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Education

Personalised learning in project management education: Insights from an artificial intelligence-driven chatbot

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A B S T R A C T

The increasing complexity of project-based work in contemporary organisations calls for a transformation in how project management is taught. Traditional teaching approaches struggle to support self-directed, context-sensitive, and motivationally engaging learning experiences—skills that are critical for preparing future project leaders. In this context, there is growing interest in the potential of artificial intelligence-powered tools to enhance the quality and adaptability of educating future project managers. This paper explores the application of artificial intelligence-driven chatbots in university-level project management education through the lens of the two-year international project "ChatLearn" conducted across four European countries. Using an action design research methodology, the project iteratively developed and tested a chatbot in three versions, progressively integrating feedback from students and educators. The study suggests that artificial intelligence-based chatbots hold significant promise for supporting personalised learning journeys and increasing student motivation; however, their integration requires careful design, ongoing dialogue within the teaching community, and a strong alignment with pedagogical objectives.

1. Introduction

The increasing prevalence of project-based work is evidenced by the estimation that approximately one-third of the world's GDP is generated through projects (Schoper et al., 2018; Wald, Ingason and Fridgeirsson, 2025). The World Economic Forum (2024) anticipates that project management specialists will be among the most demanded professionals in the United States in the coming decade. Project management as a multidisciplinary field it is now widely taught in business and engineering programs at universities worldwide.

UNESCO (2024) underscores the significance of digital innovation in education for expanding access, advancing inclusion, and enhancing relevance and learning quality. The COVID-19 pandemic accelerated the adoption of remote learning, compelling both students and educators to adapt swiftly to new digital tools. However, effective digital education requires educators to be both pedagogically skilled and digitally literate, promoting a shift from traditional fact-based teaching to reflexive learning (Dyke, 2009).

The digitalisation of education continues to shape learning environments, requiring educators to adapt to emerging technologies such as Artificial intelligence (AI), blockchain, and chatbots (Konstantinou, Nachbagauer and Wehnes, 2023). In project management education, the shift toward digital learning is not merely a transfer of traditional teaching methods to online platforms but necessitates a fundamental rethinking of pedagogical approaches. Student-centred learning, particularly in complex disciplines, is crucial for fostering engagement and success. As educators move from being sole knowledge providers to facilitators within digital ecosystems, the ability to integrate emerging technologies and blended and distance learning effectively becomes essential for delivering high-quality, inclusive project management education (Konstantinou, Nachbagauer and Wehnes, 2023).There is primarily a need for critical thinking and lifelong learning in project management rather than merely acquiring a fixed body of knowledge (Berggren and Söderlund, 2008; Bredillet, Tywoniak and Dwivedula, 2015) and teaching methods should foster personal responsibility and engagement (Konstantinou, Nachbagauer and Wehnes, 2023). The experienced project management educators involved in the present study recognise the need for more personalised,

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interactive learning experiences. While traditional personalised teaching requires significant resources, particularly in courses that teach the fundamentals of project management with high volumes of students, innovative solutions are necessary to achieve scalability and personalization without increasing educators' workloads. Furthermore, an increased focus is on offering online learning opportunities and courses. This highlights the need to develop digital solutions that can adapt the learning content and support the learning processes of different online learners.

Among the available digital technologies, chatbots occupy a prominent position due to their capacity to support personalised and adaptive learning experiences. Recent studies have explored their use in education (Okonkwo and Ade-Ibijola, 2021; Labadze, Grigolia and Machaidze, 2023a), although many applications of personalised learning lack the adoption of a structured design framework or theoretical foundation (Bahja, Hammad and Butt, 2020; Kuhail et al., 2023a). Educational chatbots are most commonly employed in STEM (Science, Technology, Engineering and Mathematics) disciplines and language learning (Winkler and Soellner, 2018a; Wollny et al., 2021), as well as for administrative tasks and the training of healthcare professionals (Sharma et al., 2022). In a multidisciplinary field such as project management with a growing demand for developing core competencies and promoting lifelong learning, chatbots and generative AI hold significant promise (Konstantinou et al., 2023). Personalised and adaptive learning chatbots, in particular, can assist learners in acquiring project management skills aligned with their individual goals and learning trajectories, both within and beyond formal educational contexts.

The Erasmus + project "ChatLearn - Personalized Project Management Learning with Chatbots" aimed to deliver personalised online learning experiences by integrating educational chatbots and high-quality digital materials, with the goal of preparing higher education students for future management roles. The initiative, was a strategic partnership involving the University of Oulu (Finland, coordinator), WU Vienna (Austria), Politecnico di Milano (Italy), and Reykjavik University (Iceland). Collectively, these institutions teach project management to more than 5000 students annually. The project also engaged several associated partners: the International Project Management Association (IPMA) supported global dissemination efforts; SORPA bs (Iceland) and the Vienna University Children's Office (Austria) contributed real-world data for developing case studies; and WISE up Engineering (Italy) provided technical development support.

Despite the digital transformation in many organisations, a skills gap remains, as many educators are not yet equipped to deliver engaging digital teaching that meets students' personal needs. This paper presents the development journey of the educational chatbot PMTutor—created in the ChatLearn project—and reflects on the design principles, pedagogical learnings, and integration guidelines that emerged from its implementation. The design of PMTutor aligns with broader developments in AI-supported adaptive learning, where digital tools respond to learner needs through personalised feedback and dynamic content delivery (Alam, 2022).

Drawing on Action Design Research (ADR) (Sein et al., 2011) as the guiding methodological framework, the study explores how iterative design cycles can inform and support innovative educational practices in project management teaching. Rather than focusing on the technical performance of the chatbot itself, the paper investigates how digital artefacts can be intentionally designed to enable personalised and reflective learning experiences in higher education. Therefore, the research question guiding this study is:

RQ: How can an educational chatbot be designed and integrated into project management education to foster practice-based, personalised learning based on pedagogical innovation?

The paper focuses specifically on educational chatbots as one representative application of artificial intelligence in project management education. While other AI-based tools (e.g., learning analytics, VR/AR solutions, or adaptive platforms) are relevant, they fall outside the scope of this paper. The remainder of this paper is structured as follows. The literature review (Section 2) is organised in four parts: it first establishes the need for AI-based and student-centred approaches in project management education, then introduces the concept and evolution of educational chatbots, followed by a review of empirical evidence on their pedagogical impacts in higher education, and finally discusses design principles and ethical considerations for their effective use. The methodology section (Section 3) explains the Action Design Research (ADR) approach and clarifies how it was applied in this study to iteratively design, test, and refine the PMTutor chatbot in collaboration with educators and students, highlighting the distinctive value of ADR for combining artefact design with pedagogical reflection. The results (Section 4) present empirical findings from multi-site trials, integrating quantitative survey data on student motivation and usability with qualitative insights from interviews and reflections with educators, thereby offering a multi-dimensional view of chatbot integration into PM curricula. The discussion (Section 5) interprets these findings in light of ongoing debates on digitalisation and pedagogical innovation in project management education, and synthesises them into actionable design guidelines for educators. Finally, the conclusion (Section 6) outlines the main contributions to project management research—specifically, insights into capability development, professional identity formation, and digital pedagogy—as well as practical implications for institutions seeking to embed AI-supported learning tools.

