Navigating the role of Large Language Models in Problem-Based Learning: A rapid review

Stefan Jongen (MSP/FSE/EDLAB), Paula Aldaz Laquidain (EDLAB) and Spoorti Ramesh (EDLAB) wrote this paper. Walter Jansen (EDLAB), Freddy Schwoerer (SBE) and Lonneke Bevers (UCM/FSE) provided feedback.

The paper was written as part of the EDLAB innovation project 'LLM and PBL' and the EDLAB research fellowship of Stefan Jongen.

INTRODUCTION

Large Language Models in education

The rapid advancements in Artificial Intelligence (AI) have opened new avenues for enhancing traditional educational paradigms, particularly with the emergence of Large Language Models (LLMs). These models, including OpenAI's ChatGPT, are a type of generative AI that uses Natural Language Processing (NLP) transformers to generate human-like text based on vast training datasets (Kasneci et al., 2023). Since the release of ChatGPT in November 2022, both students and educators have started using it to support various aspects of learning and teaching. This swift and widespread use of LLMs in higher education has sparked debates over whether these models enhance learning by increasing productivity and providing personalised feedback, or if they detract from deep, critical understanding by automating essential cognitive processes.

In a comprehensive systematic review, Zawacki-Richter and colleagues (2019) explored AI applications in higher education, identifying four key areas where AI impacts teaching and learning. These key areas are 1) adaptive systems and personalisation, 2) assessment and evaluation, 3) profiling and prediction and 4) intelligent tutoring systems. Despite highlighting the potential of AI in education, the authors stress the need for greater pedagogical reflection and theoretical grounding. This highlights a critical gap since AI's potential is often driven by technological innovation. Yet, the pedagogical implications - especially for student-centred, active learning models such as Problem-Based Learning (PBL) remain underexplored.

Problem-Based Learning at Maastricht University

Problem-Based Learning (PBL) is a well-established pedagogical approach that shifts away from teacher-centred learning towards student-centred learning. Originating at McMaster University in the 1960s, PBL organises curriculum content around authentic problem scenarios rather than academic disciplines (Savin-Baden, 2001). It is a learner-driven educational model in which students actively construct their understanding, while the teacher or tutor provides guidance. While there is no universally accepted definition of PBL, implementations of PBL share some characteristics (Loyens et al., 2023).

At Maastricht University, where PBL is a cornerstone of the educational approach, students engage in small group discussions, guided by a tutor, to solve complex problems that mirror real-life professional tasks. This educational process encourages students to construct and reconstruct knowledge, enhancing their ability to apply critical thinking and problem-solving skills in a real-world context (Frambach et al., 2019).

PBL is structured around four core principles of learning: constructive, contextual, collaborative, and self-directed, referred to as the CCCS principles (Maastricht University, 2023). First, the acquisition of new knowledge is a critical pillar of PBL, supported by the constructive learning principle. This principle involves active engagement where students construct and reconstruct their knowledge networks, creating meaningful deep understanding. This process includes activating prior knowledge, elaborating on new information, and relating it to prior knowledge to enhance long-term knowledge, critical evaluation, and application in real-life problems (Loyens et al., 2023)

Second, the contextual learning principle implies that learning should be focused on task-centred instruction (Francom, 2016), where students compare and contrast complex, ill-

defined tasks from meaningful, authentic, and professionally relevant contexts. This integration of knowledge, skills, and attitudes is presented through real-life problems, cases, or projects encountered in the future work setting (Dolmans et al., 2019).

Moreover, PBL is based on small group settings, where students actively participate and share knowledge. Collaborative learning involves students working together on complex tasks, sharing a common goal, and depending on each other's contributions (Dolmans et al., 2019). It requires open dialogue, co-construction of ideas, and resolving cognitive disagreements. Psychological safety and social cohesion are essential for effective collaboration (Loyens et al., 2023).

Lastly, self-directed learning (SDL) enables students to assume responsibility for their educational journey by identifying learning needs, setting meaningful goals, and developing effective strategies (Lin, 2024). This approach emphasises creating a supportive environment that provides autonomy, allowing students to customise learning experiences (Dolmans et al., 2019). Students actively engage in the learning process by formulating questions, defining learning issues, and selecting relevant resources.

The potential role of LLMs in PBL

LLMs such as ChatGPT hold considerable potential to enhance the PBL framework by aligning with each core principle. For example, LLMs can assist with constructive learning by helping students activate prior knowledge, engage with new concepts, and receive instant, personalised feedback. In addition, LLMs could support contextual learning by generating realistic, profession-specific problem scenarios that students can explore. In collaborative learning, LLMs could facilitate group discussions by providing diverse perspectives and solutions and encouraging students to compare, contrast, and refine their ideas. Finally, in self-directed learning, LLMs could act as intelligent tutoring systems, answering individual questions, offering tailored resources, and allowing students to assess their progress through self-quizzing (Kasneci et al., 2023, Moorhouse et al., 2023).

