Using Generative AI to Enhance Personalised and Self-Regulated Learning

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Abstract: The advent of Generative AI presents a remarkable opportunity for enhancing personalised and self-regulated learning. This paper introduces the AI-Enhanced Personal Learning Environment (AI-PLE) as a learner-focused digital space that uses Generative AI to provide personalised, adaptive, and collaborative learning experiences. The AI-PLE supports Self-Regulated Learning (SRL) by helping learners set goals, monitor progress, and refine strategies while offering curated resources, real-time feedback, and reflective prompts. By fostering engagement, inclusivity, and innovation, the AI-PLE empowers learners to take charge of their education, blending dynamic tools with social learning interactions. Initial findings from a case study in teacher education suggest that the AI-PLE holds significant potential in facilitating SRL among pre-service teachers by improving their ability to set goals, reflect on their progress, and stay motivated. However, certain challenges such as potential over-reliance on AI need to be addressed to ensure that pre-service teachers retain autonomy and confidence in their self-regulation abilities.

Introduction

Generative AI has recently emerged as a category of Artificial Intelligence (AI) algorithms and models designed to generate new content, such as images, text, and music, that resembles human-created content (Sabzalieva and Valentini, 2023). Generative AI utilises techniques such as deep learning and neural networks to mimic human creativity and produce outputs that are not explicitly programmed or predefined. The models are trained on vast amounts of data, learning the underlying patterns, and then generate new content based on those patterns (Gozalo-Brizuela and Garrido-Merchan, 2023). It is important to note that Generative AI also comes with ethical considerations, such as the potential for misuse or the generation of deceptive or malicious content (Bozkurt *et al.*, 2023, Floridi, 2023).

Namatherdhala *et al.* (2022) in their research categorised the role of AI in education into educational administration, instructional design, and learning, as it is widespread and covers learning, teaching, and administration-management. The role of AI as a key player in the learning process, starting from the execution of general tasks e.g., outlining the lesson of a textbook, or automatic assessment using data, comes to secure its place in the increase of educational content, whether complementing traditional classroom teaching (Hwang *et al.*, 2020), or simply as an intelligent host of certain learning activities with a common denominator the personalisation of the educational field (Chiu, 2023, Su and Yang, 2023). AI supports teaching and learning by generating questions, providing answers, and evaluating student performance (Bhutoria, 2022, Bahroun *et al.*, 2023, Griva *et al.*, 2024).

The Personal Learning Environment (PLE) was first introduced by Van Harmelen (2006) as a facility for helping learners manage and take control of their own learning. The PLE promotes self-regulation in learning by allowing learners to aggregate, manipulate and share digital artefacts within a flexible and versatile online space. The emergence of Generative AI offers new opportunities towards enhancing the PLE by offering highly personalised learning content and services to the individual learner. By providing resources, guidance, and adaptive learning

experiences, Generative AI can support the development of skills and strategies that are crucial for self-regulated learning (Nussbaumer *et al.*, 2015, Mikroyannidis and Armakolas, 2024).

In this paper, we introduce the AI-Enhanced Personal Learning Environment (AI-PLE) as a learner-centred digital ecosystem that leverages Generative AI to facilitate personalised, adaptive, and collaborative learning. We discuss the range of pedagogical capabilities offered by the AI-PLE, as well as how these capabilities support self-regulation in learning. Additionally, we discuss a case study on the use of the AI-PLE in teacher education and we present initial findings based on the feedback obtained from the participating pre-service teachers.

The remainder of this paper is organised as follows. First, we discuss the original PLE concept and how this enables self-regulated learning. We then present the AI-PLE and its pedagogical capabilities for enhancing personalisation and self-regulation in learning. This is followed by the presentation of the teacher education case study and the discussion of the initial findings from this case study. Finally, the paper is concluded and the main directions for future work are outlined.

