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The impact of Generative AI (GenAI) on practices, policies and research direction in education: a case of ChatGPT and Midjourney

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Abstract

Generative artificial intelligence (GenAI) tools have become increasingly accessible and have impacted school education in numerous ways. However, most of the discussions occur in higher education. In schools, teachers' perspectives are crucial for making sense of innovative technologies. Accordingly, this qualitative study aims to investigate how GenAI changes our school education from the perspectives of teachers and leaders. It used four domains – learning, teaching, assessment, and administration – as the initial framework suggested in a systematic literature review study on AI in education. The participants were 88 school teachers and leaders of different backgrounds. They completed a survey and joined a focus group to share how ChatGPT and Midjourney had a GenAI effect on school education. Thematic analysis identified four main themes and 12 subthemes. The findings provide three suggestions for practices: know-it-all attitude, new prerequisite knowledge, interdisciplinary teaching, and three implications for policy: new assessment, AI education, and professional standards. They also further suggest six future research directions for GenAI in education.

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1. Introduction

How does Generative AI (GenAI) change education? Most of the current discussions on this question are related to a GenAI application, ChatGPT. For example, how do teachers plan their assignments? What policies should educational institutions add and revise? Some teachers are more reluctant to allow students to use the application to finish assignments, while others are more welcome and change their assessments (Kasneci et al., 2023). GenAI allows users to generate new content, such as text, images, audio, videos, and 3D models, by typing their requests (Dwivedi et al., 2023). ChatGPT is a type of GenAI and an AI chatbot that creates humanlike conversational dialogue (Chiu, Moorhouse, et al., 2023). Another GenAI application is Midjourney, which has a significant impact on art education. These applications can act as teachers, tutors, clerks, and designers. They have been changing the way students study, how teachers teach and assess learning outcomes, and how institutions have revised their policies (Dwivedi et al., 2023). For example, by using

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ChatGPT, in <30 s, students could retrieve a 1000 words essay, solve a mathematics problem, and compose music. ChatGPT enhances students' learning capabilities by finding information and curating it in a storytelling manner. This could (i) allow students to learn anything faster and in different ways, (ii) help teachers grow by providing different perspectives, and (iii) automatize/simplify institutions' administrative work (Chiu, Xia, et al., 2023). However, ChatGPT like webpages are not completely reliable, and still have errors and generate inaccurate outputs. Are students able to judge whether the output is appropriate and trustworthy for their learning? Are they aware of ethical and moral issues such as copyright? Many educational institutions do not currently account for Generative AI in their policies on academic dishonesty (Dwivedi et al., 2023).

It is still in the early days of understanding how GenAI can be used and applied in educational contexts. Many educators and policymakers have questions about what GenAI is capable of, and what its limitations are (Rahman & Watanobe, 2023). Most studies and discussions have been conducted in the higher education field. However, compared with university students, school students are younger adolescents, and their cognition and emotional intelligence are nurtured in schools (Chiu, 2022). Their self-regulated learning skills are less sophisticated, and their classroom learning is often under the supervision of teachers (Perry et al., 2002). This implies that teachers play a key role in supporting learning and teaching using technology in classrooms. To our knowledge, no empirical studies have been conducted to understand how GenAI has changed school education. Therefore, this qualitative study aims to investigate the impact of GenAI on school education from the perspectives of school teachers and leaders. It used ChatGPT and Midjourney as GenAI to collect data from the teachers and leaders.

2. Conceptual framework

The present study used a systematic literature review on AI in the education of Chiu, Xia, et al. (2023) to suggest a conceptual framework for collecting and analyzing qualitative data. The review study adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses and proceeded in three steps: (i) article selection, (ii) article screening and inclusion, and (iii) data coding, extraction, and analysis. It selected 92 articles from 1418 articles from four academic databases – Web of Science, SCOPUS, ERIC, and ProQuest – for systematic review and suggested opportunities and research challenges of AI in education. It identified 13 roles for AI in education in four key domains: learning, teaching, assessment, and administration, and seven major learning outcomes of teachers and students. The review study provides an overview of AI-based tools, such as adaptive learning systems and predictive systems, automated marking systems, and chatbots.

ChatGPT and Midjournal are innovative AI technologies that can change education. ChatGPT is an artificial-intelligence chatbot developed by OpenAI, which is built on large language models and allows users to have human-like conversations and much more with the chatbot. It answers follow-up questions, admits mistakes, challenges incorrect assumptions, and rejects inappropriate requests. It can communicate with users and assist them with tasks such as composing music, analyzing and comparing data, writing essays, and coding a program (Dwivedi et al., 2023; Kasneci et al., 2023). Midjourney is an application can generate artist images to fit users' request. These two applications generate outputs based on user requests. Hence, not all the roles and outcomes suggested in the review study fit this study, using ChatGPT and Midjuornery as GenAI examples. The following sections discuss the conceptual framework used to analyze the data on teachers' views on GenAI in education.