However, the integration of LLMs into PBL environments also raises significant challenges. There are concerns that LLMs, while efficient in generating information, may reduce the need for deep, critical engagement, potentially leading to superficial learning, Additionally, questions remain about the ethical use of generative AI in educational contexts, particularly in terms of data privacy, academic integrity, and the balance between human and machine-driven learning. These concerns underscore the importance of human educators, who remain essential in facilitating meaningful, complex learning experiences and ensuring that LLMs are used responsibly (Jeon & Lee, 2023).

Focus of rapid review

Despite the increasing use of LLMs in higher education, there is limited research on their specific impact within a PBL framework, both for educators and students. This rapid review seeks to address this gap by exploring the following research questions:

1. What is the impact of Large Language Models on Problem-Based Learning (PBL) for educators in higher education, particularly in terms of designing educational content and facilitating student learning experiences?

2. How do Large Language Models influence student learning outcomes and engagement in Problem-Based Learning (PBL), and what strategies can be implemented to enhance student learning through the integration of these models?

By examining the intersection of LLMs and PBL, this review aims to provide valuable insights for educators, researchers and students seeking to optimise Problem-Based Learning environments with the use of these tools.

METHODS

The methodology used for this review was based on a literature search. Two different methods were considered for each research question.

The first research question is 'What is the impact of Large Language Models on Problem-Based Learning (PBL) for educators in higher education, particularly in terms of designing educational content and facilitating student learning experiences?' The inclusion search criteria for the first research question were limited to the English language. Relevant papers were selected by looking at their title, abstracts and results section. A review on Large Language Models, Problem-Based Learning, teaching higher education, as well as other relevant aspects of this research question was performed by using the Clarivate - Web of Science™ database, University Maastricht Library, and Google Scholar. We used these search terms: "ChatGPT", "ChatGPT in education", "Large Language Models in education", "Large Language Models education research", "Large Language Models for teaching staff", "Large Language Models and assessment", "Large Language Models and feedback" and "AI in Problem-Based Learning".

The second research question is: 'How do Large Language Models influence student learning outcomes and engagement in Problem-Based Learning (PBL), and what strategies can be implemented to enhance student learning through the integration of these models?'. To answer this, a review was performed on the Clarivate - Web of Science™ database, University Maastricht Library, and Google Scholar. We used these search terms: "ChatGPT", "ChatGPT in education", "Large Language Models in education", "Large Language Models for students", "Large Language models and Problem-Based Learning", Large Language and self-directed learning", "Large Language models and constructive learning", "Large Language models and contextual learning", "Large Language models and collaborative learning". The inclusion criteria for this second research question were studies limited to the English language.

Relevant papers were selected by looking at their title, abstracts and results section. Moreover, the snowballing system was used for both research questions, which is where the citations from the selected papers are used as guidance for further research, hence adopted as citations for the current paper.

RESULTS

The role of LLMs in course design within PBL

LLMs have shown potential in supporting educators with course design, particularly within a PBL framework. Kasneci and colleagues (2023) highlight how LLMs like ChatGPT can assist in creating diverse and realistic learning materials that align with learning objectives and the needs of students, directly supporting *contextual* learning by embedding educational content in real-life professional scenarios. Rasul and colleagues (2023) further explored the integration of LLMs from a constructivist perspective, emphasising the adaptability of these models in providing personalised learning experiences and facilitating the creation of engaging, dynamic educational activities. The study underscores that LLMs, such as ChatGPT, support *constructive* learning by offering feedback and resources tailored to individual student needs, which helps students build on prior knowledge and refine their understanding. However, the study also warns against over-reliance on LLMs, noting the importance of addressing potential biases and ensuring that these models do not undermine academic integrity or equitable access to education. In addition, this study highlights the importance of maintaining human oversight in course design (Rasul et al., 2023). While LLMs can significantly enhance the efficiency of course design, especially in generating problem scenarios and instructional strategies, the authors emphasised the need for thoughtful integration to ensure that LLMs augment, rather than replace, traditional educational interactions. Educators must ensure that the AI-generated content is aligned with the educational context and that it supports meaningful, deep learning experiences rather than superficial knowledge acquisition.

The integration of LLMs use and course design is exemplified in a recent study exploring *constructive* alignment in a graduate-level project management course (Pereira, Nsair, Pereira, & Grant, 2024). This paper details how ChatGPT was utilised to develop a framework that aligns learning outcomes, instructional strategies, and assessment methods effectively (Biggs & Tangs, 2011). By automating initial course planning processes, the model demonstrated significant potential in reducing the workload for educators and personalising the learning experience. However, the study also emphasised the necessity for educators to critically oversee and adapt the AI-generated content, ensuring its relevance and accuracy within specific educational contexts. This approach underlines a pivotal shift towards more dynamic and technology-enhanced educational frameworks in higher education, highlighting both the potential of LLMs and the ongoing need for human judgement in curriculum design.