2. Literature review

2.1. The need of studying the role of personalised chatbot in project management education

The rapid shift to digital learning has prompted a profound transformation in project management education, with a growing body of research highlighting the importance of new pedagogical approaches, learner autonomy, and digital tools. Multiple contributions in the *Project Leadership and Society* special issue "Digital learning and Education in a Project Society" explore how digitalisation challenges traditional teaching models and opens up new learning possibilities. For instance, Minichiello et al. (2022) investigate the affective responses of Science, Technology, Engineering and Mathematics (STEM) students to emergency remote learning and underscore the need for instructors to mitigate stress through flexible, learner-centred course design. Van Der Hoorn and Killen (2021) in contrast, warn against sanitizing project management education and advocate for authentic, complex learning environments that mirror the uncertainty and ambiguity of real-world projects.

The importance of student motivation and engagement is also strongly emphasised. Afzal and Crawford (2022) drawing on self-determination theory, show how student engagement in online project management courses is deeply tied to self-motivation and peer interaction—elements central to activity-based learning. Similarly, Jones et al. (2022) apply the MUSIC model to measure and improve the motivational climate in virtual courses, demonstrating how instructors can adjust their strategies in real time to foster empowerment and engagement.

A relevant trend is the increasing adoption of interactive and experiential methods. Jonasson and Ingason (2022) argue that practice-based learning, teamwork, and real project experience are essential for developing future project leaders. Jääskä and Aaltonen (2022) provide evidence that game-based learning can increase motivation and improve students' ability to manage uncertainty. Complementary findings from Jääskä et al. (2022) highlight the pedagogical and emotional benefits of game-based approaches for instructors as well. Finally, Jaccard et al. (2022) reflect on a decade of experience with serious games, showing how these tools can shift project education toward more active and participatory models, particularly when integrated into a broader pedagogical framework.

While prior studies have already examined the role of digital and student-centred approaches in project management education, the broader potential of artificial intelligence tools in this field is still emerging. AI-based solutions such as adaptive platforms, learning analytics, and generative systems are increasingly seen as enablers of personalised and flexible learning pathways (Jääskä et al., 2022). Within this wider landscape, chatbots stand out as one representative application of AI: their ability to simulate dialogue, provide tailored feedback, and scaffold learning in real time makes them particularly well-suited to foster autonomy, interaction, and adaptability—core dimensions of contemporary project education (Konstantinou, Nachbagauer and Wehnes, 2023). In a field where collaboration and responsiveness are central, chatbots can act as scalable companions that guide learners through increasingly complex decision-making environments.

2.2. Educational chatbots

Chatbots are one of the many great promises in information technology. Initially designed as interfaces to enhance applications with chat capabilities and provide direct user support through immediate interaction, chatbots are now utilised across diverse fields. They can process natural language and offer answers and services to meet user needs (Kerly, Hall and Bull, 2007; Hwang and Chang, 2023). ELIZA was considered one of the first chatbots developed at the MIT Artificial intelligence Laboratory (Weizenbaum, 1966). ELIZA provided personalised responses by reassembling users' input questions, creating an impression of empathy. However, ELIZA lacked memory of past interactions, limiting its ability to perform more complex tasks.

The syntactic processing used by ELIZA has significantly evolved, leading to the development of advanced language-processing chatbots (Lokman and Ameedeen, 2019). Advancements in recent years have fueled a rise in the use and development of chatbots. Modern chatbot technology offers sophisticated development environments, enabling the creation of conversational agents capable of executing complex tasks with goal-driven behaviour (Adamopoulou and Moussiades, 2020). These chatbots can utilise user models and conversational context to generate tailored responses, allowing for intelligent dialogues with the user (Elsholz, Chamberlain and Kruschwitz, 2019). Also, the communication landscape has shifted, with short messaging formats becoming more common than lengthy verbal communication (Alton, 2017; Frei, Alford and Smith, 2023). As a result, modern chatbots are extensively used to provide information across various sectors. They are increasingly used in e-service, e-commerce (Gnewuch, Morana and Maedche, 2017; Misischia, Poecze and Strauss, 2022), and healthcare (Chung and Park, 2019; Palanica et al., 2019), and their application in education is also growing rapidly (Okonkwo and Ade-Ibijola, 2021).

2.3. Impacts of educational chatbots

Educational chatbots have the potential to transform student learning, interaction, and support by acting as digital assistants that provide personalised assistance and enhance engagement (Kim, Cha and Kim, 2019; Ferrell and Ferrell, 2020). Research supports the effectiveness of these chatbots, particularly within higher education settings (Thomas, 2020; Wu and Yu, 2024) and it has been shown with statistical significance how chatbots can improve learning and student satisfaction (Kuhail et al., 2023b). Their interactive and conversational interfaces can create a dynamic and enjoyable learning environment by simulating discussions, quizzing students, and offering instant feedback (Kim, Cha and Kim, 2019).

Chatbots have demonstrated their potential to support learning within specific educational contexts by fostering teamwork and enabling collaborative learning experiences (Tegos, Demetriadis and Karakostas, 2015; Cunningham-Nelson et al., 2019; Kumar, 2021). Evidence suggests that their effectiveness increases when they are employed to answer student questions, facilitate reflection, provide evaluation and feedback, and offer short-term personalised mentoring (Alemdag, 2023). Despite these promising outcomes, the majority of existing studies do not explicitly adopt personalised learning as a core design principle in chatbot development (Kuhail et al., 2023b).

A growing body of research has highlighted the diverse educational benefits associated with the use of chatbots. These tools have been shown to offer cost-efficient solution (Benotti et al., 2014; Alemdag, 2023), improve both student outcomes and overall learning experiences (Gazulla et al., 2023; Ait Baha et al., 2024) and deliver timely support in virtual learning environments (Jasin et al., 2023; Winkler and Soellner, 2018a, 2018b). Evidence suggests that chatbots contribute to increased student involvement in assignments and peer evaluation tasks in large-scale online courses (Pereira et al., 2019). Additionally, they can support learning across specific domains, enhance collaboration in group settings, and foster active knowledge construction in shared learning environments (Ait Baha et al., 2024; Alemdag, 2023; Kuhail et al., 2023a, 2023b). Although some scholars have raised concerns about the effectiveness of rule-based chatbots in higher education (Pereira et al., 2019), overall evaluations affirm their pedagogical relevance and utility (Hwang and Chang, 2023). A recent meta-analysis indicates that chatbots are particularly impactful when employed to deliver guidance, stimulate reflective thinking, provide feedback, or offer short-duration mentoring support (Alemdag, 2023).

