STEM Education

STEM Education, 6(1): 1–20
DOI: 10.3934/steme.2026001
Received: 11 July 2025
Revised: 29 October 2025
Accepted: 08 December 2025
Published: 05 January 2026

https://www.aimspress.com/journal/steme

Research article

Exploring the benefits and challenges of AI-driven lesson planning among preservice science teachers

Chua Kah Heng[1], Renuka V Sathasivam[2,*], Nofouz Mafarja[3] and Suzieleez Syrene Abdul Rahim[4]

[1] Department of Mathematics and Science Education, Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia; chuakh@um.edu.my
[2] Department of Mathematics and Science Education, Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia; renukasivam@um.edu.my
[3] Department of Mathematics and Science Education, Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia; nofouz@um.edu.my
[4] Department of Mathematics and Science Education, Faculty of Education, Universiti Malaya, 50603 Kuala Lumpur, Malaysia; suzieleez@um.edu.my

*** Correspondence:** Email: renukasivam@um.edu.my; Tel: +60379675085.

Academic Editor: Muhammad Younas

Abstract: The integration of generative artificial intelligence (AI) tools into education has gained momentum, yet their role in teacher education remains underexplored. This study investigated how preservice science teachers engage with ChatGPT during lesson planning and the perceived benefits and challenges of its use. Fourteen postgraduate chemistry education students were tasked with designing lesson plan using AI assistance and subsequently completed open-ended questionnaires reflecting on their experiences. Thematic analysis revealed two overarching themes: Perceived benefits included support in structuring lesson content, organizing instructional flow, generating activities, and saving time. However, participants also identified key challenges such as the need for precise prompting, occasional factual inaccuracies, misalignment with the Malaysian curriculum, and impractical suggestions. The findings highlight that while ChatGPT can serve as a valuable cognitive scaffold and pedagogical partner, its effectiveness is constrained by users' critical literacy and contextual judgment. This study underscores the necessity of integrating AI-pedagogical literacy into teacher education programs, enabling future educators to use AI tools reflectively and responsibly. Rather than replacing professional expertise, generative AI tools such as ChatGPT should be framed

as augmentative resources within a broader pedagogical framework.

Keywords: lesson plans, preservice teachers, science education, ChatGPT, AI-driven

1. Introduction

Artificial intelligence, commonly known as AI, has become a common term in the educational sector [1]. The integration of AI in education has changed the landscape of teaching and learning. With AI, educators do not only produce the intended output but are also given suggestions and alternative options to choose. AI technology challenges educators to evaluate and make judgment of the choices provided by AI. These advancements suggest that AI is no longer peripheral to teaching it is becoming a potential co-participant in pedagogical decision-making.

In Malaysia, the integration of artificial intelligence (AI) in education is closely aligned with national aspirations for digital transformation and 21st-century skill development. The Malaysia Education Blueprint 2013–2025 emphasizes the cultivation of higher-order thinking, creativity, and innovation through technology-enabled pedagogy. Complementing this vision, the National Artificial Intelligence Roadmap 2021–2025 and the Digital Education Policy 2023 outline the government's commitment to embedding AI across educational ecosystems to enhance teaching and learning efficiency. Within this policy landscape, teacher education institutions are increasingly expected to prepare future educators who can effectively integrate digital tools into their instructional practices while maintaining alignment with the Dokumen Standard Kurikulum dan Pentaksiran (DSKP).

The Malaysian chemistry curriculum under the Sijil Pelajaran Malaysia (SPM) framework is designed to foster scientific reasoning, inquiry-based learning, and contextual understanding of scientific concepts. Lesson planning, therefore, plays a critical role in ensuring that teaching objectives are aligned with these curriculum standards and learning outcomes. However, preservice teachers often struggle to balance pedagogical design, content accuracy, and curriculum compliance challenges that may be amplified when using generative AI tools such as ChatGPT. While AI can provide structured templates and suggest instructional ideas, its lack of contextual awareness often results in outputs that are misaligned with local curricular expectations. This tension underscores the necessity of developing pedagogical literacy that incorporates both digital competence and contextual judgment within the Malaysian education system.

Despite the government's efforts to promote digital and AI competencies, AI literacy has yet to be formally integrated into teacher preparation programs. As a result, preservice teachers' engagement with AI during lesson planning remains largely self-initiated, exploratory, and unsupported by formal pedagogical frameworks. Examining how Malaysian preservice science teachers interact with AI during authentic lesson design tasks thus provides critical insights into the opportunities and constraints of AI-driven pedagogical innovation within the nation's evolving educational landscape.

Despite the growing presence of AI in education, its integration into teacher education programs remains uneven. Many preservice teachers are introduced to digital tools, but few receive formal guidance on how to use AI specifically in instructional design. Preservice science teachers are those novice teachers that have just been introduced to the teaching philosophy and pedagogy. They are still in the learning process to balance pedagogical knowledge and specific science content

knowledge [2]. Lesson planning is a central component of preservice teacher education, serving as both a practical and reflective activity through which novice teachers develop instructional coherence and pedagogical judgment. It plays a key role in translating subject matter knowledge into teachable content and aligning learning goals with activities and assessments [3,4].

Lesson planning can be defined as a structured pedagogical process through which teachers translate curriculum standards and learning objectives into sequenced, meaningful instructional experiences [3,4]. It encompasses not only the procedural organization of lessons but also reflective and creative decision-making that shapes how knowledge is represented to learners. In the context of generative AI, lesson planning is increasingly seen as a co-creative process, where the teacher's professional agency and pedagogical vision mediate between algorithmic outputs and instructional reality. Rather than merely automating content generation, GenAI tools invite teachers to exercise critical judgment, adapt suggestions, and negotiate their professional identities as designers of learning. This intersection raises important questions about teacher creativity and autonomy: whether AI functions as an assistant or as a constraining influence on teachers' reflective and imaginative work [10]. Consequently, lesson planning in the AI era is not only a technical task but also a site of pedagogical negotiation, where human expertise, ethics, and creativity remain central.

Hence, constructing a holistic lesson plan that covers all the elements within the lesson plan might be very challenging for the preservice teacher. Various challenges might be faced by preservice teachers when it comes to planning lessons. For instance, aligning lessons with curriculum standards, addressing the diverse needs of students, and managing and allocating time effectively [2–5]. Moreover, the lesson plan that they design may not consider real-life situations of a classroom setting as they lack experience in that area.

Introducing AI to assist preservice science teachers in lesson planning might be a feasible solution because AI can generate and provide suggestions for routine tasks as science teachers are constructing their lesson plans. For instance, AI generative tools can assist science teachers to find suitable resources for teaching and learning, align the lesson with the curriculum standards, language and grammar checking, as well as creating worksheets and assessment questions [6]. This allows the preservice science teachers to have more time to handle critical and higher order thinking tasks such as adopting the science content to meet the needs of diverse students. The reduction in more administrative tasks might reduce the load of preservice science teachers and allow them to pay more attention to designing more creative instructional materials and learning activities [1].