Takeaway for educators: While LLMs can enhance course design efficiency and personalisation, human educators must remain actively involved to ensure content accuracy, relevance, and depth.

Personalised feedback using LLMs in PBL

Feedback is an essential component of students' knowledge acquisition and development. However, the creation of individual feedback is often a challenging and time-intensive task for teachers (Meyer et al., 2024). Dai and colleagues (2023) discovered that LLMs offered comprehensible feedback on reports written by university students and that LLMs have become a promising solution for automated feedback. By using LLMs, Meyer and colleagues (2024) support that teachers are able to provide tailored feedback to a large number of students, adapt the feedback to specific evaluation criteria and suggest materials that align with the student's specific learning needs.

Additionally, by automating feedback, educators can focus on facilitating *collaborative* learning activities, such as tutorials, where LLMs can provide diverse perspectives for group discussion. However, ensuring the accuracy and depth of AI-generated feedback remains a challenge that requires educator supervision.

Takeaway for educators: LLMs can streamline the feedback process and support collaborative learning activities. Educators should ensure that AI-generated feedback is accurate and promotes deep learning.

LLMs for operational efficiency and administrative support

The systematic scoping review by Yan and colleagues (2023) critically evaluates the integration of LLMs such as GPT-3 into higher education, unveiling both innovative applications and multifaceted challenges. The study identified nine functional categories where LLMs are used for automating educational tasks, ranging from content generation to assessment grading. This study aligns with previous research, suggesting that in the areas of teaching support, assessment and grading, feedback, and content generation, LLMs could significantly reduce teachers' workload and mental stress as they have the potential to automate time-consuming tasks, allowing teachers to focus on more meaningful interactions with students.

However, the authors raise profound ethical and practical concerns, such as data privacy, bias propagation, and the need for technological maturity before these models can be fully integrated into educational systems (Yan et al., 2023). The authors advocate for a paradigm shift towards open-source models and a human-centred approach in the development of educational technologies, urging stakeholders to recognise the dual potential of LLMs to both advance and complicate the pedagogical landscape. This critical insight invites further exploration into how LLMs can be ethically and effectively harnessed to enrich higher education, ensuring they augment rather than undermine educational integrity and inclusivity.

Terwiesch (2023) demonstrated that LLMs could significantly reduce the time spent on developing academic tasks, potentially increasing operational efficiency. This time-saving aspect allows teachers to dedicate more time to improving instructional strategies and interaction with students, thereby enhancing overall educational effectiveness (Alshater, 2022). Moreover, studies by Kashyap (2023) and Owston (2023) have demonstrated that the use of LLMs can significantly reduce teachers' administrative burdens. LLMs provide

personalised assistance with basic writing and communication tasks, help in organising schedules and to-do lists, and facilitate rapid idea generation (Kim & Adolf, 2024). Similarly, Moorhouse and colleagues (2023) found that LLMs facilitate the generation of course content, saving educators time and allowing for more complex, profession-relevant tasks.

Takeaway for educators: LLMs can free up time for more meaningful student engagement, but educators must address ethical and practical challenges to ensure these tools are used responsibly.

LLMs in professional development for educators

According to Kasneci and colleagues (2023), LLMs can also support teachers' professional development by offering access to various resources, summaries, and explanations related to state-of-the-art teaching methods, technologies, and materials. This assistance enables educators to remain current with the latest trends and advancements in education, ultimately enhancing their teaching effectiveness. Additionally, these models help clarify teaching materials and facilitate the discovery of relevant information or resources necessary for on-the-job learning as well as be effectively utilised in training programmes related to presentation and communication skills.

Another systematic review by Mai, Da, and Hanh (2024) investigated the impact of ChatGPT on teaching and learning through a strength, weaknesses, opportunities, and threats (SWOT) analysis framework. The study integrated evidence from 51 articles selected, exploring the strengths, weaknesses, opportunities, and threats of ChatGPT in educational contexts by using Biggs' Presage-Process-Product (3P) model, which breaks down teaching and learning into three stages. These stages are Presage (focus on student characteristics and teaching contexts), Process (examines specific learning tasks and how ChatGPT affects them) and Product (evaluates learning outcomes achieved through the integration of ChatGPT).

The *constructive* learning principle is supported by several strengths in this study, such as ChatGPT's ability to provide personalised learning experiences and immediate feedback on tasks. However, the weaknesses identified, such as offering biased or inaccurate information, pose challenges to constructive learning, as students may inadvertently build upon incorrect or shallow knowledge.