2.1. Four key domains – learning, teaching, assessment and administration

In the review study by Chiu, Xia, et al. (2023), the first key domain was AI in student learning, and its four roles were suggested. The two roles of assigning personalized tasks and analyzing student work

for feedback are not discussed in this framework, because they do not fit this study. The other two roles, providing human–machine conversations and increasing adaptability and interactivity in digital environments, fit how ChatGPT enhances student learning. Providing human–machine conversations: For example, AI chatbots allow students to have conversations with machines about their learning. These chatbots help students develop their communication abilities through ongoing dialogues (Chiu, Moorhouse, et al., 2023; Kim et al., 2021; Koc-Januchta et al., 2020; Vazquez-Cano et al., 2021). ChatGPT can answer student questions or requests in a human-like manner. Increasing adaptability and interactivity in digital environments: For example, AI technologies have been implemented to capture student learning data and facilitate interaction in more adaptive and interactive digital environments. An advanced digital learning environment can capture student data to generate learning tasks (Samarakou et al., 2015). ChatGPT could adopt question-and-answer or answer-and-question approaches, that is, sequential questions along an evolving line of inquiry, to interact with students. It uses students’ responses and questions to clarify their problems, which adapt to their needs and foster a more positive learning experience. Hence, the conceptual framework of this study includes these two roles.

The second key domain is AI in teaching and has three roles. ChatGPT can support teachers’ professional development, but not the other two roles – enhancing teachers’ ability to teach and providing adaptive teaching strategies. Supporting teachers’ professional development: the systematic review revealed that AI technologies were used to support teachers’ continuous professional development activities. AI agents provide teachers with comments and suggestions on their teaching (e.g. questioning skills) by analyzing real-time data in classrooms (Gunawan et al., 2021; Lamos et al., 2021). To support teacher professional development, ChatGPT can inspire teachers by providing new teaching ideas, such as learning design strategies and self-regulated learning tasks/activities. Therefore, this role is included in the conceptual framework.

The third domain is AI in assessment, and concerns how AI technologies assess student performance. This review discusses how AI provides automatic markings and predicts student performance (Costa-Mendes et al., 2021; Hu, 2021; Sun, 2021). The assessment activities may not be supported by ChatGPT. However, ChatGPT may play a novel role in this domain. Therefore, this domain was retained in the conceptual framework.

The final domain is AI in administration. ChatGPT can support the three main roles discussed in the review. Improving the performance of management platforms: A review study revealed that AI has significantly enhanced the performance of management platforms by completing routines, laboring tasks, and increasing security (Khan & Alotaibi, 2020; Li, 2021; Ruiperez-Valiente et al., 2019; Tang & Hai, 2021). The management team might use ChatGPT to (i) generate a draft of emails and proposals and (ii) analyze data and generate reports to enhance their efficiency. Providing convenient and personalized services: The review study also revealed that AI-enabled activity recommendation systems can recommend activities that best fit students’ needs (Villegas-Ch et al., 2020). Management teams might request ChatGPT to recommend activities or decisions by presenting their cases. Supporting educational decision-making with evidence: This review study suggests that AI technologies can help educational management teams make their decisions by presenting evidence. For example, they used student data to predict the probability of students discontinuing their courses and assist students with course/activity selection (Cukurova et al., 2020; Tsai et al., 2020; Villegas-Ch et al., 2020). ChatGPT may analyze data from other sources and provide the analyzed data as evidence to the management team for decision-making and academic advising. Therefore, these three roles are included in the framework.

2.2. Student and teacher learning outcomes

In addition to the four key domains, student and teacher learning outcomes are included in the conceptual framework, as ChatGPT has the potential to foster learning outcomes. In the reviewed studies, student outcomes include twenty-first century skills, motivation and engagement, academic

performance, and non-cognitive aspects. AI technologies have positive effects on these outcomes (Chiu, Xia, et al., 2023). For example, human-robot or human-chatbot interactions make low-achieving or low-self-esteem students feel less embarrassed and more confident when facing challenges or difficulties (Chiu, Moorhouse, et al., 2023; Yang et al., 2020). This significantly improves students' academic performance (e.g. Kim et al., 2021). The reviewed studies also showed that AI-enabled feedback learning systems improved students problem-solving skills (Mokmin, 2020), communication skills (Hill et al., 2015), self-directed learning capacity (Rodríguez et al., 2021), and creativity (Huang, 2018). AI chatbots enhance students' confidence and reduce their anxiety regarding English learning (Chiu, Moorhouse, et al., 2023; Yang & Shulruf, 2019). Moreover, ChatGPT has the potential to improve the learning outcomes of students when used appropriately. Hence, these four learning outcomes were included in the conceptual framework.

The other outcome is teacher learning and has three areas: working efficiency, teaching competence, and attitude toward AI. The first outcome is related to tasks that can reduce teacher teaching load, such as online classroom management, course enrollment, student attendance (Aldeman et al., 2021), and auto-marking (Fu et al., 2020). This was not supported by ChatGPT and Midjourney; therefore, it was excluded from the framework. Moreover, teaching competence is improved by encouraging teachers' self-reflection, and giving them different (new) ideas and perspectives (Chiu, Xia, et al., 2023), which is supported by ChatGPT. Furthermore, the reviewed studies suggested that most teachers found teaching with these emerging AI technologies (i.e. ChatGPT) fun and interesting. They would like to learn more about technologies and pedagogies (Gunawan et al., 2021; Yau et al., 2022). Thus, only the last two outcomes are included in the framework.