The rapid progress in natural language processing—particularly the emergence of generative AI models like ChatGPT—has reshaped expectations around chatbot capabilities in education (Kong and Yang, 2024; Akpan et al., 2025). Today's students increasingly anticipate AI systems that can respond in individualised ways (Kong and Yang, 2024). As the discourse on generative AI continues, there is an urgent need for empirical investigations that can inform responsible and effective integration strategies across educational contexts (Gill et al., 2024).

Although some studies have incorporated elements of personalised or adaptive learning in chatbot design (Gazulla, Martins and Fernández-Ferrer, 2023; Dahri et al., 2024; Kong and Yang, 2024), these applications have generally lacked a strong pedagogical grounding or theoretical framework to support the systematic development of personalization strategies. Nevertheless, these contributions highlight the potential of chatbots to tailor educational experiences to individual learners' needs and preferences—a feature particularly valuable in disciplines where learners' backgrounds and competences vary widely. In this regard, project management education could significantly benefit from such personalization, especially given its multidisciplinary nature and the increasing demand for flexible, learner-centred approaches. However, despite this promising potential, the use of chatbots to support personalised or adaptive learning in project management education remains virtually unexplored, thus revealing a clear gap in both research and practice.

2.4. Design principles of educational chatbots

The design of educational chatbots requires more than technical sophistication; it must be guided by clear pedagogical objectives and user-centred thinking. A core design principle is adaptability - chatbots should respond to individual learning styles, paces, and needs, offering personalised learning pathways that increase engagement and effectiveness (Winkler and Soellner, 2018a, 2018b). By tracking learner behaviour and performance, chatbots can recommend tailored content, adapt the level of difficulty, and propose targeted practice activities (Hwang and Chang, 2021; Wollny et al., 2021). These capabilities are especially relevant in large and open online learning environments, where human-led personalization is impractical. Effective chatbot design should also focus on enhancing active learning. Studies show that well-designed chatbots can stimulate participation in assignments and peer-to-peer assessments, facilitate collaborative activities, and support content-specific inquiry across diverse learning contexts (Winkler and Soellner, 2018b; Cunningham-Nelson et al., 2019; Pereira et al., 2019;

Smutny and Schreiberova, 2020; Jasin et al., 2023; Labadze, Grigolia and Machaidze, 2023b). To maximise these outcomes, chatbots should be conceived as interactive companions—rather than content providers—capable of encouraging reflection, offering feedback, and supporting metacognitive processes.

Equally important are the ethical and organisational principles that should inform the chatbot design process to consider issues such as information reliability, assessment transparency, and data protection (Kooli, 2023).

UNESCO (2023) emphasize that AI tools should be implemented in ways that support and enhance—rather than replace—human agency and intellectual development. Educational chatbots should therefore be integrated as assistants to educators—providing support, not substitution—and always under pedagogical supervision (Hwang and Chang, 2021).

Educators retain a key role in shaping interactions, validating outputs, and guiding critical engagement with the chatbot's suggestions. In summary, designing educational chatbots require balancing personalization and pedagogical coherence with ethical responsibility and governance, ensuring that these tools genuinely support learning while respecting the complexity of educational environments (Kooli, 2023).

Recent research has highlighted the importance of understanding user acceptance and behavioural intention in the adoption of educational technologies, including AI-powered educational chatbots. Models such as the Technology Acceptance Model (TAM) and its extensions have been widely applied to explain how perceived usefulness and ease of use influence learners' engagement with digital systems. In the context of AI-supported education, such models provide a useful lens for interpreting how students perceive and adopt chatbot-based learning environments (Holden and Karsh, 2010). For instance, Papakostas et al. (2023) used an extended TAM framework to explore behavioural intention in the adoption of mobile augmented reality in education, offering valuable insights that can be applied to the study of chatbots and generative AI in learning contexts. Integrating such models helps frame the evaluation of learner motivation and interaction beyond usability, pointing to deeper cognitive and emotional factors that shape the educational experience

3. Method

3.1. Research design

Action Design Research (ADR) is a specialised branch of Design Science Research (DSR) developed to address complex organisational problems through the iterative co-construction of artefacts and knowledge (Hevner et al., 2004). While DSR focuses on designing and evaluating artefacts to solve identified problems ADR extends this logic by recognising that the artefact evolves not in isolation but through dynamic interaction with its organisational context. As articulated by Sein et al. (2011), ADR integrates design, implementation, and evaluation in real settings, allowing both the artefact and the associated knowledge to co-evolve. Given the applied and exploratory nature of the ChatLearn project—where the goal was to develop a pedagogical chatbot for higher education—the ADR framework offered a suitable methodological lens, enabling both technological experimentation and theoretical reflection and has been frequently ustilised in project literature (Mikkelsen and Aaltonen, 2022; Svejvig, Sankaran and Lindhult, 2023).

ADR was chosen for this study not only to structure the iterative development of the chatbot (PMTutor), but also to generate actionable knowledge about the pedagogical integration of AI-based tools in project management education. Unlike traditional development cycles, ADR explicitly requires theoretical insights to inform and reshape the design across its phases. This was critical for ChatLearn, where emergent educational needs (e.g., personalization, blended learning, student autonomy) and the rapid evolution of generative AI required continuous reassessment of the system's functionalities and pedagogical alignment.

The ADR methodology is unfolded through its four canonical stages (Sein et al., 2011). Each of them contributes in a specific way to design decisions and research findings:

1. **Problem Formulation**: This phase was grounded in both practice-based observations and gaps in the literature. The consortium identified a shared challenge among project educators: how to provide scalable, personalised support to diverse student groups in digital environments. Theoretical insights on student-centred learning (Ingason and Eskerod, 2024), digital literacy, and reflexive education (Jääskä and Aaltonen, 2022; Konstantinou, Nachbagauer and Wehnes, 2023) informed the articulation of the need for an AI-based chatbot that could simulate tutoring and adapt to individual learning paths. These insights shaped the design objectives of PMTutor from the outset.
2. **Building, Intervention, and Evaluation:** This core phase was operationalised through three design cycles, combining iterative development, deployment in real classrooms, and assessment of both technical and pedagogical effectiveness. The design of each PMTutor version was influenced not only by user feedback, but also by theoretical constructs such as Keller's ARCS motivational (Keller, 1987) and the MUSIC model for engagement (Jones, 2020) which directly informed both content presentation and user interaction features. Evaluation methods included surveys, observations, usage data, and qualitative reflections, providing feedback that refined both artefact features (e.g., interface design, content structure) and design principles. The evaluation approach adopted in this study primarily relied on students' self-reported perceptions of motivation, usability, and perceived learning, rather than direct measurement of cognitive performance or learning gains.
3. **Reflection and Learning:** At this stage, findings from multiple pilots were synthesised to extract generalisable knowledge. For instance, the limited efficacy of rule-based interactions observed in early versions of PMTutor led to the integration of generative AI (OpenAI GPT-3 and later GPT-4), aligning with the theoretical shift toward adaptive and conversational learning agents (Gill et al., 2024). Furthermore, four structured interviews were conducted with the national teams in early spring 2024—Finland (3 participants), Iceland (2 participants), Austria (1 participant), and Italy (1 participant)—to capture systematic feedback. These discussions, where participants often acted in both teacher and researcher roles, helped formalise design guidelines for future chatbot implementations in project education, linking empirical observations to broader theoretical constructs around digital pedagogy and the role of AI in education. Complementary retrospective meetings were also held, and their outcomes were documented in the lessons learned database.
4. **Formalisation of Learning:** The final phase involved codifying the learnings into transferable design knowledge. This included the definition of pedagogical guidelines (e.g., for individual vs group use), as well as the articulation of design principles for AI-enhanced educational chatbots.

Fig. 1 illustrates those phases, articulating briefly the fundamental content of each phase in the ChatLearn project (see Fig. 2).

Each phase of the ADR process will be explained in detail in the following sections.

3.2. Problem formulation

The first phase in the action design research process is focused on problem formulation, where both the need from practice and theory can be considered important. Work with the problem formulation started in 2021 when planning the ChatLearn project. It should be pointed out that the technology offered by OpenAI and their ChatGPT application was unavailable at the beginning of this project. The practical need for the educational chatbot was inspired by the participants' experiences as

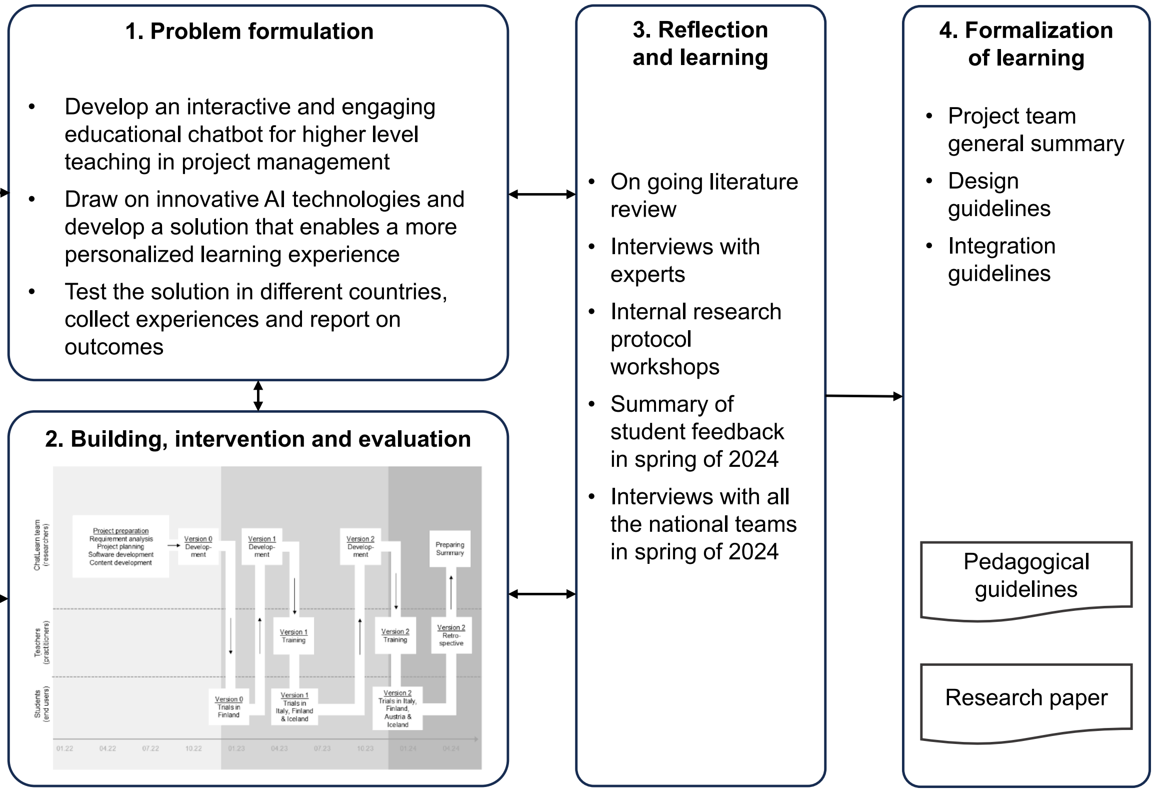

Fig. 1. Action design research process - presented in four phases.

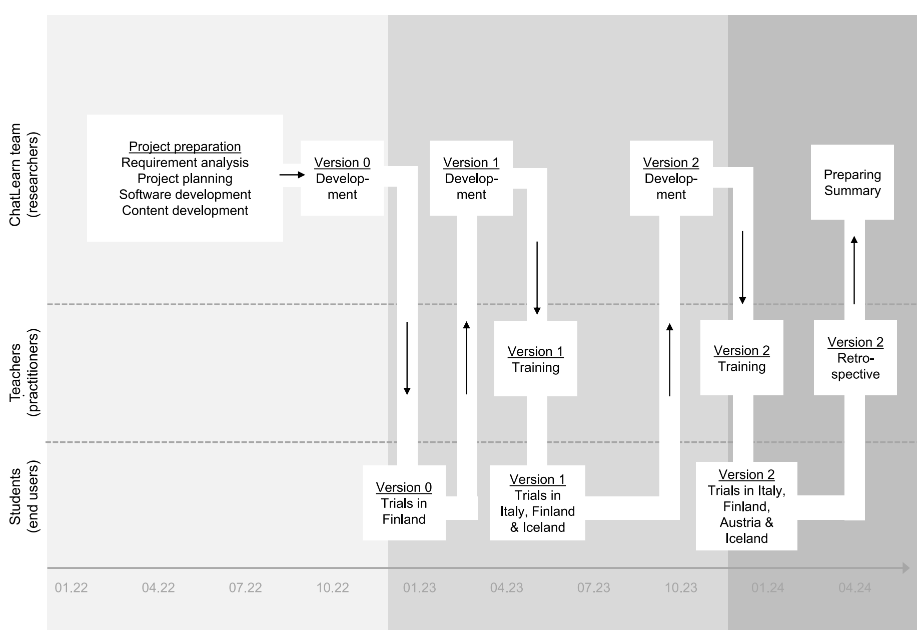

Fig. 2. A flowchart of the project timeline, showing trials and participation of three categories of direct participants: researchers, practitioners and end users.

educators. A need had been identified to offer personalised and tailored learning content for a wide range of students with diverse competencies with features that enable continuous support. In addition, as online teaching was used increasingly due to the COVID-19 pandemic, there was a need to offer digital and online education in an efficient way. The technological landscape was also developing, but chatbot solutions were primarily built and developed based on rule-based approaches. One of the most advanced ones was IBM's Watson Assistant, a computer system that can answer questions in natural language («IBM Watson», 2020). One of the practical motivations was also related to the limited amount of available and open project management teaching resources that would gather and offer access to a wide variety of educational materials used in higher education courses.