In terms of *contextual* learning, the opportunities highlighted by Mai, Da, and Hanh (2024) include enhancing traditional teaching methods by providing more interactive and professionally relevant learning environments. By scaffolding personalised learning experiences, ChatGPT can help students engage with real-world problem scenarios, allowing them to apply theoretical knowledge in meaningful, context-driven tasks. However, threats such as academic dishonesty and plagiarism undermine the integrity of contextual learning, as they risk disconnecting students from authentic engagement with the content and real-world problems.

The *collaborative* learning process is less directly addressed in the SWOT analysis, but there are implications for group work and peer interaction. For instance, the development of interactive environments and immediate automated assistance in writing tasks may enhance group discussions and collaboration. However, one challenge lies in how students might rely

too heavily on AI-generated responses rather than engaging deeply with their peers. Collaborative learning could be undermined if students use ChatGPT as a shortcut, rather than as a tool to facilitate meaningful interaction and co-construction of knowledge.

Lastly, *self-directed* learning can be supported by ChatGPT's ability to provide on-demand personalised assistance, enabling students to take control of their learning journey. By generating quizzes, answering individual questions, and offering personalised writing support, ChatGPT empowers students to independently identify and address gaps in their knowledge. This aligns with the *self-directed l*earning principle of PBL, where students take responsibility for their own learning processes. However, threats such as the potential for students to misuse ChatGPT for cheating or shortcutting tasks could diminish the effectiveness of *self-directed* learning by encouraging passive reliance on LLMs rather than active, self-motivated learning.

See below the full overview of results (figure 4, Mai, Da & Hanh, 2024)

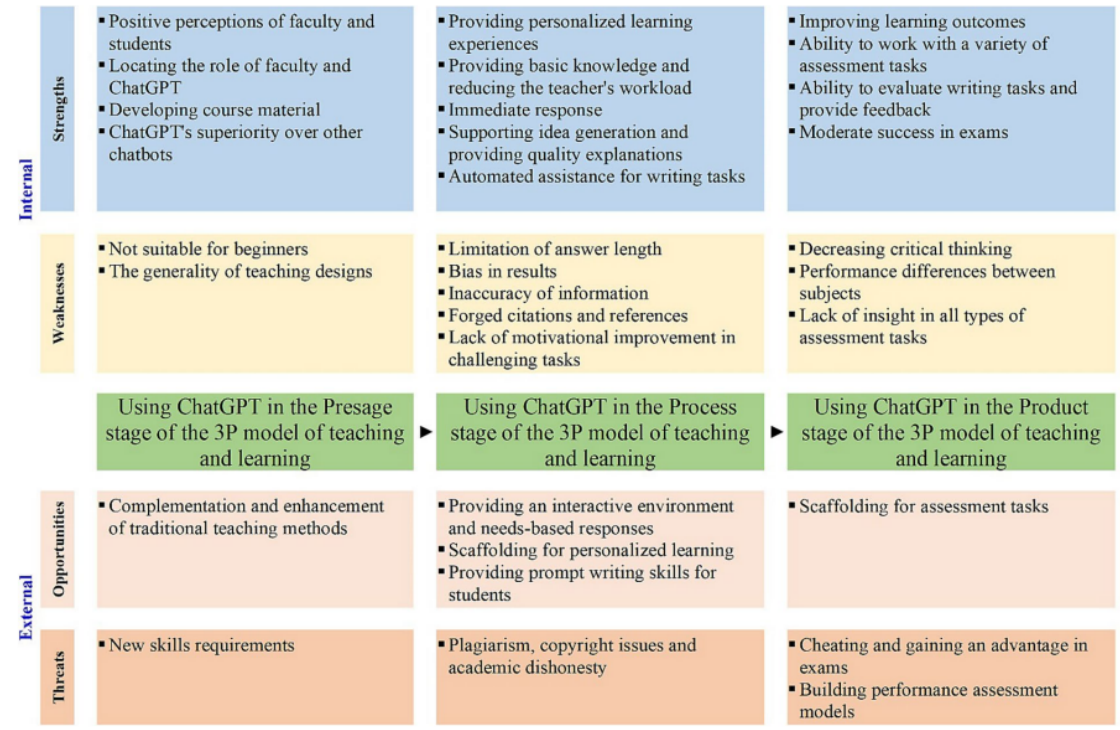

FIGURE 4

Takeaway for educators:
LLMs can be powerful tools for supporting educators' professional development by providing personalised, up-to-date resources and facilitating on-the-job learning. However, educators must critically assess generated materials by LLMs to ensure they are relevant, accurate, and aligned with their specific educational goals. While LLMs offer opportunities for enhancing learning, educators should be mindful of potential biases and ethical challenges, ensuring that AI augments professional growth without undermining critical human oversight and engagement.