In summary, the conceptual framework driven by the systematic review study of Chiu, Xia, et al. (2023) include six roles in the four key domains and six areas in two learning outcomes. It serves as the initial framework for collecting and analyzing qualitative teacher data. Moreover, ChatGPT and Midjourney are new to school teachers. Teachers' views on education are more likely to add and revise the roles or themes in the framework.

3. This study and method

3.1. Research gap and goal

GenAI is new to educators and institutions. In the education sector, most of the current discussions occur in higher education and focus on policy development and pedagogy. There is a serious lack of relevant studies on what future education should be, particularly in schools. GenAI is emerging, interfering, and disruptive, thus offering opportunities to advance our education or reinforce innovative practices, as well as challenging schools, teachers, and students. Teachers' perspectives are crucial for making sense of any innovative technology (ChatGPT and Midjourney as GenAI in this study) for learning, teaching, assessment, and administration (Yau et al., 2023). Accordingly, this qualitative study aims to investigate how GenAI, more specifically ChatGPT and Midjourney, changes our school education from a teacher's perspective. Accordingly, the main research question is:

How do ChatGPT and Midjourney as GenAI impact school education in the four key educational domains – learning, teaching, assessment and administration – and learning outcomes, from the perspectives of teachers and leaders?

3.2. Participants and data collection

The participants were school teachers and leaders. Participants with different backgrounds are likely to perceive different views about how to use GenAI – ChatGPT and Midjourney – in education and how it changes our education. Therefore, purposeful sampling was used to select participants to collect different views (Tongco, 2007) from 30 primary and secondary schools. Schools have

different backgrounds in terms of students' academic ability (from weak to strong academic performance) and have joined a funded project related to AI and education. Two to four teachers were recruited from each school, resulting in 88 teacher participants. Their ages ranged from 25 to 59 years old; 43 of them were female and 45 were male. Fourteen of them were English Language teachers, 12 were Chinese Language, 13 were mathematics, 13 were science, 14 were humanities, 14 were technology, and 8 were art, physical education, and music. Moreover, thirty-nine of them were school leaders (i.e. subject panel, vice-principal or principal).

Before collecting the qualitative data, all participants attended one 2-hour seminar and two 3-hour workshops on ChatGPT and Midjourney run by the project leader. In the seminar, the leader explained what AI technologies, including GenAI, are, how they process data, and what ethical issues and impact they make on our society. In the workshops, the participants explored promoting with ChatGPT, and Midjourney, and shared how their promoting techniques. They also discussed how they used them in teaching and learning, and shared some of their concerns. This arrangement was to ensure that they had a very good understanding of what GenAI, ChatGPT, and Midjourney are and how to use them in classrooms and schools. This study used two stages to collect the participants' views. First, the participants completed an open-ended question survey to express their views on the four key domains and two major learning outcomes suggested in the conceptual framework (Chiu, Xia, et al., 2023). They were asked to focus on changes in school education. The survey also collected their concerns about using ChatGPT and Midjourney in school education. It was expected to be completed within 60 min. After the survey, the project leader and two research assistants conducted and audio recorded 14 focus groups with the participants (mean duration: 86 min). The focus groups were purposefully assigned to the participants. Participants in the groups were of various teaching disciplines and genders. The group size was 4–5. Before conducting the focus groups, the project leader read what the participants filled in the survey to prepare follow-up questions. During the focus groups, participants were free to share their views on the 12 roles suggested in the conceptual framework, and the project leader asked the prepared questions to clarify what they wrote or said.

3.3. Data analysis

Because GenAI is new to educational researchers, new ideas or features are expected to be revealed by the participants. To analyze the data to identify ideas, it uses a hybrid inductive and deductive thematic analysis that summarizes key features across the datasets by highlighting differences and similarities. It identifies themes related to the conceptual framework and helps researchers to develop new themes. This analysis approach is a useful method to inform policy and pedagogies (Braun & Clarke, 2006), as researchers produce clear and organized results. Moreover, the sample size of 88 in this study is sufficient to generate codes for thematic analysis (Ando et al., 2014). This study used the following four steps to analyze the data, which were used to analyze qualitative data in AI curriculum planning (Chiu & Chai, 2020).

- Step 1: Examining data: The research team, which includes the project leader and two research assistants, is familiar with the survey and focus group data. The authors used a framework to generate the initial codes. One research assistant annotated the data using the codes.
- Step 2: Generating themes: Another research assistant reviewed all annotated data by examining codes and identifying any differences in interpretation. The project leader acted as a mediator of any differences in interpretation. Finally, they generated the initial themes and subthemes.
- Step 3: Reviewing themes: They used a cycle process to determine if they could group or split all themes and subthemes.
- Step 4: Naming themes: The research team defined and named the themes to make them more meaningful.

Table 1. The results of thematic analysis.