The Personal Learning Environment

The Personal Learning Environment (PLE) is a facility for a learner to access, aggregate, manipulate, and share digital artefacts of their online learning journey. The PLE follows a learner-centric approach, allowing the use of lightweight online services and tools that belong to and are controlled by individual learners. Rather than integrating different services into a centralised system, the PLE provides learners with a variety of online services and hands over control to them to select and use these services the way they deem fit (Mikroyannidis *et al.*, 2015). As such, the PLE promotes self-regulation in learning and allows learners to aggregate, manipulate and share digital artefacts within a flexible and versatile online space (Armakolas *et al.*, 2016).

The PLE is commonly enabled by widgets, which are micro-applications performing a dedicated task. This task can be as simple as showing news headlines or weather forecasts, or more complex such as facilitating language learning or collaborative authoring of a shared document. A key characteristic of widgets is that they are interchangeable and can be used as the building blocks of the PLE in a fashion similar to using plain LEGOs to build a more complex structure. Using widgets to build a PLE is offering the learner with the ability to create an individually controlled and preferred learning environment.

Figure 1 shows an example of a widget-enabled PLE used in the context of Inquiry-Based Learning. The pedagogical approach of Inquiry-Based Learning allows learners to take the role of an explorer and a scientist as they try to solve issues they came across and that made them wonder, thus tapping into their personal feelings of curiosity. Figure 1 shows a PLE for the "Discuss the findings" phase of a particular inquiry, which explores the everyday use of batteries and their impact on the environment. In this phase, learners use collaboratively three widgets in order to discuss and interpret their inquiry findings. In particular, they use the "Inquiry discussion" widget to exchange their views asynchronously in a discussion forum. They also use the "Questions" widget in order to provide answers to the key research questions of this inquiry and vote for the best answers. Finally, they create and share mind maps containing interpretations of their inquiry findings via the "Mind maps" widget.

Self-regulated learning (SRL) comprises an essential aspect of the PLE, as it enables learners to become *"metacognitively, motivationally, and behaviourally active participants in their own learning process"* (Zimmerman, 1989). Although the psycho-pedagogical theories around SRL predate very much the advent of the PLE, SRL is a core characteristic of the latter. SRL is enabled within the PLE through the learner-driven assembly of independent resources in a way that fulfils a specific learning goal. By following this paradigm, the PLE allows learners to regulate their own learning, thus greatly enhancing their learning outcomes (Steffens, 2006, Fruhmann *et al.*, 2010).

SRL is activated in the PLE and is focused on connecting independent resources in a way that fulfils a particular learning goal. Following this example, SRL allows learners to be their own regulator regarding their learning process; thus, learning outcomes are significantly increased (Mikroyannidis *et al.*, 2014, Armakolas *et al.*, 2015). The ability to offer face-to-face and online courses that meet students' interests and abilities has been a subject considered a guide for new materials and content (İpek *et al.*, 2023). This has led researchers to suggest that a) students should be encouraged to develop skills and gain confidence by selecting, applying and using social media tools for personalised learning, and that b) new pedagogical approaches and models are required in order to enhance students' abilities to organise and adapt their own learning context and to promote their autonomy and self-knowledge in a PLE (Armakolas *et al.*, 2016).