LLM use in PBL for students

As earlier stated, PBL is guided by the core principles of constructive, contextual, collaborative and self-directed (CCCS) learning. In PBL, students work together (for example in tutorial groups) and engage in self-directed learning activities. This section explores how LLMs can support both synchronous (i.e students and educators gather at the same time and place) and asynchronous learning (i.e. individual students accessing materials at their own pace, time, and place).

SYNCHRONOUS LEARNING (IN GROUPS)

Pre-discussion and formulating learning goals

As part of UM's PBL framework, students regularly identify their learning goals through *collaborative* brainstorming. ChatGPT can assist this process by providing quick, tailored answers to student queries and helping groups refine their goals based on individual needs (Huang et al., 2022 for a systematic review). By learning from user interactions, ChatGPT tailors content to the skill sets of tutorial groups, facilitating idea generation and reflection to refine learning goals (Kim & Adlof, 2023b). With effective prompts, ChatGPT can paint a *contextual* picture of the problem at hand, which can enable students to picture real-time scenarios and assist them in critically identifying the required learning goals. However, while LLMs can help facilitate this process, it is important that students remain active participants in formulating their learning goals.

Takeaway for students: Use LLMs to generate ideas and refine learning goals, but ensure you actively contribute and think critically during discussions.

Post-discussions

During post-discussions, students usually engage in *collaborative* discussions to deepen their understanding of topics. ChatGPT can support these discussions by summarising key points and offering alternative views. However, students should avoid overreliance on LLMs, as it may hinder peer interaction and collaboration (Kim & Adlof, 2023b). Instead, ChatGPT can be used to provide fact checking or feedback on ideas presented during the session.

Takeaway for students: LLMs can help fact-check information and summarise discussions but be careful not to let it replace critical thinking and collaboration with your peers.

ASYNCHRONOUS LEARNING (INDIVIDUAL)

Seeking resources

Once learning goals are collaboratively established, students engage in self-study, utilising resources provided by UM and supplementing them with external (digital) sources. While the vast expanse of online information can be overwhelming, ChatGPT can adapt resources to suit students' individual preferences and suggest relevant online workshops or courses to augment

their knowledge (Lin, 2023). However, it is important for students to first engage with the required literature and use ChatGPT as a supplementary tool for comparison and summarisation.

Takeaway for students: Use LLMs to enhance your resource research, but make sure you engage deeply with the required readings on your own.

Self-studying

With learning goals and resources in hand, students are encouraged to take control of their learning (i.e. *self-directed* learning. Encouraged to question and reason, students can leverage LLMs to automate literature searches and break down complex theories into manageable themes, freeing up time for critical interpretation and deeper understanding (Darwin et al., 2023). ChatGPT aids in identifying knowledge gaps and comparing theories, fostering the *constructive* learning approach of exploring topics from various perspectives (Kim & Adlof, 2023; Thủy et al., 2024).

A study by Kim & Adlof (2023b) delves into how advanced LLMs can support *self-directed* learning (SDL) within asynchronous online learning environments. Their analysis highlights ChatGPT's potential to assist learners by setting personalised learning goals, sourcing educational materials, and offering tailored feedback, thereby enhancing learner autonomy and engagement. *Contextual* learning (which emphasises the application of abstract concepts to real-life scenarios), is facilitated by ChatGPT's provision of meaningful examples, guiding students toward practical applications of theoretical knowledge (Kim & Adlof, 2023b).

Learning extends beyond tutorials, necessitating long-term study goals to consolidate and deepen knowledge. UM emphasises self-directed learning, urging students to set specific, measurable, achievable, relevant and time-bound (SMART) goals. ChatGPT serves as a virtual tutor, available round-the-clock to assist students in formulating study plans tailored to their needs and goals, suggesting time-management techniques and assessing their knowledge (Lin, 2023; Thủy et al., 2024).

Takeaway for students: LLMs can significantly enhance your self-directed learning by helping you automate tasks like literature searches and breaking down complex topics. It can act as a virtual tutor, offering personalised support, setting learning goals, and providing meaningful examples to apply theoretical knowledge to real-world scenarios. However, to get the most out of LLMs, use it as a tool to deepen your understanding and manage your study plan, while staying actively engaged and setting clear, achievable goals.

Personalised learning

Multiple systematic reviews (e.g. Chiu et al., 2023, Zawacki-Richter et al., 2019, Chen et al., 2020) have focused on the utilisation of LLMs to facilitate personalised learning. AI technologies have been instrumental in democratising access to high-quality education for students globally, regardless of geographical location, socioeconomic status and individual learning differences. For example, the one-on-one interaction feature of ChatGPT exemplifies a personalised approach, allowing students to ask unlimited questions and tailor the learning experience to their specific needs.

Takeaway for students: LLMs can make high-quality education more accessible and personalised, allowing you to ask unlimited questions and tailor your learning to your specific needs, regardless of your location or background. This helps you take control of your learning and focus on the areas where you need the most support.