As a result, while AI has the potential to support key teaching practices such as lesson planning, reflection, and resource development, its role in the professional formation of new teachers is still underexplored [7,8]. Despite growing interest in the role of AI in education, research on how preservice teachers, particularly in subject-specific contexts like science, interact with generative AI tools during authentic instructional design tasks remains limited. Existing studies tend to focus on the technological affordances of AI or present speculative arguments about its classroom potential, often without attending to the nuanced pedagogical challenges faced by novice teachers [9,10]. Furthermore, there is a notable absence of empirical work capturing the lived experiences, reflective insights, and professional dilemmas that emerge when preservice teachers use tools like ChatGPT for lesson planning. This gap is especially relevant given the epistemic tensions between automated content generation and the situated, ethical, and reflective nature of pedagogical design.

The present study addresses this underexplored area by examining how preservice science

teachers engage with AI-driven lesson planning, what benefits and constraints they perceive, and how these tools shape (or fail to shape) their developing instructional thinking. Two research questions are (i) How do preservice science teachers describe the ways in which ChatGPT supported their lesson planning? (ii) What specific challenges do preservice teachers encounter when using ChatGPT for lesson planning?

2. Literature review

Lesson planning can be defined as the deliberate process through which teachers design, organize, and sequence learning experiences to achieve specific instructional goals [3,4]. It involves aligning curriculum standards with pedagogy, anticipating learner needs, and selecting appropriate assessment strategies. Beyond a technical exercise, lesson planning reflects teachers' pedagogical reasoning and their ability to transform subject matter knowledge into teachable content while considering students' prior knowledge, motivation, and context [6]. In teacher education, lesson planning serves as both a cognitive apprenticeship and a professional identity-building activity, as preservice teachers learn to think like educators by translating abstract educational theory into classroom practice.

While generative AI tools hold promises as valuable aids in lesson planning, it is essential for higher education faculty to exercise caution when introducing these tools to preservice teachers. Before these future educators can effectively integrate AI into their instructional practices, they must first develop a clear understanding of the tools' value and limitations [16,17]. For instance, ChatGPT-generated lesson plans frequently contain issues such as incomplete components or inaccurate information. Therefore, cultivating a critical and reflective stance toward AI-generated content is crucial. Preservice teachers must be guided in understanding not only the appropriate contexts and purposes for using generative AI, but also how to critically evaluate and refine its outputs. A scaffolded instructional approach can support this learning process, helping them to build the necessary skills incrementally. Additionally, they will require targeted instruction on how to align AI-generated lesson content with local curricular standards and educational objectives. Research conducted in higher education settings has indicated that students begin to acknowledge significant concerns surrounding accuracy, data privacy, ethical use, and the implications of AI on their professional identity and growth [18].

Within the context of generative AI, lesson planning is no longer solely a human-centered design task but a collaborative cognitive process between teacher and technology. This raises questions about authorship, creativity, and pedagogical control. When AI suggests content structures or learning activities, the teacher's role shifts from originator to curator and evaluator of pedagogical ideas. This dynamic redefines the boundaries of teacher agency teachers are still central decision-makers, but their creative and professional judgment becomes mediated through algorithmic suggestions. Hence, AI-driven lesson planning invites a re-examination of what it means to be an autonomous and reflective practitioner in a technologically augmented teaching environment [10,13].

ChatGPT has emerged as the most rapidly adopted tool of its kind [11]. Its open-access model has sparked widespread attention within educational circles [12], helping to democratize access to AI across various learning environments [13]. Notably, many recent graduates from teacher education programs report a willingness to use ChatGPT for lesson planning, highlighting the urgency of equipping preservice teachers with the skills and knowledge to use such tools ethically and effectively [14,15]. In addition to ChatGPT, educators now have access to a growing range of

generative AI tools designed to support lesson development, including platforms such as LessonPlans.ai, MagicSchool.ai, Google Gemini, and Microsoft Copilot. The widespread availability of these tools has prompted scholarly inquiry into their effectiveness, as researchers seek to evaluate both the benefits and limitations of using generative AI for complex instructional tasks like lesson planning. As a result, a significant body of research has emerged in recent years. The following section provides a synthesis of key findings from generative AI lesson planning studies published in 2023 and 2024.

Initial outputs generated by ChatGPT for lesson planning may not always align with teachers' specific preferences or instructional goals, necessitating ongoing revision and refinement to achieve the desired outcomes [19]. In many instances, the tool produces general or ambiguous references such as unspecified videos or warm-up activities that require further clarification through additional prompting. When prompted for elaboration, ChatGPT can often suggest relevant video resources and offer guidance on how to effectively incorporate them into instruction. This iterative and collaborative process between the educator and the AI tool represents a novel approach to lesson planning and instructional material development one that was not readily available in previous years. However, it is crucial to recognize that ChatGPT is not a fully autonomous solution for lesson planning. Rather, it serves as a supportive tool that can enhance the planning process when used appropriately. The presence and professional judgment of a human teacher remain indispensable for ensuring effective teaching, meaningful learning experiences, and valid assessment practices [20].

In the context of developing high school chemistry lessons, ChatGPT has demonstrated several strengths, including its capacity to generate lesson plan outlines, suggest relevant instructional resources, provide accurate subject content, propose instructional strategies, differentiate material for learners at varying levels, and formulate assessment questions [21]. At the time of this research, ChatGPT 3.5, has notable limitations, particularly in its inability to produce visual aids, presentation slides, or fully developed, detailed lesson plans. While ChatGPT serves as a valuable supplementary resource in lesson planning, it is not a substitute for the professional expertise of educators in creating comprehensive instructional materials. Interestingly, research conducted in Korea examining preservice teachers' use of ChatGPT for designing science lesson plans revealed that these students were already critically evaluating AI-generated content and were able to develop lesson plans with moderate success and minimal faculty intervention [22,23].

Research on the use of generative AI by special education teachers indicates that these tools can significantly enhance the efficiency and quality of the lesson planning process [24,25]. Generative AI holds the potential to promote educational equity by offering various assistive features that support students with disabilities and international learners, thereby contributing to their academic success [26]. By leveraging a range of generative AI tools, educators can create diverse instructional materials including images, text, and videos which may transform the teaching and learning experiences of students with varying needs. However, despite these advantages, the absence of a human element in AI-generated content necessitates careful consideration of empathy, creativity, and the individual needs of students when employing such tools as instructional planning aids [27,28].