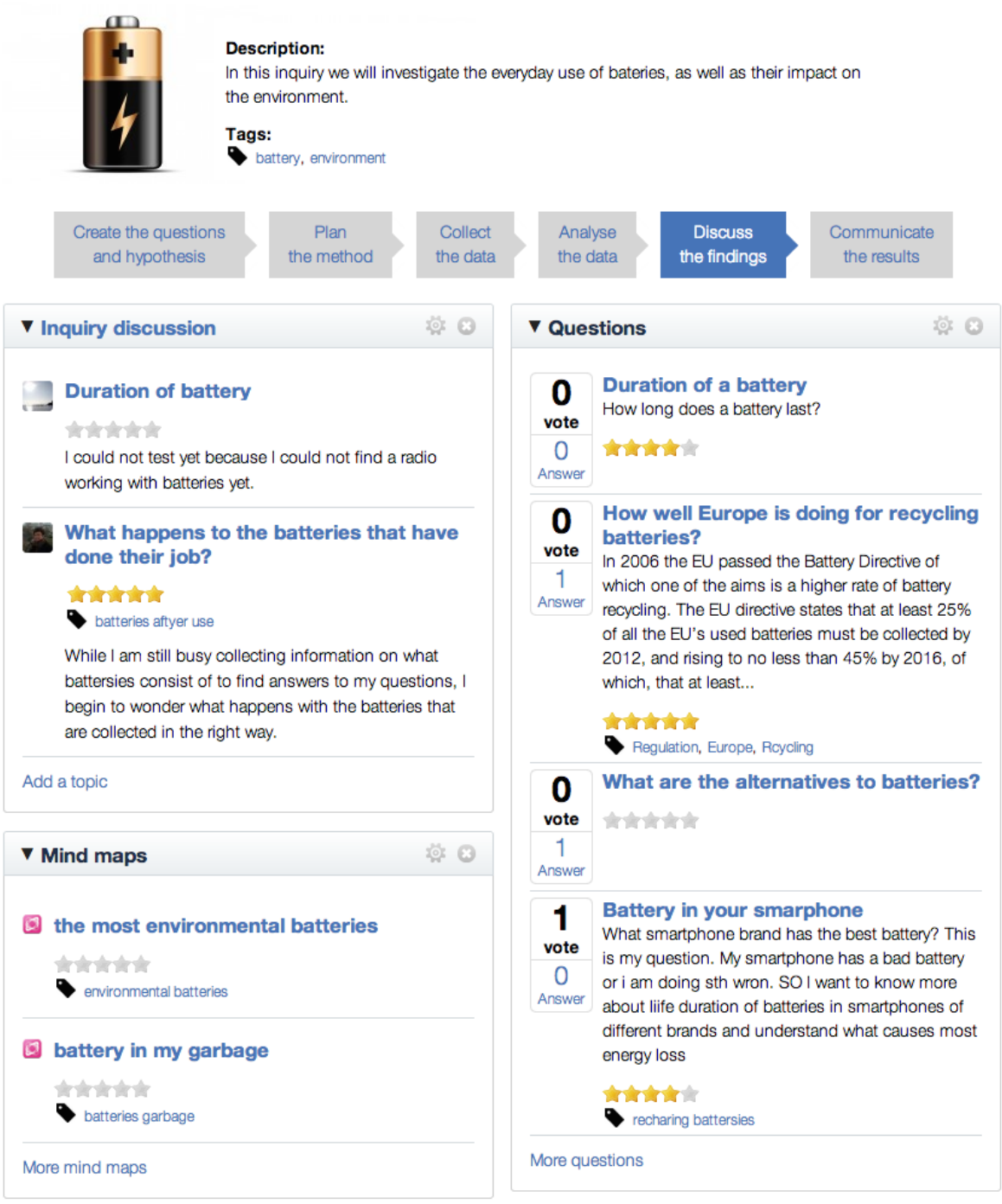

Figure 1: A PLE consisting of widgets for discussing and interpreting the findings of an inquiry, used in the context of Inquiry-Based Learning.

The AI-Enhanced Personal Learning Environment

The AI-Enhanced Personal Learning Environment (AI-PLE) is a learner-centred digital ecosystem that integrates AI to support personalised, adaptive, and collaborative learning experiences. It empowers learners to take control of their educational journey by leveraging AI to curate resources, provide real-time feedback, suggest adaptive learning pathways, and foster reflective practices. Self-Regulated Learning (SRL) plays a central role in this

environment, as AI tools actively support learners in setting goals, monitoring progress, and adjusting strategies to achieve their learning goals. By combining dynamic tools and social interactions, the AI-PLE accommodates personalised learning, promotes SRL, and enhances engagement through interactive and innovative learning facilities.

The following sections outline the main pedagogical capabilities of the AI-PLE and highlight the ways that AI enhances the PLE by empowering learners to take full control of their learning journey while benefiting from the novel features offered by AI. Additionally, the following sections outline the main strategies for facilitating SRL within the AI-PLE, by supporting the *metacognitive*, *motivational*, and *behavioural* aspects of SRL.