DISCUSSION

The aim of this rapid review was to review the impact of Large Language Models (LLMs) on Problem-Based Learning (PBL) for educators and students in higher education. The reviewed literature highlights the potential of LLMs, such as ChatGPT, in enhancing higher education, particularly within a PBL framework. The integration of LLMs into teaching and learning at Maastricht University (UM), focusing on the principles of constructive, contextual, collaborative, and self-directed (CCCS) learning presents substantial opportunities but also notable challenges. This section discusses these opportunities and challenges in detail.

Constructive learning

LLMs can enhance constructive learning by streamlining course design and offering personalised learning experiences. For instance, Pereira and colleagues (2024) illustrated how LLMs can automate initial course planning, reducing the workload for educators while offering more dynamic, tailored learning paths for students. Similarly, multiple systematic reviews (Chiu et al., 2023, Zawacki-Richter et al., 2019, Chen et al., 2020), emphasised the benefits of integrating LLMs into constructive learning frameworks (Rasul et al., 2023).

In summary, these are three opportunities for using LLMs for constructive learning: 1) streamlining course design: LLMs allow educators to efficiently create engaging and personalised learning materials, freeing up time for meaningful teaching and learning activities. 2) personalised learning paths: LLMs can help educators develop tailored learning plans that cater to individual student needs, promoting deeper understanding and retention, and 3) support for critical thinking: LLMs can provide diverse perspectives and examples that foster critical engagement and deeper analysis. Despite these potential benefits, there are concerns that the ease of obtaining LLM-generated information may lead to superficial understanding. Students might rely on LLMs without fully engaging with the learning material. In addition, LLMs may propagate biases present in their training data and provide

inaccurate information, potentially misleading students. Furthermore, over-reliance on LLMs can diminish students' critical thinking skills, as they might rely too heavily on automated responses rather than independent problem solving.

Contextual learning

LLMs can significantly enhance contextual learning by generating complex, real-world scenarios that help students apply theoretical knowledge to practical situations. Moorhouse et al. (2023) and Kim & Adolf (2023b) highlight how LLMs can assist in creating contextually relevant learning materials, while Holstein and colleagues (2020) emphasise the importance of human expertise in guiding LLM's adaptability in creating comprehensive learning experiences.

In summary, LLM can generate complex, real-world scenarios that help students apply theoretical knowledge in practical contexts. In addition, it can enhance collaboration by providing diverse perspectives. This can facilitate richer, more meaningful discussions among students. Despite these opportunities, there are several challenges. Balancing LLM and human input. While LLMs can generate valuable information, the expertise and judgement of educators are essential to ensure that the content is accurate and applicable in real-world contexts. Over-reliance on LLMs could result in contextually inaccurate or irrelevant learning materials, leading to misapplication of theoretical knowledge.

Self-directed learning among students

LLMs can support self-directed learning by offering personalised study plans, immediate access to resources, and continuous feedback. Huang et al. (2022), Lin (2023), and Thủy et al. (2024b) highlight how LLMs can enhance students' autonomy and engagement, enabling students to take control over their learning. In short, LLMs could help with setting and achieving personalised learning goals, enhancing their self-directed learning. In addition, LLMs could suggest relevant resources and study materials. Furthermore, LLMs can provide continuous support and guidance, acting as virtual tutors being instantly available.

While LLMs can promote students' autonomy, there is a risk of students becoming overly dependent on LLM-generated suggestions. This reliance could undermine their ability to independently search for information, critically evaluate resources, and engage deeply with the content. Educators must encourage students to use LLMs as tools to supplement, not replace, their own critical thinking and independent learning processes.

Assessment

The role of LLMs in assessment within PBL is still developing, but the potential for automated grading and feedback provision is promising. Yan et al. (2023) discuss both the benefits and ethical concerns associated with using LLMs in educational assessment. The potential for these models is to automate tasks such as creating suitable questions, grading and feedback provision. However, they also emphasised ethical concerns, such as data privacy and bias propagation, which must be carefully managed. Clear guidelines and ethical standards are needed to govern the use of LLMs in educational assessment, ensuring it complements rather than replaces human judgement.

Time efficiency

LLMs offer the potential to reduce the administrative burden on educators, allowing them to focus more on instructional strategies and student engagement. Many studies highlight how LLMs can optimise workflows by automating repetitive tasks (e.g. Alshater, 2022, Darwin et al., 2024, Kashyap, 2023, Terwiesch, 2023, Thuy et al., 2024). While LLMs can enhance efficiency, there are concerns about over-reliance on automation for tasks that require human judgement, such as grading complex assignments or providing nuanced feedback. Additionally, ethical considerations such as data privacy and biases must be addressed to ensure the responsible use of these tools in educational settings.