Teachers who have incorporated ChatGPT into their lesson planning practices have reported that the tool offers valuable support in enhancing various pedagogical elements, including the development of learning outcomes, fostering student engagement and motivation, and improving teaching strategies and beliefs [29,30]. Nonetheless, the lesson plans generated with ChatGPT have

demonstrated notable weaknesses, particularly in the domains of assessment design and feedback provision [31]. Among the primary concerns expressed by educators are issues related to the accuracy of information and the presence of potential biases. DeCarlo et al. [32] argue that preservice teachers should be encouraged to use generative AI tools to analyze relevant student assessment data as part of the lesson planning process.

In this regard, Sakamoto et al. [33] observed that lesson plans created without sufficient integration of student data lacked instructional adequacy. Cultivating data literacy skills in tandem with the use of generative AI will enable preservice teachers to design more effective, data-informed instruction. However, the use of AI in handling student data raises important ethical and practical concerns, particularly regarding the protection of sensitive information. It is imperative that educators safeguard student privacy and ensure compliance with both state and federal regulations governing data security [25,30,31].

AI could facilitate personalized learning. By analyzing students' learning styles, preferences, and abilities, generative AI enables the customization of lesson plans to meet individual student needs. This tailored approach not only enhances student engagement but also promotes deeper comprehension, thereby improving the overall effectiveness of instruction. Additionally, generative AI serves as a catalyst for creativity. By offering diverse and innovative teaching materials, these tools stimulate the creative capacities of preservice teachers, encouraging them to design lessons that are both pedagogically sound and engaging. Such creativity fosters a dynamic learning environment that captures students' attention and motivates active participation.

Furthermore, generative AI contributes to time efficiency in the lesson planning process. Through the automation of content generation, the suggestion of appropriate teaching methodologies, and the provision of assessment tools, these technologies significantly reduce the time and effort required for planning. This efficiency allows preservice teachers to allocate more time to other critical aspects of their professional growth, such as classroom management and reflective practice [3,10,28,30].

The intersection between AI-driven lesson planning and teacher identity is particularly significant. Teachers' sense of professional autonomy and creativity may be challenged when AI-generated outputs appear to "outperform" their initial ideas. Yet, as participants' reflections show, AI does not replace pedagogical creativity—it extends it by providing scaffolds that prompt new instructional insights. This aligns with emerging scholarship suggesting that teacher agency in the AI era involves the capacity to critique, adapt, and humanize algorithmic outputs [1,10]. Thus, integrating AI into lesson planning should be framed not as a loss of professional control but as an opportunity to redefine teaching as an interpretive and evaluative profession in which human creativity and ethical judgment remain indispensable.

The potential of ChatGPT presents exciting opportunities for pedagogical innovation and creative instructional design [32]. However, despite its promise, it is essential to exercise caution and maintain a critical perspective when integrating such tools into teaching and learning processes, particularly given their known limitations and embedded biases [13,33]. Preservice and student teachers must be equipped with the critical competencies necessary to evaluate the instructional quality and accuracy of AI-generated materials [14,34]. To develop these competencies, teacher education programs should incorporate guided practice in using ChatGPT through two primary methods: first, writing and refining prompts to produce lesson plans that are responsive to students' diverse needs, interests, and cultural backgrounds, and second, evaluating the pedagogical soundness

of AI-generated lessons.

Ethical considerations are paramount; thus, preservice teachers require clear guidance on responsible AI usage, supported by access to AI literacy frameworks [16,20]. As preservice teachers become more proficient in these areas, they are more likely to adopt interactive, AI-powered tools to enhance student learning experiences [35–38]. Nonetheless, preparing future educators to critically and ethically use AI technologies is a multifaceted endeavour that also demands robust professional development opportunities for teacher educators themselves [36,37,39,40–42].

It is equally important to consider learner preferences and perceptions when integrating generative AI tools into educational contexts. Smolansky et al. [43] found that some higher education students express reservations about the use of generative AI, perceiving it as potentially stifling to creativity. The authors argue that educational efforts should move beyond merely teaching technical AI skills, instead focusing on supporting students in navigating the complex interplay among technology, cognition, social interaction, and individual values. In contrast, Chiu [44] reported that many university students are eager to acquire generative AI competencies, recognizing their value in enhancing future employability, particularly as employers increasingly seek applicants with AI-related expertise [41,42].

This underscores a critical institutional responsibility: Universities must equip students with the skills necessary to meet the evolving demands of the workforce, which increasingly emphasize AI literacy and competency [43]. Moreover, fostering positive attitudes toward generative AI among preservice teachers is essential to encourage the adoption of innovative pedagogical practices [44]. Such efforts should be accompanied by an emphasis on holistic development, cultivating personal attributes such as perseverance and grit, which are vital for adaptability and resilience in a rapidly changing educational and professional landscape [45].

A particularly underexplored area is the need for a new form of pedagogical literacy: the ability to prompt AI tools effectively, critically assess the output, and revise accordingly. Without explicit training in these skills, there is a risk that preservice teachers may over-rely on AI-generated content or fail to recognize its pedagogical misalignments. This challenge underscores the importance of studying not only how AI supports instructional design, but also how novice teachers interpret, adapt, reflect on its use in practice.

3. Methodology

This study employed an exploratory qualitative design to investigate how preservice science teachers engage with generative AI tools in the context of lesson planning. The aim was to explore participants' perceptions of the benefits and challenges of AI use, and the processes involved when interacting with AI for pedagogical design. A written open-ended questionnaire was selected as the primary data collection instrument to allow for in-depth, reflective responses while maintaining consistency across participants.

3.1. Participants and context

The participants of this study were fourteen preservice teachers enrolled in the Postgraduate Diploma in Education (PGDE) program with a specialization in chemistry at a leading public university in Malaysia. The PGDE program, accredited by the Malaysian Qualifications Agency

(MQA) and regulated by the Ministry of Education (MOE), aims to prepare graduates with the pedagogical, technological, and professional competencies required for effective classroom teaching. The program combines theoretical coursework with microteaching and school practicum components, aligning with Malaysia's Standards for Teacher Education and Training.

At the time of the study, participants were completing a course on chemistry teaching methods that focused on curriculum design, instructional strategies, and lesson evaluation based on the Dokumen Standard Kurikulum dan Pentaksiran (DSKP) for Chemistry. The DSKP serves as the guiding document for lesson planning and implementation in Malaysian schools, emphasizing scientific inquiry, contextual application, and student-centered learning. Within this framework, preservice teachers are expected to develop lesson plans that align with specific learning standards, assessment criteria, and pedagogical outcomes. Participants were instructed to employ generative AI tools, specifically ChatGPT, to assist in designing a chemistry lesson plan aligned with Malaysian curriculum objectives. While the use of AI in teacher education remains emergent in Malaysia, this study situates itself within the broader national agenda of digital transformation and educational innovation. By exploring how these novice teachers engage with AI to support curriculum-aligned lesson planning, this research contributes to a deeper understanding of AI's pedagogical potential and contextual limitations in Malaysian teacher education.