Personalised Learning Content

The AI-PLE offers personalised learning content by tailoring learning materials to match the learner's unique needs and interests. By analysing the learner's strengths, weaknesses, and preferences, the AI-PLE can generate personalised study materials, including summaries, concept explanations, or practice exercises (Mikroyannidis *et al.*, 2024a). This allows learners to focus on areas where they need improvement while reinforcing existing knowledge. For example, a learner struggling with calculus may receive simpler, step-by-step problem explanations, while another more advanced learner could get challenging applications of the same concepts (Chan and Hu, 2023). Additionally, the AI-PLE can adjust the difficulty level of practice questions, ensuring that the learner is continuously challenged without being overwhelmed. This personalised approach fosters *metacognitive* skills as learners become aware of their progress and gaps, encouraging strategic adjustments in their study plans. This approach also boosts *motivation*, as tailored content feels more relevant and manageable. *Behaviourally*, learners are more likely to engage with materials that are directly applicable to their goals.

Adaptive Learning Pathways

The AI-PLE dynamically adapts learning pathways in order to guide learners through personalised trajectories that evolve based on their progress. As the learner interacts with the content, the AI-PLE monitors their performance, identifying strengths and weaknesses. It then adjusts the learning pathway accordingly, introducing new topics when the learner is ready or revisiting concepts that need reinforcement. This adaptive approach ensures learners spend time effectively, revisiting challenging concepts or advancing when ready. By continually adjusting the learning trajectory, the AI-PLE ensures that the educational journey remains aligned with the learner's evolving needs and goals (Bozkurt, 2023). This approach supports *metacognitive* development by prompting learners to reflect on their understanding and adjust strategies accordingly. The *motivational* aspect is evident as learners experience a sense of accomplishment from achieving goals tailored to their skill level. *Behaviourally*, adaptive pathways encourage consistency in study habits, as learners are continuously engaged with content that aligns with their readiness and ambitions.

Interactive Learning Tools

The AI-PLE offers interactive learning tools for enhancing learner engagement and understanding. These tools include AI-powered virtual tutors that provide real-time feedback and explanations, helping learners grasp complex concepts at their own pace (Mikroyannidis *et al.*, 2024a). Additionally, the AI-PLE can generate simulations and scenario-based learning environments that offer experiential learning opportunities. For example, a medical student can practice diagnosing patients in a simulated environment with dynamically adjusted scenarios based on the student's preferences (Bozkurt *et al.*, 2023). These tools strengthen *metacognition* by enabling learners to assess their grasp of concepts through practice and immediate feedback. They also sustain *motivation* by making learning enjoyable and dynamic, reducing monotony. *Behaviourally*, learners actively participate in problem-solving and exploratory tasks, which promotes sustained engagement and deeper learning.

Collaboration and Peer Learning

The AI-PLE facilitates collaboration and peer learning by connecting learners with similar interests and complementing their strengths. The AI-PLE can analyse the profiles of learners in order to suggest study groups or collaborative projects that maximise peer learning opportunities. Moreover, it can generate discussion prompts, moderate debates, and even simulate different viewpoints to stimulate critical thinking and deeper exploration of topics. By enhancing peer-to-peer interaction, the AI-PLE offers a social and collaborative learning environment, where learners can benefit from the insights and experiences of their peers (Sharples, 2023). This collaborative

approach develops *metacognitive* skills by encouraging learners to reflect on their own understanding and articulate their thoughts while engaging with others. It bolsters *motivation* through the social aspect of learning, fostering a sense of belonging and shared achievement. *Behaviourally*, learners actively contribute to group discussions, helping them practice teamwork and effective communication.

Content Curation and Aggregation

The AI-PLE acts as a content curator and aggregator by streamlining the vast amount of information available online. It can sift through numerous resources, selecting the most relevant and high-quality materials based on the learner's current focus (Hwang *et al.*, 2020). It can extract key points from lectures, or compile topic-specific articles, saving learners time and effort. For example, a learner studying climate change can receive a curated list of articles, videos, and datasets tailored to their focus area. Additionally, the AI-PLE can provide summaries of lengthy documents, allowing learners to quickly grasp key concepts and decide whether to explore the full content (Mikroyannidis *et al.*, 2024b). This capability enhances *metacognition* by helping learners prioritise their study resources and plan effectively. It sustains *motivation* by reducing the cognitive load of searching for content, allowing learners to focus on learning itself. *Behaviourally*, curated content encourages learners to engage more systematically with high-quality resources, fostering efficient study habits.