Ethical and practical considerations

While LLMs present many advantages, they come with their own set of challenges as well as ethical concerns. LLMs have come under scrutiny for many reasons. Chiu et al. (2023) discussed some of these challenges, namely the lack of knowledge among educators and students about the working of these tools leading to inefficient results. LLMs are constantly improving to be more intuitive to users' needs, but it helps to be aware of their opportunities and limitations

Rasul et al. (2023) and Kim & Adolf (2023) criticised the over-reliance on LLMs arguing that it can lead to biased outcomes as well as hinder peer collaboration in problem-based learning. Students might opt to use LLMs instead of engaging with peers. This can undermine collaborative learning as one of the core principles of PBL. It needs to be stated that LLMs should be used to supplement learning rather replace human tutors and peers.

Limitations and future research

This rapid review has several limitations that should be acknowledged. First, the scope of the literature reviewed was limited due to the rapid nature of the process, potentially overlooking important studies or insights from broader contexts. Additionally, much of the research discussed focuses on the short-term impact of LLMs in PBL, with limited evidence on the long-term effects of these technologies on students' problem-solving skills and critical thinking abilities. The rapid review methodology itself also imposes constraints, as it limits the depth of analysis and comprehensiveness of the literature search, potentially missing key studies or perspectives. Lastly, LLMs are still emerging technologies and the lack of longitudinal studies assessing their sustained impact on education means that current findings may become outdated as these tools and their applications continue to evolve.

There are several key areas where future research on the use of LLMs in PBL can be expanded. Empirical studies are crucial to better understand the practical implications of LLMs in real classroom settings, particularly within PBL environments. Research that directly examines how LLMs affect student learning outcomes, engagement, and collaboration in synchronous PBL tutorials would provide more evidence of their effectiveness and limitations in practice. There is also a need for longitudinal studies to assess the long-term impact of LLM use on students' critical thinking, problem-solving skills, and independence. Such research would help determine whether prolonged exposure to LLMs influences students' ability to learn independently and engage in deep, critical analysis of complex problems. Additionally,

research should explore how educators can best integrate LLMs with traditional pedagogical strategies in PBL, examining how teachers balance LLM use with their teaching activities to maximise student learning and how to mitigate the risk of over-reliance on LLMs. Finally, there is a pressing need for research on the ethical dimensions of LLM use in education, particularly regarding data privacy, bias, and intellectual property issues associated with AI-generated content. Establishing ethical guidelines and best practices for using LLMs in PBL settings will be crucial as these technologies become more widespread in educational contexts.

Conclusion

The reviewed literature suggests that LLMs offer the potential to have a positive impact on teaching and learning within PBL frameworks, particularly by streamlining course design, reducing administrative burdens and providing real-time feedback. However, the integration of LLMs requires careful attention to ethical implications, such as data privacy, bias, and the need for human judgement in key areas of education. LLMs should be viewed as tools that support, rather than replace, educators and human interaction in the learning process.

By thoughtfully integrating LLMs into PBL practices, UM can leverage these tools to create more dynamic, personalised, and effective learning environments, while maintaining the crucial role of educators in guiding and mentoring students in their learning process.

REFERENCE LIST

Alshater, M. (2022). Exploring the Role of Artificial Intelligence in Enhancing Academic Performance: A Case Study of ChatGPT. *SSRN Electronic Journal*. Available from: https://www.ssrn.com/abstract=4312358

Chen, L, Chen, P and, Lin, Z. (2020), Artificial Intelligence in Education: A Review, in IEEE Access, *8*, 75264-75278, https://doi.org/10.1109/ACCESS.2020.2988510

Darwin, Rusdin, D., Mukminatien, N., Suryati, N., Laksmi, E. D., & Marzuki. (2024). Critical thinking in the AI era: An exploration of EFL students' perceptions, benefits, and limitations. *Cogent Education*, *11*(1), 2290342. http://dx.doi.org/10.1080/2331186X.2023.2290342

Dai, W., Lin, J., Jin, F., Li, T., Tsai, Y. S., Gasevic, D., et al. (2023). Can Large Language Models Provide Feedback to Students? A Case Study on ChatGPT. https://doi.org/10.35542/osf.io/hcgzj

Dolmans, D. H. J. M. (2019). How theory and design-based research can mature PBL practice and research. *Advances in Health Sciences Education*, 24(5), 879-891. https://link.springer.com/article/10.1007/s10459-019-09940-2

Frambach, J. M., Talaat, W., Wasenitz, S., & Martimianakis, M. A. (2019). The case for plural PBL: An analysis of dominant and marginalized perspectives in the globalization of problem-based learning. *Advances in Health Sciences Education*, 24(5), 931-942. https://doi.org/10.1007/s10459-019-09930-4

Francom, G. M. (2016). Principles for task-centered instruction. In C. M. Reigeluth, B. J. Beaty, & R. D. Myers (Eds.), *Instructional-design theories and models* (Vol. IV, pp. 81-108). New York: Routledge.