Following this activity, participants completed a seven-question open-ended questionnaire designed to elicit reflections on their experiences. Example items included: "How did ChatGPT assist you in structuring and organizing your lesson plan? Did it offer helpful suggestions or insights into lesson sequencing and activities? What were they?" and "Reflect on the challenges you encountered while using ChatGPT to develop your lesson plan. What aspects of the process were difficult or frustrating?" Fourteen of the 19 enrolled students voluntarily provided written consent for their questionnaire responses to be included in the study. Ethical clearance was obtained from the university's Research Ethics Committee (Ref. No. UM.TNC2/UMREC_3605).

3.2. Data collection instrument

The open-ended questionnaire was developed by the research team and informed by emerging literature on AI use in teacher education [46]. The instrument included prompts designed to capture participants' evaluations of the AI's usefulness or not, their prompting strategies and the quality of AI-generated suggestions. The instrument on AI was piloted informally with a small group of preservice teachers from a different cohort for clarity and content relevance. Participants completed the questionnaire individually, in writing, after the lesson planning activity. Responses varied in length and depth, reflecting the diversity of perspectives within the cohort.

3.3. Data analysis

The data was analysed using thematic analysis, following the six-phase approach outlined by Braun and Clarke [47]: (1) familiarization with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report. An inductive approach was used to allow themes to emerge directly from the participants' language without imposing pre-existing frameworks.

Two researchers independently coded the data to ensure analytical rigor. Initial coding was

followed by collaborative discussions to refine the emerging themes and resolve discrepancies. Intercoder agreement was achieved through negotiated consensus rather than statistical measures, which is appropriate for qualitative exploratory studies [47]. Thematic saturation was reached when no new codes or concepts emerged from the data.

For the context of this study, the analysis produced two overarching themes–one focused on the perceived benefits of integrating AI in lesson planning and the other on the challenges encountered. Within each theme, four distinct subthemes were identified, reflecting patterns across participants' responses. These themes are presented in detail in the Findings section, with illustrative excerpts.

4. Findings

Thematic analysis of the open-ended responses revealed two overarching categories: the benefits and challenges of using AI tools (specifically ChatGPT) for lesson planning. Four key benefits and four central challenges were identified, reflecting the nuanced perceptions of the preservice chemistry teachers.

4.1. Benefits of AI in lesson planning

4.1.1. Structuring and organizing lesson plan content

Participants frequently noted that AI facilitated the logical structuring and sequencing of lesson plans. ChatGPT helped them generate coherent instructional flows that aligned with typical lesson plan components.

> *AI did help me in structuring and organising my lesson plan* (P1).

> *... suggested good sequence for introducing key concepts like aromaticity, Kekule structure, and resonance, followed by naming and drawing benzene derivatives*. (P2)

Others commented that AI-generated outlines mirrored conventional pedagogical formats.

> *ChatGPT is consistent with the common lesson plan which has introduction, content development, worksheet activity, discussion or recap and closure parts. (P12)*

Thus, P2 added that this structuring with the correct sequencing allowed for '*the lesson flow more smoothly and ensured all essential topics were covered in a logical manner*' (P2). To echo what P2 had said, P7 stated that when AI assistance was applied:

> *... it can organise the material in a way that builds on what the students already know, making sure that the information flows smoothly and become more complex gradually.* (P7)

Both P12 and P13 explained that the sequence and organization of the lesson plan were consistent with the common components of the lesson plan.

> *ChatGPT is consistent with the common lesson plan which has introduction, content development, worksheet activity, discussion or recap and closure parts*. (P12)

> *ChatGPT gives ideas on how to arrange the activity in a proper manner with respect time.* (P13)

These insights suggest that AI can scaffold preservice teachers in designing instructionally sound and well-sequenced lessons, particularly those who may lack confidence in pedagogical planning.

4.1.2. Supporting coherent thought organization

In addition to structuring content, participants emphasized that ChatGPT supported their cognitive organization by helping them clarify, extend and sequence their own ideas.

> *ChatGPT help to expand some ideas I had in my mind… help to organise my thoughts, particularly the flow of my content teaching … so the flow is smoother and easier for others to understand.* (P6)

> *It (ChatGPT) is indeed a helpful platform in helping us to start planning lesson. … gives rough ideas on how to do the induction…* (P4)

ChatGPT was especially appreciated by those with limited lesson-planning experience, who usually would not have thought of these ideas on their own.

> *ChatGPT is wonderful in 'bombing' ideas, especially when one utterly has no ides at all what to do*…(P10)

Here, AI acts not only as a content generator but also as a thinking partner, supporting the development of preservice teachers' pedagogical reasoning.

4.1.3. Activity generation and implementation guidance

Several participants highlighted ChatGPT's usefulness in suggesting engaging and age-appropriate student activities. For example, when one participant wanted her students to do a poster presentation, she asked ChatGPT to generate suitable prompts.

> *They suggestions were good and appropriate, so it is suitable for students to make a poster about their knowledge that they had learned that day.* (P8)

Participants found that AI could offer guidance not just on what to do, but how to implement specific instructional strategies, contributing to their pedagogical repertoire.

4.1.4. Saving time in lesson design

Time efficiency emerged as a recurring theme. Participants valued how quickly AI could generate suggestions, brainstorm activities, or draft outlines.

> *The power of ChatGPT is enormous in the way that simple request can be accomplished in a matter of seconds.* (P10)

Given the often-time-consuming nature of lesson planning, this aspect was especially appreciated during high-stake courses or microteaching preparation.

4.2. Challenges of using AI in lesson planning

4.2.1. Unhelpful or impractical suggestions

Despite its utility, many participants encountered AI outputs that were too generic, irrelevant, or unrealistic for their teaching contexts.

> *... it had suggested inviting a guest speaker or organising a field trip to learn about natural rubber, which is not realistic given my time constraints and budget limitations.* (P1)

> *Suggestions from ChatGPT is usually general and sometimes unrelated ... when I asked ChatGPT to give elaboration or theories, it went too deep and detailed, it might be unnecessary for chemistry students.* (P13)

> *... when I asked different questions, the same "ideas" for the answers were shown*. (P4)

Accordingly, P4 stated it was "*very frustrating as I was not able to get the exact answer that I wanted*". These comments highlight that while AI can provide content, its usefulness is constrained by its lack of contextual awareness.

4.2.2. Difficulty with prompting

AI requires very specific prompts if they are to give any useful ideas for lesson planning. The preservice teachers, P2, P4, P7, P9, and P10, commented that this is one of the challenges of using AI in developing lesson plans.