In addition to the practical needs, there was a lack of research on educational chatbots' development, use and impacts. Occasional reports on the developed educational chatbot solutions were found, but most were from other fields, particularly STEM subjects. Hence, apparent research gaps in the literature on educational chatbots and reflections on their pedagogical side also existed.

With practical and theoretical needs and inspirations in mind, a group of experienced project management educators and scholars came together to develop an interactive and engaging educational chatbot for personalised higher-level project management teaching. The aim was to create a working AI-driven IT artefact that would be developed through user testing in iterative cycles. In addition to the artefact, the formalisation of the design principles around the educational chatbots and the pedagogical guidelines related to their use were considered essential learning outcomes.

Current project management education at universities caters to diverse student groups, but there is a need for more personalised and interactive learning experiences. The ChatLearn project addressed this using AI-powered educational chatbots and high-quality digital materials to provide personalised online learning. The project was designed to bridge the skills gap in digital tool usage among educators and support inclusive higher education by adapting to individual student needs. The objective was to develop guidelines for educators on utilising chatbots, specifically through a PM educational chatbot (PMTutor), which would be integrated into project management courses for research on its effectiveness and pedagogical impact.

The project was expected to produce several outcomes and results: a technology mapping report on educational chatbots, a conceptual model and templates for chatbot creation, the PMTutor chatbot for project management fundamentals, a student clustering analysis, an open PM resources material bank, implementation guidelines for chatbots usage in higher education, and a research paper on chatbot experiences.

3.3. Building, intervention and evaluation

3.3.1. ADR process overview

The project is best described in context with the ADR Generic Schema for Organization-Dominant building, intervention and evaluation. The goal is to develop design knowledge with organisational intervention as the leading innovation driver. Throughout the iterative process of building, intervening, and evaluating, participants' preconceptions about chatbots and their use in teaching were challenged to enhance the design of PMTutor. The project also included the development of practical guidelines for educators to create their subject-specific chatbots, leveraging the advancements made in PMTutor.

The emerging learnings and guidelines are framed as design principles for developing educational chatbots. The different versions of the PMTutor are framed as the IT artefact that this project delivered. The project is seen as three design cycles, starting with cycle 0 and then 1 and 2.

The flowchart illustrates the design of the ChatLearn project, which aimed to create conditions for interactive development through the collaboration of three distinct but overlapping groups: the ChatLearn research team, teachers testing PMTutor, and students (end-users). Based on the Business Process Model and Notation (BPMN) standard (Chinosi and Trombetta, 2012), the depiction shows these groups in horizontal lanes, with the project timeline represented along the X-axis, moving from left to right. Each iteration of PMTutor concluded with an evaluation of its performance.

3.3.2. Overview of PMTutor versions

Three versions of PMTutor were developed and tested during this process, and each cycle ended with an assessment of the general outcomes and the underlying design principles. All technical development was conducted at the University of Oulu. The figure indicates four stages of the project. Preparation stage (Jan 2022–August 2022), Version 0 stage (September 2022–February 2023), Version 1 stage (March 2023–September 2023) and Version 2 stage (October 2023–May 2024).

Table 1 provides an overview of the different versions of the PMTutor and the primary feature increments with each version.

Version 0 featured a simple user interface and covered only one project management knowledge area: Earned Value Management (EVM). This version was developed in the fall of 2022 and tested in Finland at the end of 2022 and the beginning of 2023. Feedback from these tests informed the development of Version 1, released in eary 2023, which expanded the chatbot's scope to include nine knowledge areas:

Stakeholder Engagement Skills, Project Initiation and Planning Skills, Risk Management Skills, Cost Management Skills, Scope Management Skills, Communication Skills, Earned Value Management Skills, Project Control Skills and Project Organizing Skills.

Table 1
Versions and feature increment.

Version	Main Feature Increments
0	• Earned value management chatbot with four exercises containing single-select questions • Providing the user with feedback based on correct and incorrect answer for each exercise question • Minimalist responsive web user interface
1	• PMTutor covering nine core project management topics. Each topic contains one or more learning modules; each module one or more exercises and learning materials. Topics are configurable using a spreadsheet template. • OpenAI GPT3 integration for answering questions beyond the scope of PMTutor content • Self-assessment: users can evaluate their competence for each topic • Topic recommendation: users can ask for topic recommendation based on their self-assessment • Seeing a summary of exercises and selecting incomplete exercises
2	• Offering case studies. A case study can be configured containing multimedia content and assignments. • Supporting open-ended questions in case study assignment • Leveraging OpenAI GPT-4 for assessing the answers to open-ended questions and for answering user questions beyond the scope of PMTutor • Users can easily select an incomplete case study assignment • Modern web user interface

3.4. Integration of ChatGPT into the PMTutor development process

The integration of generative AI into the PMTutor took place during the second design iteration of the project, following the public release of ChatGPT in late 2022. Initially, the chatbot was developed using a rule-based dialogue logic combined with natural language understanding (NLU), providing features such as tailored feedback, self-assessment, and topic recommendation. However, with the emergence of generative AI, the development team decided to enhance the chatbot's capabilities by leveraging OpenAI's GPT-3 model. This addition allowed PMTutor to respond to learner questions beyond its pre-programmed knowledge base, offering more flexible, personalised support. The generative AI module was introduced as a complementary feature, explicitly informing users when the system was using LLM-generated responses and reminding them of the possibility of inaccuracies. This hybrid approach was chosen to balance innovation with usability and data security, while progressively expanding the chatbot's capabilities. The GPT-3 integration was piloted in real learning environments across several European universities starting in early 2023, allowing the project team to collect feedback on usability, learning outcomes, and the potential of AI-powered educational tools for project management education.