Theme	Subtheme	Excerpts in the focus group
1. Student learning	1.1. AI education in schools	<ul style="list-style-type: none"> • All students should learn AI • AI literacy is a new skill and language students need for future. • AI is a prerequisite knowledge for learning with ChatGPT. • Students should understand how ChatGPT and Midjourney work, and process data. • Students should know the ethical and moral issue raise by GenAI (e.g. Midjourney).
	1.2. Critical reasoning and thinking	<ul style="list-style-type: none"> • Critical reasoning and thinking gets more important in school education than before. This thinking helps students evaluate the information given by ChatGPT and Midjourney in a critical manner • Students with good critical thinking can curate the information provided by GenAI. • Only students with weak critical thinking are unable to learn with ChatGPT effectively • Teachers must explicitly put this thinking in the curriculum / before introducing ChatGPT and Midjourney in classrooms
	1.3. Digital, media and information literacies	<ul style="list-style-type: none"> • Students should have good technical and cognitive abilities to access, evaluate, create, and communicate needed information by utilizing digital media platforms for a task when accessing and learning with ChatGPT. • Students need to have an instant or immediate judgment on the information whether they are generated by GenAI (e.g. Midjourney). This goes beyond critical thinking. • Digital literacy often is mentioned in schools. Media and information literacies are very important, but less focused in schools. The literacies have some overlapping. All students should acquire the three literacies for using GenAI (e.g. ChatGPT and Midjourney)
	1.4. Generic skills development	<ul style="list-style-type: none"> • Traditionally, disciplinary knowledge such as reading, writing, and arithmetic skills are major learning outcomes. This is driven by public examinations, and parents' expectations. Therefore, generic skills are not explicitly developed in schools. • GenAI (ChatGPT and Midjourney) highlight the importance of generic skills. • Nurturing generic skills are the jobs of all teachers. • Generic skills are long life skill, and benefit students' future work and studies • I will foster generic skills explicitly in my classrooms
2. Teacher learning	2.1. Teacher curriculum leadership	<ul style="list-style-type: none"> • I think the prerequisite knowledge for learning with ChatGPT includes AI literacy, critical thinking, and disciplinary knowledge; so, the whole school curriculum needs to be revised. • I think the school time table needs to be revised. • Some assessments for the prerequisite knowledge are required for effective learning with GenAI.
	2.2. Teacher AI literacy	<ul style="list-style-type: none"> • We all need to learn AI, and need to understand how GenAI (ChatGPT and Midjourney) work. • I need to learn AI Ethical and moral issues • With good understanding of AI, I feel more confident to use GenAI in classrooms. And I am able to choose the right tools • I can understand the pros and con of ChatGPT. • Understanding the limitation of ChatGPT is important.
	2.3. Teacher facilitating skills	<ul style="list-style-type: none"> • We need to change the way how we facilitate student learning or discussions. • We should enhance student questioning skills to ask ChatGPT and Midjourney useful questions, instead of guiding students to complete subject-oriented tasks. • ChatGPT could give answers or solutions to student quicker than I am (mathematics). • We should encourage students to ask better questions and defend them. • Students should learn how to use different types or levels of questions – boarder and specific, clarify and generalize a concept.

(Continued)

Table 1. Continued.

Theme	Subtheme	Excerpts in the focus group
	2.4. Interdisciplinary teaching	<ul style="list-style-type: none"> • The responses from GenAI are often in an interdisciplinary way. They provide answers that are driven from various resources. • I am not understanding the answers that are partially from other disciplines. • It is good for project-based and STEM learning. • We need more across curriculum activities (interdisciplinary teaching). It is very important.
3.Assessment.	3.1. Assessment approaches	<ul style="list-style-type: none"> • I am a learner when using ChatGPT and Midjourney in classrooms. • Homework is less important. • Project and examinations remain important in schools. • The assessment should be easily accessible to all students. They can assessment their generic skills and prerequisite knowledge anytime and anywhere by themselves.
	3.2. Dimensions of assessment	<ul style="list-style-type: none"> • The assessment for generic skills and prerequisite knowledge should be formal and regular. • The assessment for generic skills become more important than before. However, its assessment is less mature. The skills are not easily to be objectively assessed.
4. Administration	4.1. Effective work with evidence	<ul style="list-style-type: none"> • I do think working with ChatGPT and Midjourney, we can complete routine and labour tasks faster and more effectively. • We (school leaders) need to learn more how ChatGPT help us analyse data for decision making.
	4.2. Attitude of school administrative team	<ul style="list-style-type: none"> • I found many administrative staff are not aware of how powerful ChatGPT and Midjourney (making posters) are • We do not have related workshops for our administrative staff

4. Results and discussions

The final thematic map devised in the results identifies four main themes and twelve subthemes, see [Table 1](#). Our analysis shows that the four key domains cover the two major outcomes proposed in the initial conceptual framework because the participants expressed that students, teachers and administrators would have different prerequisite knowledge and new focused learning outcomes in the four domains. The inter-rater reliability is 0.82.