> *If we do not write the right prompt, the response (from the AI) will be too broad… some things that the students do not need to learn about yet.* (P10)

> *If I gave an incorrect command the subsequent responses from ChatGPT would be based on that mistake, leading to confusion.* (P2)

> *The challenge rises when I'm trying to identify the precise answer template that is required. As a result, multiple layers of prompts need to be developed in order to achieve the desired outcome*. (P7)

This suggests that prompt engineering is a literacy in itself–one that preservice teachers may not yet possess and that current teacher education programs do not typically address.

4.2.3. Misalignment with curriculum requirements

Several participants noted a mismatch between ChatGPT's suggestion and the Malaysian Chemistry Curriculum at the Malaysian Certificate of Education (SPM) level. This created confusion and necessitated additional verification.

> *ChatGPT do not have specific knowledge about the curriculum standards and Malaysian's national curriculum. This makes it challenging to ensure if the lesson plan aligns perfectly with the specific educational standards and learning objectives*. (P9)

> *ChatGPT might suggest pre-university content if we do not specify correctly. For example, Chat GPT might include the hybridisation of orbitals which we learn in Malaysian Higher School Certificate (STPM) level but not at SPM level.* (P6)

> *Even if the idea is good, we need to ensure that our planning is tally with the DSKP and students' preferences. (P8)*

This reflects a key limitation of general-purpose AI tools–they are not yet calibrated for national curricular frameworks, requiring the teacher's intervention for contextualization.

4.2.4. Occasional inaccuracies and conceptual errors

Finally, participants encountered factual errors in the AI-generated content, reinforcing the importance of domain expertise.

> *Main example given (by ChatGPT) is the smell of lemon and orange are different because of two enantiomers. The more accurate information is that the different percentages of these two enantiomers responsible for their distinct smells…* (P12).

In these cases, inaccurate information could lead to the unintentional misconception transmission if not critically evaluated.

5. Discussion

This study explored how preservice teachers engage with ChatGPT for lesson planning, revealing both its pedagogical benefits and challenges. The findings contribute to emerging discourse on generative AI in teacher education by offering empirical insights into real-world usage rather than theoretical speculation. Consistent with prior research, the findings reinforce the importance of structured and intentional planning in fostering effective pedagogical practices [19,20,24,27]. The participants' reflections indicate that ChatGPT effectively supported the structuring, sequencing and conceptual organization of lesson plans, functioning not only as a content generator, but also as a cognitive aid. The support AI offers to preservice teachers' thinking reflects principles of cognitive load theory [21,23], as it reduces extraneous load and allows them to allocate more cognitive resources toward pedagogical decision-making [46–48].

In line with Vygotskian perspectives on scaffolding, AI tools such as ChatGPT can act as

scaffolding mechanisms for preservice teachers who are still forming their instructional identities. This is in line with the zone of proximal development, wherein AI becomes a form of temporary mediation that supports more complex thinking until independent mastery is achieved [49,50]. Participants reported increased confidence, improved lesson organization, and more efficient time management. These findings suggest that generative AI may play a meaningful role in enabling novice educators to bridge the gap between curriculum standards and practical classroom planning.

Despite the perceived utility of ChatGPT in accelerating planning and ideation, participants encountered significant constraints related to context specificity. Some participants found AI-generated suggestions too general or contextually misaligned, echoing concerns raised in recent literature about the need for prompt precision and critical evaluation of AI outputs [51,52]. In these cases, preservice teachers' ability to adapt content to local curricula and classroom needs became essential. This study underscores the risk of treating AI-generated content as pedagogically neutral or universally applicable. The issue of epistemic reliability wherein inaccurate or overgeneralized information is presented as authoritative raises important concerns about overreliance and the potential erosion of reflective instructional judgement.

A salient theme in the findings is the struggle preservice teachers experienced in crafting effective prompts a task that requires metacognitive awareness, content clarity, and iterative experimentation. This aligns with calls for the development of ‘AI-pedagogical literacy’, a new competency involving the ability to critically engage with generative tools through precise prompting, evaluative scrutiny, and adaptive revision [34]. The notion of AI-pedagogical literacy extends beyond basic digital competence; it refers to teachers’ ability to critically and ethically engage with AI tools for instructional design, assessment, and reflection. Drawing on the TPACK framework (Technological Pedagogical Content Knowledge [6]). AI-pedagogical literacy can be viewed as an evolved dimension where technological fluency merges with pedagogical intentionality and content understanding in AI-mediated contexts. Within this framework, preservice teachers must learn not only how to operate AI systems but how to integrate them meaningfully to support student learning, maintain curricular alignment, and uphold academic integrity. This aligns with Ertmer and Ottenbreit-Leftwich’s [53] argument that teacher beliefs and contextual knowledge are pivotal in determining how technology is pedagogically appropriated. Hence, developing AI-pedagogical literacy in teacher education should involve explicit instruction in prompt engineering, bias detection, ethical use, and reflective adaptation of AI outputs core practices that situate AI use within teachers’ evolving professional identities and values.

The iterative nature of working with ChatGPT, including refining prompts and verifying revisions, mirrors the recursive processes of lesson design but also introduces a new layer of technical interaction that teacher education programs are largely unprepared to address [54,55].

A nuanced finding in this study is the tension between AI's promise of efficiency and the pedagogical risks of overreliance. While AI eased the burden of lesson planning, its occasional inaccuracies or irrelevant outputs could mislead users lacking strong content knowledge. This raises important questions about where the line lies between assistance and dependence. Moreover, some participants struggled to reconcile AI-generated materials with their local teaching contexts or the expectations of their lecturers, illustrating the situated nature of teaching and the need to localize educational technologies [56,57]. However, Selwyn, Ljungqvist, and Sonesson [58] critically examine the pedagogical implications of generative AI tools by focusing on how teachers manage

their inherent limitations in educational contexts. The study reveals that when these AI systems fail to meet instructional expectations, particularly in producing accurate, contextually relevant, and conceptually deep outputs, teachers engage in significant compensatory practices. These include editing, contextualizing, verifying, and reframing AI-generated content to align with curricular goals and learning outcomes. Such "invisible labor," while often unacknowledged, becomes essential for sustaining pedagogical quality and ensuring that AI tools serve educational rather than merely technological purposes. Selwyn et al. [57] argue that the integration of generative AI in teaching does not diminish the professional role of educators but instead redefines it, requiring heightened critical awareness, adaptive expertise, and ongoing evaluative judgment. Ultimately, the article calls for a nuanced understanding of AI's role in education, emphasizing the importance of recognizing and supporting the complex human work that underpins effective AI-mediated pedagogy.