3.5. Testing phases

Testing of Version 1 was carried out in Finland, Italy, and Iceland during spring 2023, delivering insights that guided the development of Version 2. The later version had an improved user interface developed by IT students. It incorporated additional case studies, including topics such as change management and project planning, based on real-world examples like the "Children University" in Vienna, a proposed Waste-to-

Energy plant in Reykjavik, and cultural preservation efforts along the Po river in Italy ("Dock for change").

Testing of Version 2 took place from December 2023 to May 2024 in Austria, Italy, and Iceland.Table 2 gives an overview of all trials for all versions of the PM tutor and the universities involved, the university conducting the trial and the university where the trial took place (shown in parenthesis if different from the university conducting the trial). Also, the timing of the trial, the number of students that participated, their level of education, the trial's focus (competence areas or casework), whether the students participated as individuals or in teams, and whether the trial was integrated into a course.

3.5.1. Overview of trials

The table shows that for version 0, there was one trial with 30 undergraduate students. For version 1, there were three trials with 169 students, one with undergraduate students and two with continuing education students. For version 2, there were six trials with 174 students. The single trial conducted with version 0 illustrates an early prototype, with more extensive testing occurring in subsequent versions. Three trials included undergraduate students, three included graduate students, three included continuing education students, and one included high school students.

Most trials (a total of 6) were integrated into existing courses, some being part of an on-site course and others integrated into an online course. Four trials were not part of any formal course, and students participated voluntarily.

Most of the trials (6 out of 10) had students working individually, while three trials involved students working in groups, and one trial had a combination where students worked both individually and in groups.

Most trials (7) focused exclusively on developing specific project management competence areas, with no accompanying case study. These trials often emphasised specific skills such as risk management, cost management, or earned value management. One trial involved a complex case study focused on a Waste-to-Energy facility. This trial combined the study of competence areas with the practical application of knowledge through the case study. In two trials, there was a combination of the study of competence areas with additional case studies, mainly the case "Dock for change."

The trials were generally prepared with a straightforward, methodical approach to ensure students were well-informed and comfortable using the PMTutor. The approach was different based on, e.g. if the trial was an integrated part of a course, but typically, students got information through email messages and/or the use of learning systems such as Moodle. More importantly, in most cases, there were on-site or online sessions with the students before and after the trial.

In most trials, students registered to the PMTutor system and were given a set period, often one week, to interact with the system and explore its functionalities at their own pace. In some trials, students also completed specific case studies, such as "Dock for change" or the Waste-to-Energy (WtE) project. These cases were often segmented into sections, and students were required to complete each section sequentially, using PMTutor as an assistant throughout the process.

The assessment of the trials always included an integrated system pre-test and post-test survey that every student did to measure students' learning outcomes and experiences. Some trials also employed Keller's ARCS model (Keller, 1987) through SurveyMonkey surveys to assess motivation and satisfaction. The model focuses on four key components: Attention, Relevance, Confidence, and Satisfaction. It has been widely recognised for its effectiveness in educational contexts (Li and Keller, 2018). Keller's model was applied with all trials in the spring of 2024, with version 2. Retrospective sessions using tools like Menti software were occasionally organised to facilitate discussions and gather qualitative data in hindsight. In some trials, students were required to submit group reports reflecting on their experiences, and in a few cases, semi-structured reports were used for a more comprehensive evaluation.

3.5.2. Overview of meetings

Fig. 3 gives an overview of all formal meetings held in the project. Three types of meetings were held: regular project, technical, and research team meetings. Different topics were discussed during these meetings, as indicated in the figure.

This overview gives an impression of the influences mutually exerted by the IT artefact and the organisational context, i.e. the perceptions of the people conducting the trials, as well as feedback from the students. The initial design of the IT artefact (version 0) was formed during the preparation stage - subsequent stages aimed at further shaping the artefact through organisational use and further design cycles. Each stage thus included an assessment of the artefact, i.e. the different versions of the PMtutor and the design principles it represented. Ongoing mutual learning occurred among the project participants during the building, intervention and evaluation. Decisions about designing the artefact and how it was integrated into the work practices were interwoven with ongoing evaluation, which was happening concurrently. The outcome of the last stage (version 2 stage) is the current realised design of the artefact at the end of the project.

4. Results: reflection and learning

This section presents the main findings from the implementation and evaluation of the PMTutor chatbot during its second development cycle. The analysis draws on a combination of quantitative data (collected through structured Likert-scale surveys) and qualitative insights (gathered through semi-structured interviews and open-ended feedback). The surveys focused on students' motivational responses using Keller's ARCS model and on perceived usability, while interviews with educators provided in-depth reflections on pedagogical integration, technical performance, and potential improvements (Keller, 1987). The aim is to offer a multi-dimensional perspective on the chatbot's effectiveness, limitations, and future development potential in the context of project management education. The results are organised to highlight both user

Table 2
Overview of all trials with the different versions of the PMTutor from December 2022 to May 2024.

Trial number	Universites involved	Time of trial	PM tutor version	No. of students	Education Level	Trial Focus	Work Type	Course Integration
UO1	UO	Dec.22	0	30	Undergr.	Competence	Indiv.	No
RU1	RU (UI)	Mar.23	1	8	Cont. ed.	Competence	Indiv.	No
RU2	RU	Apr.23	1	130	Grad.	Competence	Mixed	Yes
UO2	UO (SUAS)	Apr.23	1	30	Cont. ed.	Competence	Indiv.	Yes
RU3	RU	Mar.24	2	40	Grad.	Mixed	Group	Yes
RU4	RU	Feb.24	2	24	Grad.	Competence	Indiv.	Yes
UO3	UO	Dec.23	2	24	Undergr	Competence	Indiv.	Yes
AUT1	WU	Apr.24	2	27	Cont. ed.	Mixed	Indiv.	No
AUT&IT1	PM (WU and ISISEM)	May.24	2	39	High school	Mixed	Groups	Yes
AUT&IT2	PM (WU and UCSC)	May.24	2	20	Undergr.	Mixed	Groups	Yes

UO: University of Oulu, RU: Reykjavik University, PM: Politecnico di Milano, WU: Vienna University of Economics and Business UI: University of Iceland, SUAS: Seinäjoki University of Applied Science, ISISEM: Istituto Statale di Istruzione Superiore Enrico Mattei, UCSC: Università Cattolica del Sacro Cuore.