4.1. Theme 1: Student learning

Theme 1 discusses how GenAI, that is, ChatGPT and Midjourney, changes the teacher participants' views and beliefs about a new learning outcome (e.g. AI literacy), prerequisite knowledge for learning with GenAI (e.g. critical reasoning and thinking, digital, media, information literacies), and the importance of generic skills. GenAI encourages participants to rethink what school education should offer for future learning and the workforce. The analyzed data revealed changes in the following four subthemes:

4.1.1. Subtheme 1.1. AI education in schools

The analysis revealed that both technology and non-technology teachers equally expressed the importance of introducing AI into the school curriculum. AI is often seen as a technology subject; however, most non-technology teachers who are not familiar with AI strongly support the need for AI education for school students. They expressed that young children must understand what AI is, as well as how it works and impacts society. They should understand what ChatGPT can and cannot do. The analyzed data also reflected that AI literacy is a prerequisite knowledge/skill for learning with ChatGPT. Students should understand the source of the information in the responses generated by ChatGPT to their requests. These results are aligned with studies of global educational initiatives that introduce AI in K-12 learning and teaching (Chiu et al., 2022). In AI education, students

should learn three major areas of AI: (1) basic AI technical knowledge – big data, machine learning, and cloud computing; (2) applications of AI – computer vision and speech; and (3) the impact of AI on us and our society – ethical issues and the future of work (Chiu et al., 2022). This subtheme suggests that AI should be taught to all citizens, as more applications of GenAI will be integrated in our daily life, such as word processing and financial investment.

4.1.2. Subtheme 1.2. Critical reasoning and thinking

All the teacher participants expressed that critical reasoning and thinking are also prerequisite skills when learning with ChatGPT. In future classrooms, they are expected to enhance students' ability to critically evaluate disciplinary information from ChatGPT, instead of providing them with facts and knowledge. They also stated that a foundation course or module should be included in the early years of school education. Students should be able to learn how to evaluate the information given by ChatGPT in a critical manner and begin to curate the information (Tiili et al., 2023). It is essential for future teachers to teach students critical reasoning and thinking skills in foundational learning.

4.1.3. Subtheme 1.3. Digital, media and information literacies

In the analyzed data, the participants expressed that some essential skills that fall into the intersection of digital, media, and information literacies are very important for school students in the GenAI-based world. Digital, media, and information literacy have overlapping skills. For example, students should have good technical and cognitive abilities to access, evaluate, create, and communicate needed information by utilizing digital media platforms for a task when accessing and learning with GenAI applications, such as ChatGPT and Midjourney. For example, not all pictures on the Internet are true as they could be generated by Midjourney; not all articles have the correct content as they could be generated by ChatGPT. These skills go beyond critical reasoning and thinking and enable an instant or immediate judgment on the information whether they are generated by GenAI (Cooper, 2023; Dwivedi et al., 2023). In this study, individuals with good skills in the interaction between digital, media, and information literacy had a high level of awareness of GenAI information, while individuals with good critical reasoning thinking skills were more likely to assess the information from their disciplinary knowledge.

4.1.4. Subtheme 1.4. Generic skills development

Education policy and research have highlighted the importance of students' generic skills development (such as lifelong learning skills and twenty-first century skills) in school education; however, practically, most teachers and students tend to care for disciplinary knowledge such as reading, writing, and arithmetic skills as major learning outcomes, particularly in Eastern cultures (Kwok, 2004). This is driven by public examinations, university admission academic requirements, parents' expectations and so on. Some teacher participants expressed nurturing generic skills often runs in a slogan mode, that is, as a side product of their teaching. This subtheme is supported by subtheme 1.2 and 1.3. For example, enhancing digital or information literacy is seen as a technology teacher's job, but not non-technology teachers; creativity is seen as an art/STREAM teacher's job, but not mathematics or science teachers. The analysis shows that ChatGPT and Midjourney changed the views of most teacher participants about the importance of generic skills. They expressed that all subject teachers should nurture students' generic skills together with a strategic plan. Generic skills will benefit students' future work and studies, which is aligned with the contemporary education (Chiu et al., 2022; Dwivedi et al., 2023; Rahman & Watanobe, 2023). In other words, GenAI enhanced teachers' beliefs about students' generic skills. These skills have become more important since the appearance of GenAI.

4.2. Theme 2: Teacher learning

Theme 2 concerns teacher learning and discusses what teacher participants need for future classrooms that are GenAI-based and driven. All the participants expressed that ChatGPT and Midjourney were so powerful in producing articles, essays, and artwork. They all want to know how to work and learn more about other GenAI applications. The analysis shows that teacher capacity should include curriculum leadership, AI literacy, new facilitating skills, and teacher beliefs about their interdisciplinary teaching.