Beyond the chemistry-specific context of this study, these findings have broader implications for science education and teacher preparation. As generative AI tools become more prevalent, there is a pressing need to develop structured frameworks for their ethical and pedagogical integration into teacher training programs. This underscores the importance of integrating AI literacy into teacher education not merely as technical training, but as a form of critical digital pedagogy. This includes creating opportunities for critical reflection, promoting awareness of algorithmic bias, and modeling effective prompt engineering within content-specific methods courses. If implemented thoughtfully, AI has the potential not only to enhance lesson planning but also to foster adaptive expertise among future educators [58].

While this study adopts an appropriate qualitative design to explore preservice teachers' experiences with AI-assisted lesson planning, several methodological and conceptual limitations constrain the breadth and depth of its findings. These limitations, if addressed, could significantly enhance the robustness and applicability of future research in this domain. Although participants were given the freedom to select any generative AI platform, all ultimately chose ChatGPT, primarily due to its accessibility and familiarity. This homogeneous tool usage limits the study's capacity to draw comparative insights across AI platforms with differing affordances. For instance, tools such as LessonPlans.ai provide curriculum-alignment features, while Google Gemini offers direct integration with Google Classroom capabilities that may influence the quality, practicality, and contextual relevance of generated lesson plans. Consequently, the findings reflect user experiences with a single tool rather than the broader phenomenon of AI-driven lesson planning. Future research would benefit from a comparative design that systematically evaluates the pedagogical affordances, usability, and contextual adaptability of multiple AI tools.

The study identifies curriculum misalignment, specifically ChatGPT's limited familiarity with Malaysia's SPM/STPM chemistry curriculum as a major challenge. However, this issue is addressed only through participants' reflections and lacks systematic investigation. A more rigorous approach could involve content mapping between AI-generated lesson components (objectives, activities, and assessments) and the Dokumen Standard Kurikulum dan Pentaksiran (DSKP) for Chemistry. Quantifying this alignment (e.g., "30% of AI-generated objectives exceeded SPM-level content") would yield concrete evidence of the extent and nature of the misalignment. Moreover, incorporating perspectives from Malaysian in-service teachers or curriculum developers could provide valuable insights into how generative AI models might be locally calibrated or fine-tuned to align with national education standards.

The study persuasively underscores the need for "AI-pedagogical literacy," yet provides limited

operational detail on how this competence might be cultivated within teacher education programs. While the authors conceptualize this literacy as the ability to prompt, evaluate, and adapt AI outputs, the absence of a concrete framework or curricular pathway constrains the practical implications of this finding. Future work could delineate specific instructional modules, guided practice opportunities, or assessment rubrics for developing AI-pedagogical literacy—such as courses or workshops emphasizing effective prompting strategies, critical evaluation of AI-generated materials, and ethical considerations in AI-assisted pedagogy.

The study's cross-sectional design, based on a single reflective questionnaire, captures participants' immediate perceptions but does not examine the evolving influence of AI use on their pedagogical growth. As such, questions remain regarding whether sustained exposure to AI tools enhances preservice teachers' instructional design competence or fosters dependency and reduced creativity. A longitudinal research design tracking participants' evolving competencies, attitudes, and reflective practices over time would provide richer insights into the enduring pedagogical implications of AI-assisted lesson planning.

6. Conclusions

In conclusion, while generative AI cannot replace the creativity, empathy, and contextual awareness that define effective teaching, it can serve as a valuable cognitive and pedagogical support when used critically. This study contributes to the growing body of literature advocating for AI-literate teacher education by demonstrating how AI can scaffold preservice teachers' lesson planning, reduce cognitive burden, and support reflective instructional design. As science education continues to evolve in the digital age, preparing teachers to navigate and critically engage with AI tools will be essential for fostering both pedagogical innovation and professional agency.

Author contributions

Chua Kah Heng: Conceptualization; Renuka V Sathasivam: Conceptualization, methodology, analysis, and Writing – original draft; Nofouz Mafarja: Writing – original draft; Suzieleez Syrene Abdul Rahim: Resources.

Use of Generative-AI tools declaration

AI was used solely to support language formulation and structure. All intellectual content, data interpretation, and critical analysis were conceived and developed by the human authors. The authors have reviewed and edited the AI-assisted text to ensure accuracy, clarity, and adherence to academic standards, and they accept full responsibility for the content of this work.

Acknowledgments

We would like to thank Faculty of Education, Universiti Malaya to allowing us to conduct this research.

Conflict of interest

The authors declare that they do not have any conflicts of interest.

Ethics declaration

This study was approved by the Universiti Malaya research ethics committee number (UM. TNC2/UMREC_3605).

References

1. Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., et al., ChatGPT for good? On opportunities and challenges of large language models for education. *Learning and Individual Differences*, 2023, 103: 102274. https://doi.org/10.1016/j.lindif.2023.102274
2. Adiguzel, T., Kaya, M.H. and Cansu, F.K., Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. *Contemporary Educational Technology*, 2023, 15(3): ep429. https://doi.org/10.30935/cedtech/13152
3. Grossman, P.L., *The Making of a Teacher: Teacher Knowledge and Teacher Education*, Teachers College Press, 1990.
4. Shulman, L.S., Knowledge and Teaching: Foundations of the New Reform. *Harvard Educational Review*, 1987, 57: 1–22. http://dx.doi.org/10.17763/haer.57.1.j463w79r56455411
5. Cooper, G., Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. *Journal of Science Education and Technology*, 2023, 32: 444–452. https://doi.org/10.1007/s10956-023-10039-y
6. Cope, B., Kalantzis, M. and Searsmith, D., Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies. *Educational Philosophy and Theory*, 2020, 53: 1–17. http://doi.org/10.1080/00131857.2020.1728732
7. Uysal, B.Ç.B. and Yüksel, İ., AI-powered lesson planning: Insights from future EFL teachers. In *AI in Language Teaching, Learning, and Assessment* (pp. 101-132). IGI Global Scientific Publishing, 2024. http://doi.org/10.4018/979-8-3693-0872-1.ch006
8. Sawalha, G., Taj, I. and Shoufan, A., Analyzing student prompts and their effect on ChatGPT's performance. *Cogent Education*, 2024, 11(1): 2397200. https://doi.org/10.1080/2331186X.2024.2397200
9. Zawacki-Richter, O., Marín, V.I., Bond, M. and Gouverneur, F., Systematic review of research on artificial intelligence applications in higher education–where are the educators? *International journal of educational technology in higher education*, 2019, 16(1): 1–27. https://doi.org/10.1186/s41239-019-0171-0
10. Selwyn, N., Hillman, T., Bergviken-Rensfeldt, A. and Perrotta, C., Making sense of the digital automation of education. *Postdigital Science and Education*, 2023, 5(1): 1–14. https://doi.org/10.1007/s42438-022-00362-9
11. Michel-Villarreal, R., Vilalta-Perdomo, E., Salinas-Navarro, D.E., Thierry-Aguilera, R. and Gerardou, F.S., Challenges and opportunities of generative AI for higher education as explained by ChatGPT. *Education Sciences*, 2023, 13(9): 856. https://doi.org/10.3390/educsci13090856
12. Yusuf, A., Pervin, N. and Román-González, M., Generative AI and the future of higher education: A threat to academic integrity or reformation? Evidence from multicultural

perspectives. *International Journal of Educational Technology in Higher Education,* 2024, 21(1): 21. https://doi.org/10.1186/s41239-024-00453-6