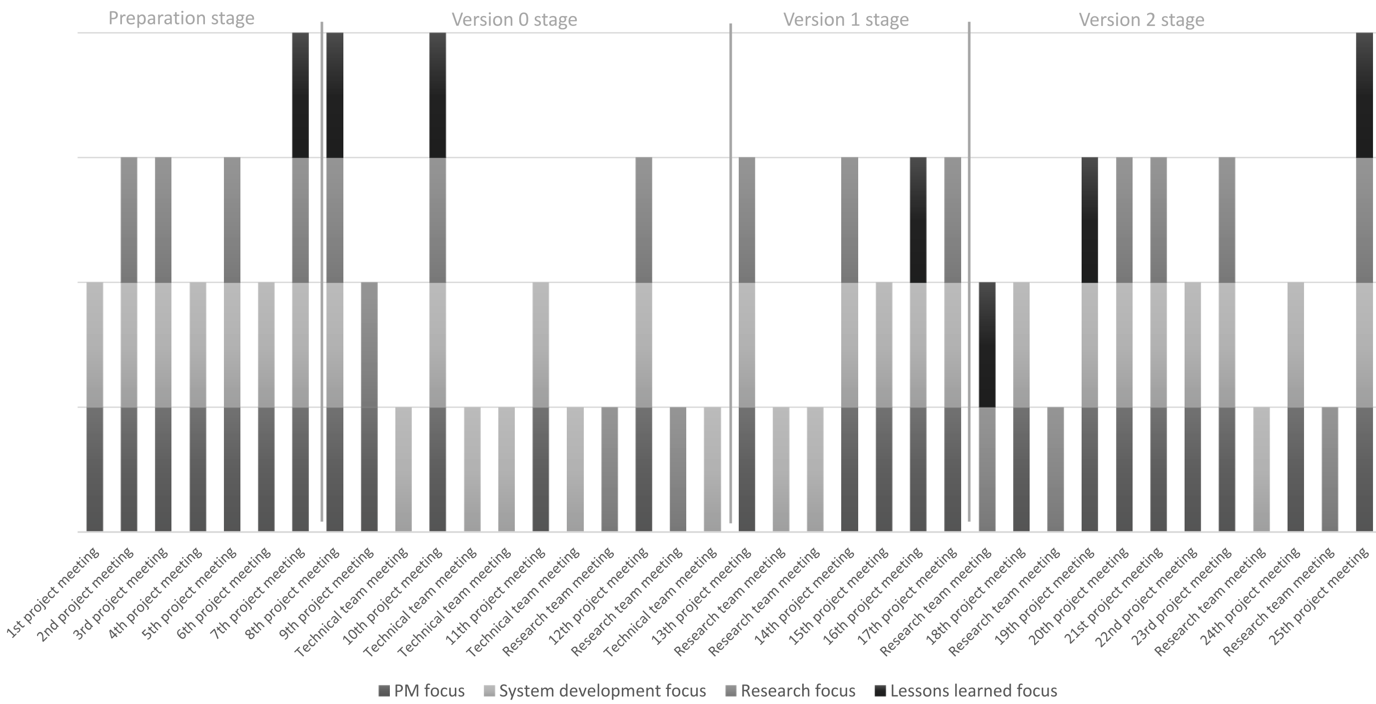

Fig. 3. Overview of formal meetings in the correct sequence from top to bottom. Four classes of topics being focused on during the sessions: project management focus, system development focus, research focus and lessons learned focus.

experience and pedagogical insight, with a focus on how PMTutor supported student engagement, learning reinforcement, and instructional practices across diverse institutional settings.

4.1. Motivational patterns across learner groups

This section presents the results of the multi-site survey conducted during five trials of PMTutor Version 2 in spring 2024. The participating groups included RU3 (MSc engineering students, n = 17), RU4 (graduate students in project management, n = 20), AUT1 (continuing education professionals, n = 16), AUT&IT1 (high school students, n = 11), and AUT&IT2 (undergraduate university students, n = 6). A mixed-methods design was employed, combining quantitative data from structured Likert-scale questionnaires with qualitative input from open-ended questions. The motivational aspect of the evaluation was based on Keller's ARCS model (Keller, 1987; 2008), which assesses Attention, Relevance, Confidence, and Satisfaction—four core components that shape learner motivation in instructional contexts. Additional closed questions assessed perceptions of usability and interaction design. Fig. 4 reports the aggregated scores for each ARCS dimension across the five groups, measured on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). According to Keller's model, scores above 3.0 indicate areas of motivational strength, while scores below 3.0 point to potential weaknesses in the learning design.

Attention, which reflects the ability of the tool to capture curiosity, hovered around the neutral threshold across groups. This suggests that while the chatbot succeeded in introducing novelty, it often struggled to maintain prolonged engagement. In the engineering group (RU3, mean ≈ 2.8), the low attention score may reflect a mismatch between students' background and the chatbot's level of interactivity.

Relevance, which measures the perceived value of the tool, emerged as the strongest dimension overall. Graduate project management students (RU4, mean ≈ 3.4) and undergraduates (AUT&IT2, ≈3.3) rated the chatbot positively, likely because were well aligned with their academic and professional pathways. This suggests that students are more motivated when the tool helps them connect course content to their career development, whereas groups with less immediate application opportunities perceived the tool as less valuable.

Confidence, linked to self-efficacy, followed the same trend, with RU4 and AUT&IT2 reporting the highest values (≈3.4). These results may be attributed to the structured progression of the chatbot's tasks, the clarity of explanations, and the availability of immediate feedback,

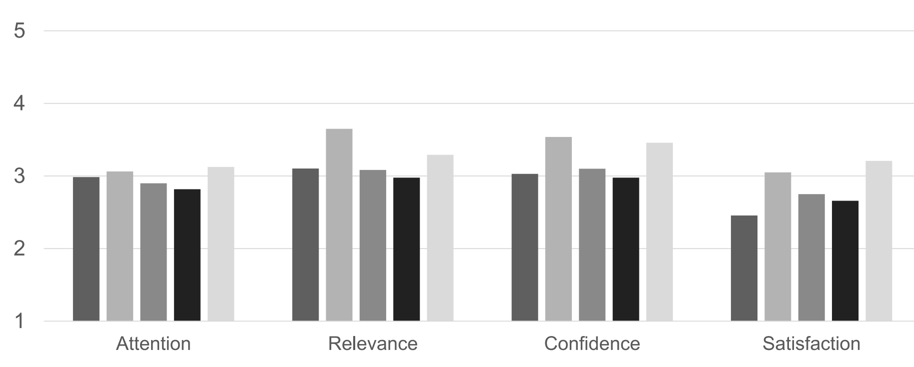

Fig. 4. Results regarding motivation, based on Keller's ARCS model.

which reassured learners of their ability to succeed. By contrast, groups with weaker backgrounds in project management may have felt less confident in navigating the tool without additional competencies.