4.2.1. Subtheme 2.1. Teacher curriculum leadership

Most participants expressed that taking students' prior knowledge, skills, and feelings into account when using ChatGPT and Midjourney in classrooms is necessary. Prior knowledge includes disciplinary, digital literacy (e.g. judging whether a website is official or reliable), and AI literacy; the skills include reading, questioning, and clarifying skills; and the feelings are related to students' attitudes toward and connections with the applications. This indicates that students effectively learn with ChatGPT after they acquire appropriate cognitive knowledge skills and have positive attitudes. These results are explained by three psychological needs in Self-determination Theory (SDT): autonomy, competence, and relatedness (Ryan & Deci, 2020). When learning with ChatGPT and Midjourney, students have the freedom to choose what to ask and answer. These could support the student's need for autonomy (Chiu, 2021, 2022); that is, using the two GenAI applications in teaching and learning generally satisfies this need. Moreover, students' prior knowledge and skills were strongly associated with their mastery experience and were effective in learning activities with the two applications (Chiu, Moorhouse, et al., 2023). In other words, the applications are more likely to satisfy the need for competence of students who hold higher levels of disciplinary and/or AI knowledge and skills. The last need is relatedness. Students who find applications fun and connected are more likely to be satisfied with their relatedness. Hence, according to SDT, the two applications better satisfy the needs of students with higher learning abilities and more positive attitudes toward GenAI. This is aligned with most of SDT-based students on digital education (Chiu, 2021, 2022; Hartnett, 2015; Trenshaw et al., 2016). Compared with university students, school students are less mature; most of them are less likely to learn effectively with ChatGPT by themselves (Chiu, 2022). Can these applications benefit all students in a classroom? Will the applications widen the digital divide and cause educational inequality? Addressing diversity in learning is important for school education. School leaders should strategically plan or redesign curricula to address learning diversity when introducing GenAI in schools.

4.2.2. Subtheme 2.2. Teacher AI literacy (including ethics and moral issues)

The analyzed data showed that all teachers should have good AI literacy based on the participants' views. Most participants expressed that they were more interested in learning GenAI than non-GenAI applications (such as learning management systems and instant response systems) for learning and teaching in classrooms. They found that GenAI applications are more useful in classrooms; therefore, they want to learn more about their development and affordances. They also expressed that students and teachers could have better communication and interaction with applications. However, the participants also had concerns about ethical and moral issues brought about by the applications and the reliability of their responses given by the applications. To address these issues, they expressed that all teachers should have good AI literacy to understand how ChatGPT and Midjourney work. This is supported by one of the major ethical principles of transparency (Chiu et al., 2022; Long & Magerko, 2022). Teachers should be able to understand how GenAI applications work, thereby effectively supporting classroom teaching and learning. This implies that AI should be included in teacher education. In future education, GenAI will be included in teaching (Zawacki-Richter et al., 2019); hereby, AI education should be provided to pre- and in-service teachers (Yau et al., 2022).

4.2.3. Subtheme 2.3. Teacher facilitating skills

This sub-theme concerns the need for changes in teacher-facilitating skills. The analysis shows that teachers' facilitating skills should focus on enhancing student questioning skills to ask ChatGPT useful questions, instead of guiding students to complete subject-oriented tasks. Teachers should encourage students to ask better questions and defend them. This learning is precisely how scientists and researchers work (Seymour et al., 2004). When interacting with ChatGPT, students were required to use different types or levels of questions. Students should be able to use broader or more specific questions to clarify or generalize a concept, and to challenge the responses from ChatGPT by using questions. This result is aligned with Fung (2014) study suggesting using questioning skills better foster critical thinking skills. This result indicates that professional development programs should enhance teachers' questioning skills and their capacity to develop student questioning skills in GenAI-based learning environments.

4.2.4. Subtheme 2.4. Interdisciplinary teaching

This subtheme suggests that ChatGPT encourages teachers to adopt interdisciplinary teaching. This GenAI application responds to students' questions in an interdisciplinary way and provides answers that analyze data retrieved from various resources (Miao & Ahn, 2023). This indicates that the answers can be formed from different disciplines or perspectives. This interdisciplinary teaching is aligned with the advocacy of real-world problems or authentic learning in schools, e.g. STEM education, (Lin et al., 2019). School students are expected to apply what they have learned from different disciplines to solve complex problems. The GenAI application encourages teachers to break the boundaries of disciplines to deliver more interdisciplinary instruction in classrooms. This indicates that GenAI enhances teachers' beliefs about interdisciplinary teaching by identifying its needs and benefits.

4.3. Theme 3: Assessment

This theme discusses how ChatGPT and Midjourney change teachers' views on assessment, resulting in two subthemes: approaches and dimensions of assessment.

4.3.1. Subtheme 3.1. Assessment approaches

In this subtheme, the two major assessment approaches are formative and summative. The analyses showed that ChatGPT changed the participants' views on the importance of different approaches in formative and summative assessments. Seven formative assessment approaches were discussed in the focus groups. They were (1) homework exercises as a review for class learning, (2) observations during in-class activities, (3) reflection journals, (4) spontaneous question and answer sessions, (5) meetings between teacher and student, (6) informal student sharing/presentation, and (7) student self-evaluation of performance and learning progress (Bennett, 2011; Buck & Trauth-Nare, 2009). The analysis shows that only the first approach of formative assessment becomes less important, while the importance of the other approaches remains unchanged. However, in schools, the majority of formative assessments adopt a homework exercise approach. The appearance of ChatGPT encourages teachers to adopt the last six approaches. This subtheme suggests that school teachers and parents should expect less home exercises. However, the feedback from the six approaches is less visible or explicit, and students may not feel that they receive feedback from teachers. Therefore, teachers should provide more visible feedback; students should be able to assess the skills and knowledge anytime and anywhere by themselves.