Language Support and Accessibility

The AI-PLE improves the accessibility of learning materials by providing robust language support and accommodating diverse learning needs. AI-powered translation can convert learning content into the learner's preferred language, making educational resources accessible to a global audience (Fu and Liu, 2024). Additionally, the AI-PLE can localise content, adjusting examples and references to align with the learner's cultural context (Mikroyannidis *et al.*, 2024b). For learners with disabilities, the AI-PLE can generate content in various formats, such as audio descriptions for visually impaired learners or simplified text for those with cognitive challenges (Glazko *et al.*, 2023). This adaptability supports *metacognition* by enabling learners to focus on understanding concepts rather than struggling with language or accessibility barriers. It also boosts *motivation* by creating an inclusive environment where learners feel confident in their ability to succeed. *Behaviourally*, learners are encouraged to explore diverse content formats and engage with materials that might otherwise be inaccessible.

Reflective Learning and Feedback

The AI-PLE promotes reflective learning and provides personalised feedback, helping learners to deepen their understanding and self-assess their progress. After a learning session or assessment, the AI-PLE can generate reflective prompts tailored to the learner's activities, encouraging them to think critically about what they have learned and how they can apply it (Bozkurt *et al.*, 2023). Additionally, the AI-PLE can provide instant feedback on assessments, not only indicating whether answers are correct but also offering detailed explanations, highlighting areas of improvement, and suggesting further study topics. This immediate, personalised feedback helps learners to identify their strengths and weaknesses, fostering a more introspective and self-directed approach to learning (Mikroyannidis *et al.*, 2024a). These capabilities enhance *metacognition* by encouraging learners to critically analyse their efforts and refine their strategies. Feedback also sustains *motivation* by demonstrating progress and offering clear pathways for improvement. *Behaviourally*, learners adopt a habit of self-assessment and continuous refinement, which are core to SRL.

Support for Creativity and Innovation

The AI-PLE fosters creativity and innovation by providing tools that assist learners in producing original content and developing new ideas (Sabzalieva and Valentini, 2023). Whether it is helping a learner structure a research paper, suggesting visual elements for a presentation, or generating ideas during a brainstorming session, the AI-PLE can play a crucial role in the creative process (Mikroyannidis *et al.*, 2024b). For example, Generative AI can help a learner outline a complex project by breaking it down into manageable tasks, or suggest novel approaches to problem-solving based on a vast database of existing knowledge (Zhai *et al.*, 2024). This support enables learners to think critically and apply their knowledge in novel ways. Such creative opportunities enhance *metacognitive* skills by requiring learners to evaluate the feasibility and impact of their ideas. They also boost *motivation* by making learning

more engaging and relevant to personal interests. *Behaviourally*, learners are driven to experiment, innovate, and take ownership of their learning projects, fostering deeper engagement.

Time Management and Organisation

The AI-PLE facilitates time management and organisation by automating the scheduling and prioritisation of learning tasks. It can generate personalised study schedules that take into account the learner's availability, deadlines, and overall goals. If a learner's circumstances change, the AI-PLE can dynamically adjust the schedule, ensuring that the learner stays on track without becoming overwhelmed (Chan and Hu, 2023). Additionally, the AI-PLE can prioritise tasks based on factors such as urgency, difficulty, as well as the learner's current progress (Abbas *et al.*, 2024). This organisational support allows learners to manage their time more effectively, reducing stress and enhancing productivity. These capabilities help develop *metacognitive* skills by encouraging learners to reflect on their time use and plan proactively. They also sustain *motivation* by reducing stress and providing a sense of control over their workload. *Behaviourally*, learners adopt disciplined habits and make consistent progress toward their goals, which is essential for the development of SRL skills.