Holstein, K., Aleven, V., & Rummel, N. (2020). A Conceptual Framework for Human–AI Hybrid Adaptivity in Education. In Bittencourt, I. I., Cukurova, M., Muldner, K., Luckin, R., & Millán, E. (Eds.), *Artificial Intelligence in Education* (Lecture Notes in Computer Science, Vol. 12163, pp. 240-254). Cham: Springer International Publishing. Available from: http://link.springer.com/10.1007/978-3-030-52237-7_20

Jeon, J., & Lee, S. (2023). Large language models in education: A focus on the complementary relationship between human teachers and ChatGPT. *Educational Information Technology*, 28(12), 15873-15892. http://dx.doi.org/10.1007/s10639-023-11834-1

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

Kashyap, R. (2023). A First Chat with ChatGPT: The First Step in the Road-Map for Artificial Intelligence. https://doi.org/10.32388/DFE2XG

Kim, M., & Adlof, L. (2024). Adapting to the Future: ChatGPT as a Means for Supporting Constructivist Learning Environments. *TechTrends*, 68(1), 37-46. http://dx.doi.org/10.1007/s11528-023-00899-x

Lin, X. (2023). Exploring the Role of ChatGPT as a Facilitator for Motivating Self-Directed Learning Among Adult Learners. *Adult Learning*, 34(3), 20-35. http://dx.doi.org/10.1177/10451595231184928

Loyens, S. M. M., Van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating Higher-Order, Critical, and Critical-Analytic Thinking in Problem- and Project-Based Learning Environments: A Systematic Review. *Educational Psychology Review*, 35(2), 39. https://link.springer.com/article/10.1007/s10648-023-09757-x

Mai, D. T. T., Da, C. V., & Hanh, N. V. (2024). The use of ChatGPT in teaching and learning: a systematic review through SWOT analysis approach. *Frontiers in Education, 9,* p. 1328769 https://doi.org/10.3389/feduc.2024.1328769

Meyer, J., Jansen, T., Schiller, R., Liebenow, L. W., Steinbach, M., Horbach, A., et al. (2024). Using LLMs to bring evidence-based feedback into the classroom: AI-generated feedback increases secondary students' text revision, motivation, and positive emotions. *Computers and Education: Artificial Intelligence*, 6, 100199. https://doi.org/10.1016/j.caeai.2023.100199

Moorhouse, B. L., Yeo, M. A., & Wan, Y. (2023). Generative AI tools and assessment: Guidelines of the world's top-ranking universities. *Computers and Education: Open*, 5, 100151. https://doi.org/10.1016/j.caeo.2023.100151

Owston, R (2023). *Contact North | Contact Nord to launch two new AI-powered tools at OEB Berlin*, Online Educa Berlin (OEB) Insight. https://oeb.global/oeb-insights/contact-north-contact-nord-to-launch-two-new-ai-powered-tools-at-oeb-berlin/

Pereira, E., Nsair, S., Pereira, L. R., & Grant, K. (2024). Constructive alignment in a graduate-level project management course: an innovative framework using large language models. *International Journal of Educational Technology in Higher Education*, *21*(1), 25. https://doi.org/10.1186/s41239-024-00457-2

Rasul, T., Nair, S., Kalendra, D., Robin, M., de Oliveira Santini, F., Ladeira, W. J., Sun, M., Day, I., Rather, R. A., & Heathcote, L. (2023). The role of ChatGPT in higher education: Benefits, challenges, and future research directions. *Journal of Applied Learning and Teaching*, *6*(1). https://doi.org/10.37074/jalt.2023.6.1.29

Savin-Baden, M. (2001). The problem-based learning landscape. *Planet*, 4(1), 4-6.

Terwiesch, C. (2023). Would Chat GPT3 Get a Wharton MBA? A Prediction Based on Its Performance in the Operations Management Course. *Mack Institute for Innovation Management at the Wharton School, University of Pennsylvania*.

Nguyen, Thuy & Lai, Nam & Nguyen, Quyet. (2024). Artificial Intelligence (AI) in Education: A Case Study on ChatGPT's Influence on Student Learning Behaviors. Educational Process International Journal. 13. 105-121. https://doi.org/10.22521/edupij.2024.132.7

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

Yan, L., Sha, L., Zhao, L., Li, Y., Martinez-Maldonado, R., Chen, G., Li, X., Jin, Y., & Gašević, D. (2024). Practical and ethical challenges of large language models in education: A systematic scoping review. *British Journal of Educational Technology*, *55*(1), 90-112. https://doi.org/10.1111/bjet.13370

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education–where are the educators? *International Journal of Educational Technology in Higher Education*, *16*(1), 1-27. https://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-019-0171-0