In the focus groups, the major types of summative assessments discussed were examinations and projects (Black et al., 2011). The analyses revealed that ChatGPT and Midjourney did not change teachers' views of their importance in school education. Participants expressed that K-12 is a universal education that everyone should receive. There should be a baseline for the knowledge and skills

required for future living, study, and work; therefore, a summative assessment that is seen as performance evaluation is necessary. However, the participants highlighted that ChatGPT and Midjourney changed the learning outcomes of the school students. This is discussed in the next subtheme.

4.3.2. Subtheme 3.2. Dimensions of assessment

The analysis revealed that what and how to assess student learning outcomes in school education should be revisited and revised. The participants expressed that more effort is needed to foster students' development of generic skills, particularly for digital literacy, critical thinking, and creativity. This is suggested by Subtheme 1.4. This is because ChatGPT provides better disciplinary knowledge, and stronger generic skills are needed for future work in the GenAI world. Disciplinary knowledge and generic skills are the major learning outcomes in school education. They are both important for student growth; however, most school teachers, students, and parents tend to focus on the assessment of disciplinary knowledge due to university admission or career prospects, particularly in Eastern culture (Kwok, 2004). These results advocate a more formal assessment of generic skills.

The analysis also showed that schools should have regular and formal assessments of AI, digital literacy, media literacy, and critical thinking. The participants explained that literacies and thinking are the prerequisite knowledge for learning with ChatGPT and Midjourney. Teachers and students should keep refreshing them and understand their capacity to learn using GenAI applications.

This subtheme further revealed that teachers should use more oral rather than written examinations/tests, as GenAI can create texts, images, audios, videos, audio, and 3D models more effectively. For example, homework exercises may become less important because GenAI can provide solutions and answers for homework tasks/exercises. In future classrooms, students may use GenAI to assist their learning, that is, GenAI creates/provides the necessary written information to them. Written in-class activities may not be necessary; however, students should be able to orally present their ideas or what they learn from GenAI to their peers and teachers (Tlili et al., 2023).

4.4. Theme 4: Administrative work

This theme discusses the opportunities and obstacles to using GenAI in school administrative tasks, resulting in the following two subthemes:

4.4.1. Subtheme 4.1. Effective work with evidence

Both school leaders and teachers recognized the use of ChatGPT and Midjourney in school administrative work. They can improve the performance of school offices by completing routines and laboring tasks (Khan & Alotaibi, 2020; Li, 2021; Tang & Hai, 2021). The participants highlighted that the tasks can be completed by the two GenAI applications, for example, generating a draft of emails for responding to parents' inquiry, a draft of the proposal for a replicated project, and a poster for a school event. Moreover, the participants also suggested that ChatGPT could support school educational decision-making with evidence and recommendations. For example, what activities should be used by students with attention deficit hyperactivity disorder? What is a positive educational policy? This is because ChatGPT can provide analyzed data from different resources as evidence or recommendations to the management team for decision-making.

4.4.2. Subtheme 4.2. Attitude of school administrative team

Although ChatGPT sounds promising in school administrative work, the analyses show that schools are old fashion and hardly use any AI/advanced technologies to assist administrative work. Teachers are more excited to use them in learning and teaching but not in administrative offices. This phenomenon is different from business and technology sectors that start/plan to use GenAI to

simplify administrative processes by completing clerical and routine work. A plausible explanation is that many sharing or training sections are offered to teachers but not administrative teams. Most GenAI sharing in an education field focuses on how to use them to support learning and teaching. There is a serious lack of GenAI training in the school administrative teams. This indicates that the school administrative team lacked relevant knowledge and held less positive attitude than those in the business sector.

5. Implications for practices and policies in schools

This qualitative study aimed to investigate how GenAI changes school education from the perspectives of teachers' and leaders.' These findings suggest that ChatGPT and Midjourney have changed teachers' views and beliefs about education in the GenAI world. They have three implications for practice and three for policy in school. They also suggested future research directions for GenAI in education.

5.1. Implications for practices

Know-it-all attitude: Professional teacher programs should promote learn-it-all, instead of know-it-all attitude, to improve teachers' facilitating skills and interdisciplinary teaching (subtheme 2.3 and 2.4). In classrooms, teachers are often viewed as subject experts, and students would ask them questions when facing difficulties with the subjects. They provided the final answer in the classroom. However, ChatGPT would provide quicker and more accurate responses to students' questions, as it adopts both learn-it-all and know-it-all approaches to improve the accuracy of the responses. In other words, ChatGPT provides some information or interdisciplinary knowledge that teachers do not know. Therefore, teachers should hold a learn-it-all attitude aligned with the growth mindset. Teachers with a growth mindset are more likely to adopt new technology and innovative practices in classrooms (Dillon et al., 2019). Teachers should be humble and willing to co-learn with students in the classroom. This implies that learn-it-all teachers are more likely to facilitate student learning or promote interdisciplinary teaching with GenAI.

New prerequisite knowledge: The findings suggest that AI, digital, and media literacies, and critical thinking skills are the major prerequisite knowledge for learning with GenAI (subtheme 1.1, 1.2, 1.3). The school curriculum should be reformed when introducing GenAI into classrooms (Subtheme 2.1). Schools should redesign their curricula to introduce foundation courses to help students master these skills before they learn with GenAI. These courses determine the effectiveness of GenAI in student learning. Students with these skills are more likely to learn with GenAI, and those lacking these skills receive information from GenAI. Schools are recommended to run courses regularly to refresh students' skills.