Continuous Improvement and Iteration

The AI-PLE helps learners iteratively refine their approaches by analysing behaviours and suggesting improvements. For example, the AI-PLE can track the time spent on tasks and recommend adjustments to optimise efficiency (Barcaui and Monat, 2023). Over time, learners gain insights into what methods work best for them, fostering a cycle of continuous improvement. This iterative process sharpens *metacognitive* skills as learners analyse patterns, identify effective strategies, and adjust their approach. It fuels *motivation* by showing tangible progress and reinforcing the belief that improvement is achievable. *Behaviourally*, learners actively engage in a feedback loop of planning, executing, and refining, strengthening their self-regulation.

Case Study: The AI-PLE in Teacher Education

In this section, we present a case study on the use of the AI-PLE in teacher education. The main research objective of this case study has been the investigation of the role that the AI-PLE can play in facilitating SRL among pre-service teachers, specifically in the following ways:

- Understanding how the AI-PLE can support pre-service teachers in taking ownership of their learning through goal setting, self-monitoring, and reflection.
- Investigating the impact of the AI-PLE pedagogical capabilities on the development of metacognitive, motivational, and behavioural skills among pre-service teachers.

The case study was conducted in the context of the "Educational Technology" course at a teacher education and training institution in Greece. The course was attended by approximately 200 pre-service teachers during 1 semester. The participating pre-service teachers were asked to work in groups and use the AI-PLE to carry out a range of course assignments, such as preparing lesson plans and exploring instructional strategies. More specifically, the case study participants were asked to use the AI-PLE in the pedagogical roles defined by Sharples (2023), which leverage Generative AI's potential to foster creativity, critical thinking, and collaborative skills. Table 1 presents the full range of the AI-PLE use cases that were deployed in this case study.

Use case	Description	Case study deployment
Possibility Engine	The AI-PLE generates alternative ways of expressing ideas or addressing problems.	Pre-service teachers use the AI-PLE to explore multiple instructional strategies for a single concept. For instance, when planning a lesson on fractions, the AI can propose a variety of methods: using manipulatives (e.g., fraction circles), storytelling (e.g., dividing a pizza), or real-life applications (e.g., sharing a recipe). Participants prompt the AI with questions such as: "What are three innovative ways to teach fractions to elementary school students?" and compare the responses. This approach allows pre-

		service teachers to evaluate and select strategies best suited to their future classrooms.
Socratic Opponent	The AI-PLE acts as a respondent to challenge assumptions and develop arguments.	The AI-PLE is used to simulate debates on pedagogical theories. For example, participants may pose a prompt such as: "Should technology replace traditional textbooks in the classroom?". The AI-PLE presents arguments for and against the proposition, challenging participants to defend their stance or refine their reasoning. Additionally, the AI-PLE simulates student perspectives, helping pre-service teachers practice responding to potential classroom scenarios.
Collaboration Coach	The AI-PLE supports group activities by facilitating research, problem-solving, and task organisation.	In group projects, such as designing a curriculum for a diverse classroom, the AI-PLE helps pre-service teachers organise their tasks, identify relevant resources, and propose inclusive strategies. For example, participants can use the AI-PLE to generate initial ideas for integrating cultural perspectives into lesson plans. The AI-PLE can also assist by dividing the project into manageable tasks, assigning roles, and tracking progress.
Co-Designer	The AI-PLE collaborates in the design process, providing ideas, feedback, and suggestions.	Pre-service teachers designing a classroom activity use the AI-PLE as a creative partner. For instance, while developing a lesson plan on environmental science, they may ask the AI-PLE to propose ideas for interactive activities, such as creating a virtual recycling challenge or an outdoor scavenger hunt. The AI-PLE can also assist in refining the activity by suggesting accessibility features for diverse students, such as multilingual instructions or modifications for students with disabilities.
Exploratorium	The AI-PLE provides tools to explore, visualise, and interpret data or concepts.	Pre-service teachers use the AI-PLE to analyse educational data, such as classroom demographics or assessment results, to inform their instructional strategies. For example, they can upload a dataset of student performance and prompt the AI-PLE to generate visualisations highlighting areas of improvement, such as reading comprehension trends across different age groups. Pre-service teachers can also explore different teaching approaches by simulating lesson delivery through AI, adjusting variables such as student engagement or pacing to see how outcomes might change.
Storyteller	The AI-PLE helps create narratives that reflect diverse experiences, abilities, and perspectives.	Pre-service teachers use the AI-PLE to develop inclusive classroom stories that celebrate diversity. For example, they can prompt the AI-PLE to create a story about a team of students from different cultural backgrounds collaborating to solve a community problem. The AI-PLE can generate characters, dialogues, and scenarios that participants can adapt and expand. This practice helps pre-service teachers craft narratives that are sensitive to diversity and free from stereotypes, promoting equity and representation in their future classrooms.

