of AI-enabled automatic scoring applications on learners' continuous learning intention: An empirical study in China. *British Journal of Educational Technology, 51*(5), 1674–1692. https://doi.org/10.1111/bjet.12995

Garg, S., & Sharma, S. (2020). Impact of artificial intelligence in special need education to promote inclusive pedagogy. *International Journal of Information and Education Technology, 10*(7), 523–527. https://doi.org/10.18178/ijiet.2020.10.7.1418

Hirankerd, K., & Kittisunthonphisarn, N. (2020). E-learning management system based on reality technology with AI. *International Journal of Information and Education Technology, 10*(4), 259–264. https://doi.org/10.18178/ijiet.2020.10.4.1373

Hu, J. J. (2021). Teaching evaluation system by use of machine learning and artificial intelligence Methods. *International Journal of Emerging Technologoes in Learning, 16*(5), 87–101. https://doi.org/10.3991/ijet.v16i05.20299

Jarke, J., & Macgilchrist, F. (2021). Dashboard stories: How narratives told by predictive analytics reconfigure roles, risk and sociality in education. *Big Data and Society, 8*(1). https://doi.org/10.1177/20539517211025561

Kasneci, E., Seßler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., … Kasneci, G. (2023). ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences, 103*, Article 102274. https://doi.org/10.1016/j.lindif.2023.102274

Khan, I., Ahmad, A. R., Jabeur, N., & Mahdi, M. N. (2021). An artificial intelligence approach to monitor student performance and devise preventive measures. *Smart Learning Environments, 8*(1). https://doi.org/10.1186/s40561-021-00161-y

Kim, H. S., Kim, N. Y., & Cha, Y. (2021). Is it beneficial to use AI chatbots to improve learners' speaking performance? *Journal of ASIA TEFL, 18*(1), 161–178. https://doi.org/10.18823/asiatefl.2021.18.1.10.161

Klimova, B., Pikhart, M., & Kacetl, J. (2023). Ethical issues of the use of AI-driven mobile apps for education. *Frontiers in Public Health, 10*, Article 1118116. https://doi.org/10.3389/fpubh.2022.1118116

Knight, D. B., Lattuca, L. R., Kimball, E. W., & Reason, R. D. (2013). Understanding interdisciplinarity: Curricular and organizational features of undergraduate interdisciplinary programs. *Innovative Higher Education, 38*, 143–158. https://doi.org/10.1007/s10755-012-9232-1

Kumar, V., & Boulanger, D. (2020). Explainable automated essay scoring: Deep learning really has pedagogical value. *Frontiers in Education, 5*, Article 572367. https://doi.org/10.3389/feduc.2020.572367

Lampos, V., Mintz, J., & Qu, X. (2021). An artificial intelligence approach for selecting effective teacher communication strategies in autism education. *NPJ Science of Learning, 6*(1). https://doi.org/10.1038/s41539-021-00102-x

Laupichler, M. C., Aster, A., & Raupach, T. (2023). Delphi study for the development and preliminary validation of an item set for the assessment of non-experts' AI literacy. *Computers and Education: Artificial Intelligence, 4*, Article 100126. https://doi.org/10.1016/j.caeai.2023.100126

Li, M., & Su, Y. (2020). Evaluation of online teaching quality of basic education based on artificial intelligence. *International Journal of Emerging Technologoes in Learning, 15*(16), 147–161. https://doi.org/10.3991/ijet.v15i16.15937

Liu, J., & Wu, X. (2019). Prototype of educational affective arousal evaluation system based on facial and speech emotion recognition. *International Journal of Information and Education Technology, 9*(9), 645–651. https://doi.org/10.18178/ijiet.2019.9.9.1282

Luo, D. L. (2018). Guide teaching system based on artificial intelligence. *International Journal of Emerging Technologoes in Learning, 13*(8), 90–102. https://doi.org/10.3991/ijet.v13i08.9058

Mayer, R. E. (2019). Thirty years of research on online learning. *Applied Cognitive Psychology, 33*(2), 152–159. https://doi.org/10.1002/acp.3482

Munawar, S., Toor, S. K., Aslam, M., & Hamid, M. (2018). Move to smart learning environment: Exploratory research of challenges in computer laboratory and design intelligent virtual laboratory for eLearning technology. *Eurasia Journal of Mathematics, Science and Technology Education, 14*(5), 1645–1662. https://doi.org/10.29333/ejmste/85036