Interdisciplinary teaching: To meet the needs of future education and workforce in the GenAI world, more interdisciplinary teaching is needed to break the boundaries of subject-oriented teaching, particularly in secondary schools (subtheme 2.4) (Chiu et al., 2022). The current literature provides some implementation approaches to interdisciplinary teaching, such as design thinking, STEM learning, and real-life problem centering (Cross Francis et al., 2019; Lin et al., 2019). It has been suggested that teachers use GenAI to promote interdisciplinary teaching.

5.2. Implication for policy development

New assessment: The findings of subtheme 3.1 and 3.2 suggest that new dimensions and approaches to assessment are needed for schools when GenAI is used in classrooms. First, the assessment of prerequisite knowledge (such as critical thinking, disciplinary knowledge, inquiry-based questioning skills, and AI literacy) is needed to inform teachers if their students are ready to use ChatGPT and Midjourney in learning (Chiu, Moorhouse, et al., 2023). Chiu, Moorhouse, et al. (2023) revealed that school students with appropriate digital literacy and prior subject knowledge

are only able to learn language with AI-based chatbots; those without are more likely to disengage in the learning. Second, generic skills should be assessed more often in classrooms. Although schools advocate generic skill development, they focus on assessing students' academic performance. This may be because academic performance can easily be measured using traditional tests and examinations. Generic skills are often measured through rubrics and observations. Hence, this study suggests that a generic skill-assessment platform should be developed. Students can assess their skills by themselves using the platform at any time.

AI education: AI education should be offered to all students and teachers. Although AI education in schools has become a global initiative, it is not seen as a traditional core subject, such as language, mathematics, and science (Chiu & Chai, 2020). Many teachers and students still see this as an elective technology subject. However, the future workforce requires a better understanding of AI to work with GenAI. This finding is aligned with projects on AI for K-12 in different regions (Chiu & Chai, 2020; Xia et al., 2022). The findings further suggest that AI should be seen as a core subject in school education, as students are more likely to learn any subject with GenAI. GenAI is a learning partner for school students and teachers.

Professional standards for all school employes: Findings from subtheme 2.2, and 4.1. and 4.2, suggest that AI and media literacy should be explicitly added to or included in professional standards for teachers and leaders. Unlike digital literacy, this literacy is new to schools. These standards serve as useful reference anchors for the teaching profession for teacher preparation, continuing professional development, and school leadership development. They should be forward-looking expectations of how teachers and leaders support the needs of contemporary education and nurture students today to become leaders tomorrow. These findings suggest that standards should include AI ethical and moral issues, big data and machine learning (AI literacy), and critical thinking and power of information and communication (media literacy). It encourages (i) teacher training institutions to revisit their programs to add a foundation course related to AI and education – AI knowledge – and use AI to support learning and teaching; and (ii) the education bureau runs relevant workshops with assessments for in-service teachers, leaders, and staff. These standards will benefit students, teachers, and school learning and growth in the future.

5.3. Future research direction

The discussions in the implications also suggest future research directions for school and teacher education in the future GenAI world. We identified six future research directions to prepare schools to address the challenges brought about by future GenAI classrooms.

- Most assessments of generic skills are subjective and involve teacher observations. This study suggests that educational research should create self-assessment tests by using scenarios or cases. Students can regularly assess their critical thinking skills.
- AI education is new to schools and its literacy assessment requires further study. Research on AI literacy tests is required, particularly for AI ethics and machine learning. Machine learning allows students to understand how AI works, and ethics allows students to learn with AI safely.
- Interdisciplinary teaching is important in GenAI classrooms; therefore, innovative curricula for schools are needed. We suggest that future studies propose and evaluate new standards and curriculum frameworks for interdisciplinary teaching in schools.
- New literacies such as AI, digital, and media literacy are more likely to be major outcomes for school students. Future research should investigate a new literacy model for schools.
- More AI training for schools, including teachers, leaders, and administrative staff, is required. Current training is scattered and lacks consistency. We suggest that future research should investigate how to design holistic AI education for the entire school, as AI is an emerging technology.
- Pre-service teacher training programs need to be revamped, as AI is a new literacy for teacher teaching; therefore, future research should revise technological, pedagogical, and content

knowledge as one of the key models in teacher training institutions. by adding AI elements. The revised model will benefit teacher educators in designing their programs for contemporary teachers.

6. Conclusions and limitations

This study could be the first empirical study to understand the impact of GenAI on school education from the perspectives of teachers' and leaders.' The findings provide a comprehensive overview of the use of GenAI across the four key educational domains – teaching, learning, assessment, and administration – with consideration of various prerequisite knowledge and outcomes. This study has three major limitations. First, this study was conducted in an eastern cultural region; teachers in the western region may perceive differently; future studies should conduct comparative studies to understand how GenAI impacts school education. Second, as GenAI is new, not all participants have rich experience in learning and teaching with the technology. They may change their perceptions after the integration of GenAI into classrooms. Future research should be done to compare how teachers think. Last, Midjourney is a text-to-image AI generator, which is included latest ChatGPT. Future studies should be conducted for specific functions of GenAI.

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