Table 1: The AI-PLE use cases deployed in the teacher education case study, based on the pedagogical roles defined by Sharples (2023).

Initial feedback obtained from the participating pre-service teachers indicates that the deployment of the AI-PLE in teacher education can foster collaboration, critical thinking, and creativity while enabling pre-service teachers to practice inclusive and reflective teaching strategies. In particular, the participating pre-service teachers reported that the AI-PLE helped them clarify their learning objectives and provided structured approaches to achieve them. For example, the ability to generate personalised learning plans allowed participants to set realistic, measurable goals for mastering specific pedagogical techniques. This indicates that the AI-PLE supports the metacognitive aspect of SRL by helping pre-service teachers identify their strengths, weaknesses, and areas for improvement, fostering a deeper understanding of their learning processes.

Participants found AI-generated feedback to be immediate and specific, which motivated them to address their mistakes and try alternative strategies. This finding suggests that personalised feedback can promote the motivational aspect of SRL by keeping pre-service teachers engaged and confident in their ability to progress. Several participants also noted that AI-generated reflective prompts encouraged them to think critically about their teaching strategies and decisions. For instance, after planning a lesson, they were prompted with questions like "How would this lesson cater to students with diverse learning needs?". This indicates that the AI-PLE can foster metacognitive reflection by enabling pre-service teachers to assess their teaching methods and refine their strategies.

On the other hand, some participants expressed the concern that they could become overly reliant on AI-generated recommendations, potentially reducing their ability to independently set goals or evaluate strategies. This shows that there is a risk of diminishing autonomous decision-making when overly depending on AI for guidance and validation. Additionally, some participants noted that the abundance of AI-generated recommendations felt overwhelming at times, making it difficult to decide which recommendations to prioritise and undermining their decision-making capacity.

Finally, most participants expressed increased confidence in their ability to self-regulate after using the AI-PLE, citing improvements in goal setting, monitoring progress, and adapting strategies. This indicates that the AI-PLE can have a positive impact on the overall development of SRL skills, helping prepare pre-service teachers to be proactive, reflective, and adaptive in their professional growth.

Conclusions and Future Work

This paper has introduced the AI-PLE as a learner-focused digital space that leverages Generative AI to create a personalised, adaptive, and collaborative learning ecosystem and empowers learners to take charge of their learning journey. By supporting SRL, the AI-PLE helps learners set goals, monitor progress, and refine strategies through curated resources, real-time feedback, and reflective prompts. It fosters engagement, inclusivity, and innovation by blending dynamic tools with social interactions. In a case study on teacher education, the AI-PLE has shown significant potential in facilitating SRL among pre-service teachers. Key findings included enhanced goal setting, personalised feedback, and improved time management, enabling pre-service teachers to reflect critically on their teaching strategies and adopt effective practices. However, challenges such as over-reliance on AI and overload of AI-generated recommendations highlight the need for ensuring pre-service teachers maintain autonomy and decision-making skills.

Future work could delve deeper into understanding the perceptions of pre-service teachers regarding the role of the AI-PLE in fostering SRL, as well as regarding their readiness to integrate such tools into their professional teaching practices. Future research could also explore the potential of the AI-PLE beyond teacher education, by investigating its impact on other professional training domains, such as healthcare, engineering, or business. These studies could examine how AI-powered personalisation, adaptive learning pathways, and collaborative learning tools can support the development of SRL skills and professional growth in fields with unique requirements, such as clinical decision-making in healthcare, project design in engineering, or strategic planning in business. This research direction would provide insights into the versatility of the AI-PLE and its capacity to transform training and lifelong learning across various sectors.

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