13. Kurtz, G., Amzalag, M., Shaked, N., Zaguri, Y., Kohen-Vacs, D., Gal, E., et al., Strategies for integrating generative AI into higher education: Navigating challenges and leveraging opportunities. *Education Sciences,* 2024, 14(5): Article 503. https://doi.org/10.3390/educsci14050503
14. Walczak, K. and Cellary, W., Challenges for higher education in the era of widespread access to Generative AI. *Economics and Business Review,* 2023, 9(2): 71–100. https://doi.org/10.18559/ebr.2023.2.743
15. AlAli, R., Wardat, Y., Al-Saud, K. and Alhayek, K.A., Generative AI in education: Best practices for successful implementation. *International Journal of Religion,* 2024, 5(9): 1016–1025. https://doi.org/10.61707/pkwb8402
16. Nikolopoulou, K., Generative artificial intelligence in higher education: Exploring ways of harnessing pedagogical practices with the assistance of ChatGPT. *International Journal of Changes in Education,* 2024, 1(2): 103–111. https://doi.org/10.47852/bonviewIJCE42022489
17. van den Berg, G. and du Plessis, E., ChatGPT and generative AI: Possibilities for its contribution to lesson planning, critical thinking, and openness in teacher education. *Education Sciences,* 2023, 13(10): 998. https://doi.org/10.3390/educsci13100998
18. Corp, A. and Revelle, C., ChatGPT is here to stay: Using ChatGPT with student teachers for lesson planning. *The Texas Forum of Teacher Education,* 2023, 14: 116–124.
19. Mintz, J., Holmes, W., Liu, L. and Perez-Ortiz, M., Artificial intelligence and K-12 education: Possibilities, pedagogies and risks. *Computers in the Schools,* 2023, 40(4): 325–333. https://doi.org/10.1080/07380569.2023.2279870
20. Baytak, A., The content analysis of the lesson plans created by ChatGPT and Google Gemini. *Research in Social Sciences and Technology,* 2024, 9(1): 329–350. https://doi.org/10.46303/ressat.2024.19
21. Powell, W. and Courchesne, S., Opportunities and risks involved in using ChatGPT to create first grade science lesson plans. *PloS one,* 2024, 19(6): e0305337. https://doi.org/10.1371/journal.pone.0305337
22. Chan, C.K.Y. and Hu, W., Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education,* 2023, 20(43): 1–18. https://doi.org/10.1186/s41239-023-00411-8
23. Koraishi, O., Teaching English in the age of AI: Embracing ChatGPT to optimize EFL materials and assessment. *Language Education and Technology,* 2023, 3(1): 55–72.
24. Kehoe, F., Leveraging generative AI tools for enhanced lesson planning in initial teacher education at post primary. *Irish Journal of Technology Enhanced Learning,* 2023, 7(2): 172–182. https://doi.org/10.22554/ijtel.v7i2.124
25. Clark, T.M., Fhaner, M., Stoltzfus, M. and Queen, M.S., Using ChatGPT to support lesson planning for the historical experiments of Thomson, Millikan, and Rutherford. *Journal of Chemical Education,* 2024, 101(5): 1992–1999. https://doi.org/10.1021/acs.jchemed.4c00200
26. Lee, G.G. and Zhai, X., Using ChatGPT for science learning: A Study on preservice teachers' lesson planning. *IEEE Transactions on Learning Technologies,* 2024, 17: 1643–1660.
27. Broutın, M.S.T., Exploring mathematics teacher candidates' instrumentation process of

generative artificial intelligence for developing lesson plans. *Yüksekö g! retim Dergisi*, 2024, 14(1): 165–176. https://doi.org/10.53478/yuksekogretim.1347061

28. Karaman, M.R., Are lesson plans created by ChatGPT more effective? An experimental study. *International Journal of Technology in Education*, 2024, 7(1): 107–127. https://doi.org/10.46328/ijte.607
29. Khazanchi, R. and Khazanchi, P., Generative AI to improve special education teacher preparation for inclusive classrooms. In M. Searson, E. Langran, & J. Trumble (Eds.), *Exploring new horizons: Generative artificial intelligence and teacher education*, 2024, 159–177. Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/223928/
30. Farrelly, T. and Baker, N., Generative artificial intelligence: Implications and considerations for higher education practice. *Education Sciences*, 2023, 13(11): 1109. https://doi.org/10.3390/educsci13111109
31. ElSayary, A., An investigation of teachers' perceptions of using ChatGPT as a supporting tool for teaching and learning in the digital era. *Journal of Computer Assisted Learning*, 2023, 40(3): 931–945. https://doi.org/10.1111/jcal.12926
32. DeCarlo, M., Lynch, W., Lee, V., Moix, D. and Klein, V., Assessment and instructional decision making: How AI can support data literacy development for preservice teachers. In M. Searson, E. Langran, & J. Trumble (Eds.), *Exploring new horizons: Generative artificial intelligence and teacher education*, 2024, 129–144. Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/223928/
33. Sakamoto, M., Tan, S., and Clivaz, S., Social, cultural and political perspectives of generative AI in teacher education: Lesson planning in Japanese teacher education. In M. Searson, E. Langran, & J. Trumble (Eds.), *Exploring new horizons: Generative artificial intelligence and teacher education*, 2024 178–209. Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/223928/
34. Yeralan, S. and Lee, L.A., Generative AI: Challenges to higher education. *Sustainable Engineering and Innovation*, 2023, 5(2): 107–116. https://doi.org/10.37868/sei.v5i2.id196
35. Khalid, M. and Ahmad, N., Educational innovation: Challenges and opportunities with generative AI integration. Unpublished. 2024. https://doi. org/10.13140/RG, 2(36701.83684).
36. Hodge-Zickerman, A. and York, C., Embracing ChatGPT in the evolving landscape of mathematics teacher education and assessment. In M. Searson, E. Langran, & J. Trumble (Eds.), *Exploring new horizons: Generative artificial intelligence and teacher education*, 2024, 111–128. Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/223928/
37. Mosaiyebzadeh, F., Pouriyeh, S., Parizi, R., Dehbozorgi, N., Dorodchi, M. and Macêdo Batista, D., Exploring the role of ChatGPT in education: Applications and challenges. *Proceedings of the 24th annual conference on information technology education*, 2023, 84–89.
38. Cun, A. and Huang, T., Gen AI & TPACK teacher education student perspectives. In M. Searson, E. Langran, & J. Trumble (Eds.), *Exploring new horizons: Generative artificial intelligence and teacher education*, 2024, 62–75. Association for the Advancement of Computing in Education. https://www.learntechlib.org/primary/p/223928/
39. Uzumcu, O. and Acilmis, H., Do innovative teachers use ai-powered tools more interactively?