Palasundram, K., Mohd Sharef, N., Nasharuddin, N. A., Kasmiran, K. A., & Azman, A. (2019). Sequence to sequence model performance for education chatbot. *International Journal of Emerging Technologies in Learning (iJET), 14*(24), 56–68. https://doi.org/10.3991/ijet.v14i24.12187

Peres, R., Schreier, M., Schweidel, D., & Sorescu, A. (2023). On ChatGPT and beyond: How generative artificial intelligence may affect research, teaching, and practice. *International Journal of Research in Marketing, 40*(2), 269–275. https://doi.org/10.1016/j.ijresmar.2023.03.001

Porter, B., & Grippa, F. (2020). A platform for AI-enabled real-time feedback to promote digital collaboration. *Sustainability, 12*(24), 1–13. https://doi.org/10.3390/su122410243, 10243.

Rahman, M. M., & Watanobe, Y. (2023). ChatGPT for education and research: Opportunities, threats, and strategies. *Applied Sciences, 13*(9), 5783. https://doi.org/10.3390/app13095783

Samarakou, M., Fylladitakis, E. D., Fruh, W. G., Hatziapostolou, A., & Gelegenis, J. J. (2015). An advanced elearning environment developed for engineering learners. *International Journal of Emerging Technologies in Learning, 10*(3), 22–33. https://doi.org/10.3991/ijet.v10i3.4484

Sun, Y. (2021). Application of artificial intelligence in the cultivation of art design professionals. *International Journal of Emerging Technologies in Learning, 16*(8), 221–237. https://doi.org/10.3991/ijet.v16i08.22131

Tempelaar, D., Rienties, B., & Nguyen, Q. (2020). Subjective data, objective data and the role of bias in predictive modelling: Lessons from a dispositional learning analytics application. *PLoS One, 15*(6), Article 0233977. https://doi.org/10.1371/journal.pone.0233977

Vazquez-Cano, E., Mengual-Andres, S., & Lopez-Meneses, E. (2021). Chatbot to improve learning punctuation in Spanish and to enhance open and flexible learning environments. *International Journal of Educational Technology in Higher Education, 18*(1). https://doi.org/10.1186/s41239-021-00269-8

Weng, X. J., Chiu, T. K. F., & Tsang, C. C. (2022). Promoting student creativity and entrepreneurship through real-world problem-based maker education. *Thinking Skills and Creativity, 45*, Article 101046. https://doi.org/10.1016/j.tsc.2022.101046

Westera, W., Prada, R., Mascarenhas, S., Santos, P. A., Dias, J., Guimaraes, M., Georgiadis, K., Nyamsuren, E., Bahreini, K., Yumak, Z., Christyowidiasmoro, C., Dascalu, M., Gutu-Robu, G., & Ruseti, S. (2020). Artificial intelligence moving serious gaming: Presenting reusable game AI components. *Education and Information Technologies, 25*(1), 351–380. https://doi.org/10.1007/s10639-019-09968-2

Wood, E. A., Ange, B. L., & Miller, D. D. (2021). Are we ready to integrate artificial intelligence literacy into medical school curriculum: Students and faculty survey. *Journal of Medical Education and Curricular Development, 8*. https://doi.org/10.1177/23821205211024078

Xia, Q., Chiu, T. K. F., Chai, C. S., & Xie, K. (2023). The mediating effects of needs satisfaction on the relationships between prior knowledge and self-regulated learning through artificial intelligence chatbot. *British Journal of Educational Technology, 54*(4), 967–986. https://doi.org/10.1111/bjet.13305

Xia, Q., Chiu, T. K. F., Lee, M., Temitayo, I., Dai, Y., & Chai, C. S. (2022). A Self-determination theory design approach for inclusive and diverse Artificial Intelligence (AI) K-12 education. *Computers & Education, 189*, Article 104582. https://doi.org/10.1016/j.compedu.2022.104582

Yu, J. (2021). Academic performance prediction method of online education using random forest algorithm and artificial intelligence methods. *International Journal of Emerging Technologies in Learning, 16*(5), 45–57. https://doi.org/10.3991/ijet.v16i05.20297