A study in the context of diffusion of innovation theory. *Technology, Knowledge and Learning*, 2024, 29(2): 1109–1128. https://doi.org/10.1007/s10758-023-09687-1

40. Dotan, R., Parker, L.S. and Radzilowicz, J., Responsible adoption of generative AI in higher education: Developing a "points to consider" approach based on faculty perspectives. In *The 2024 ACM conference on fairness, accountability, and transparency*, 2024, 2033–2046. Association for Computing Machinery.
41. Hughes, L., Malik, T., Dettmer, S., Al-Busaidi, A.S. and Dwivedi, Y.K., Reimagining Higher Education: Navigating the Challenges of Generative AI Adoption. *Information Systems Frontiers*, 2025, 1-23. https://doi.org/10.1007/s10796-025-10582-6
42. Saimon, M., Mtenzi, F., Lavicza, Z., Fenyvesi, K., Arnold, M. and Diego-Mantecón, J.M., Applying the 6E learning by design model to support student teachers to integrate artificial intelligence applications in their classroom. *Education and Information Technologies*, 2024, 1–18. https://doi.org/10.1007/s10639-024-12795-9
43. Smolansky, A., Cram, A., Raduescu, C., Zeivots, S., Huber, E., and Kizilcec, R.F., Educator and student perspectives on the impact of generative AI on assessments in higher education. *Proceedings of the tenth ACM conference on Learning @ Scale*, 2023, 378–382.
44. Chiu, T.K., Future research recommendations for transforming higher education with generative AI. *Computers and Education: Artificial Intelligence*, 2024, 6: 100197. https://doi.org/10.1016/j.caeai.2023.100197
45. Hajam, K.B. and Gahir, S., Unveiling the attitudes of university students toward artificial intelligence. *Journal of Educational Technology Systems*, 2024, 52(3): 335–345. https://doi.org/10.1177/00472395231225920
46. Hashmi, N. and Bal, A.S., *Generative AI in higher education and beyond*, Business Horizons, 2024.
47. Braun, V. and Clarke, V., Using thematic analysis in psychology. *Qualitative Research in Psychology*, 2006, 3(2): 77–101. https://doi.org/10.1191/1478088706qp063oa
48. Lee, D., Arnold, M., Srivastava, A., Plastow, K., Strelan, P., Ploeckl, F., et al., The impact of generative AI on higher education learning and teaching: A study of educators' perspectives. *Computers and Education: Artificial Intelligence*, 2024, 6: Article 100221. https://doi.org/10.1016/j.caeai.2024.100221
49. Adeyele, V.O. and Ramnarain, U., Exploring the integration of ChatGPT in inquiry-based learning: Teacher perspectives. *International Journal of Technology in Education*, 2024, 7(2): 200–217. https://doi.org/10.46328/ijte.638
50. Dai, Y., Liu, A. and Lim, C.P., Reconceptualizing ChatGPT and generative AI as a student-driven innovation in higher education. *Procedia CIRP*, 2023, 119: 84–90. https://doi.org/10.1016/j.procir.2023.05.002
51. Pitura, J., Using the e-questionnaire in qualitative applied linguistics research. *Research Methods in Applied Linguistics*, 2023, 2(1): 100034. https://doi.org/10.1016/j.rmal.2022.100034
52. Harris, J. and Hofer, M., Instructional planning activity types as vehicles for curriculum-based TPACK development. In C. D. Maddux, (Ed.), *Research highlights in technology and teacher education*, 2009, 99-108. Chesapeake, VA: Society for Information Technology in Teacher Education (SITE).
53. Ertmer, P. and Ottenbreit-Leftwich, A., Teacher Technology Change: How Knowledge, Beliefs,

and Culture Intersect. *Journal of Research on Technology in Education*, 2010, 42: 255-284. http://doi.org/10.1080/15391523.2010.10782551
54. Puentedura, R.R., SAMR: Moving from enhancement to transformation. 2014. Retrieved from: http://www.hippasus.com/rrpweblog/archives/000095.html
55. Wood, D., Bruner, J.S. and Ross, G., The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry*, 1976, 17(2): 89–100. https://doi.org/10.1111/j.1469-7610.1976.tb00381.x
56. Eager, B. and Brunton, R., Prompting higher education towards ai-augmented teaching and learning practice. *Journal of University Teaching & Learning Practice*, 2023, 20(5): 02. https://doi.org/10.53761/1.20.5.02
57. Luckin, R., Holmes, W., Griffiths, M. and Forcier, L.B., *Intelligence Unleashed: An argument for AI in Education*, UCL Knowledge Lab: London, UK, 2016.
58. Selwyn, N., Ljungqvist, M. and Sonesson, A., When the prompting stops: exploring teachers' work around the educational frailties of generative AI tools. *Learning, Media and Technology*, 2025, 50(3): 310–323. https://doi.org/10.1080/17439884.2025.2537959

Author's biography

Dr. Chua Kah Heng (PhD) is a senior lecturer in the department of Mathematics and Science Education Faculty of Education, Universiti Malaya. His research focuses on Innovative Pedagogy, teaching methodologies for content, classroom behaviour, Chemistry Education, Curriculum and Pedagogy.

Associate Professor. Dr. Renuka V Sathasivam (PhD) is an Associate Professor in the department of Mathematics and Science Education Faculty of Education, Universiti Malaya. Her research focuses on STEM education (Chemistry Education), teaching methods and classroom assessment.

Dr. Nofouz Mafarja (PhD) is a senior lecturer in the department of Mathematics and Science Education Faculty of Education, Universiti Malaya. Her research focuses on Science education (Physics Education), scaffolding in education, collaborative learning, word problem solving in physics, critical thinking skills, Innovative Pedagogy, and educational technology.

Dr. Suzieleez Syrene Abdul Rahim (PhD) is a senior lecturer in the department of Mathematics and Science Education Faculty of Education, Universiti Malaya. Her research focuses on Mathematics Education, Pedagogical Knowledge Development in Mathematics, Teaching and Learning Geometry, Problem-solving, Mathematical Literacy, Mathematical thinking, and Inquiry based Teaching.