Satisfaction, the emotional outcome of the learning experience, showed the widest variation. RU3 recorded the lowest score (≈2.4), which can be interpreted as a reaction to technical limitations and rigid interaction design that undermined the perceived reward of using the system. In contrast, RU4 and AUT&IT2 reported moderate satisfaction (≈3.1–3.2), indicating that while the experience was not flawless, students valued the guidance and saw enough benefit to remain positive.

The findings of the survey suggest that the motivational impact of PMTutor was closely linked to how well the tool matched learners' needs and expectations. When students perceived the chatbot as directly relevant to their academic or professional goals and received timely feedback (as in the RU4 and AUT&IT2 groups), they reported higher confidence and satisfaction. This positive response may be explained by their clearer professional orientation toward project management, which made it easier for them to recognise the utility of the tool, and by their greater familiarity with digital platforms, which reduced friction in using the system. By contrast, when interaction was rigid or usability problems interfered with the experience (as in the RU3 group), attention and satisfaction dropped significantly, undermining motivation even if the content itself was adequate. In this case, students' stronger technical background and higher expectations for interactivity likely heightened their frustration with interface limitations and rigid dialogue structures, leading to disengagement. These insights informed the redesign of PMTutor Version 3, where the integration of generative AI (ChatGPT) and improvements in interaction logic aimed to enhance engagement and satisfaction across heterogeneous learner populations.

4.2. Educators' perspectives on usability and pedagogical integration

In connection with the PMTutor trials conducted in spring 2024 (Version 3), semi-structured interviews were carried out with teaching teams from the four participating institutions. The insights below reflect educators' perspectives on pedagogical integration, technical maturity, content quality, and the tool's impact on teaching and learning processes.

4.2.1. Pedagogical integration and use

Educators reported using PMTutor as a supplementary learning tool, mostly embedded within traditional lectures or as an extension to asynchronous learning. It was applied in both individual and group activities to support students in training key project management concepts (e.g., Earned Value, Risk, and Schedule Management). These hybrid implementations align with models of blended learning that advocate for flexible pathways combining self-paced exploration with guided instruction (Hoic-Bozic, Mornar and Boticki, 2009). However, some educators observed issues with synchronisation and alignment between chatbot interactions and broader course objectives. This underscores the importance of instructional design coherence (Reiser et al., 2021), suggesting that digital tools like PMTutor must be intentionally mapped onto intended learning outcomes to avoid becoming add-ons rather than integrated learning components.

4.2.2. User experience and technical maturity

Educators were cautiously optimistic about the chatbot's technical infrastructure but pointed out its limited interactivity, lack of personalization, and rigidity in input processing. The tool was described as promising but still underdeveloped, especially in terms of user interface and intuitive design—critical factors that impact student motivation and usability (Kooli, 2023). The lack of flexibility is particularly problematic when seen through the lens of self-determination theory (Ryan and Deci, 2023) which identifies autonomy as a foundational driver of student engagement. When learners cannot explore content in a flexible, meaningful way, they may experience reduced ownership over the learning process. Moreover, technical inconsistencies in case-based modules weakened the potential for experiential learning (Labadze, Grigolia and Machaidze, 2023b) where immersion in realistic contexts is key.

4.2.3. Content design and pedagogical value

A recurrent theme across all interviews was the need to enhance and standardise the pedagogical content. Educators noted gaps in content depth, inconsistency between topics, and a lack of clear progression paths. While the idea of using recognised bodies of knowledge (e.g., IPMA Competence Baseline (ICB), A Guide to the Project management Body of Knowledge (PMBOK Guide), Projects IN Controlled Environments (PRINCE2)) was suggested to ensure content credibility, the tension between standardisation and customisability emerged as central. This reflects an ongoing challenge in educational technology: the need to design content that is both pedagogically sound and contextually adaptable (Maier and Klotz, 2022). Instructors advocated for modular content that could be adjusted to specific learning scenarios, without compromising instructional integrity.

4.2.4. Perceived benefits and student impact

From a pedagogical standpoint, teachers appreciated PMTutor's role in increasing student motivation and time-on-task, especially in blended environments. Its ability to offer instant feedback was seen as a strength, helping learners consolidate basic knowledge. However, this benefit was more evident among students already comfortable with digital tools. More tech-savvy learners were described as having higher expectations for personalization and fluency in interaction—indicating a potential engagement gap between user subgroups. In this sense, while PMTutor may scaffold foundational knowledge, further development is needed to address higher-order cognitive processes, such as reasoning, application, and reflection (Krathwohl, 2002).

4.2.5. Impact on educator practice

PMTutor's effect on the teaching workload was mixed. While some instructors reported potential time savings through automated drills and feedback, others struggled to align the tool with their pedagogical approach. These mixed reactions suggest that meaningful integration depends not only on tool usability, but also on faculty development and instructional support. As (Laurillard, 2013) notes, digital tools must be embedded within a broader learning ecology, supported by educators who understand their logic and purpose.

4.2.6. AI integration – opportunities and risks

Educators strongly recognised the potential of integrating advanced AI models (e.g., ChatGPT) to enhance PMTutor's adaptability and interaction fluency. However, they also cautioned that such integration should be governed by pedagogical principles, not technical novelty. The call for customisation, transparency, and trust reflects wider concerns in the literature around the use of AI in education (Holmes and Tuomi, 2022). Teachers emphasised the importance of maintaining structured learning paths, ensuring that AI complements—rather than replaces—intentional instructional design. In this view, AI can function as a pedagogical amplifier (Luckin and Cukurova, 2019) but only if its logic is interpretable and controllable by educators.

5. Formalisation of learning

5.1. Project team general summary (developed at a final project meeting at the project conclusion in May 2024)

The final reflection phase of the project, synthesised during a conclusive meeting in May 2024, aimed to consolidate practical learnings and formalise pedagogical insights. Central to this effort was the recognition that integrating AI-powered tools like PMTutor into project management education requires more than technical deployment; it demands thoughtful pedagogical design, grounded in established educational theory and responsive to evolving learner expectations.

In line with Keller's ARCS model of motivational design—which emphasises Attention, Relevance, Confidence, and Satisfaction—the project team acknowledged that while PMTutor fostered relevance and confidence among many students, weaknesses in the user interface and interactivity affected attention and satisfaction. These dimensions are not merely peripheral; motivation is foundational to effective learning, particularly in self-directed and digital environments. As (Keller, 1987; Li and Keller, 2018) argue, motivational strategies should be embedded into the instructional system design from the outset. Thus, maintaining learner motivation in AI-enhanced education requires that the tool not only deliver content but do so in a way that sustains attention and promotes a sense of accomplishment.

From a design standpoint, the integration of AI should support, rather than substitute, structured pedagogical pathways. The PMTutor was most effective when it offered clarity in learning trajectories and timely, targeted feedback. However, the integration of case studies—despite their recognised potential to encourage reflection and contextualised learning (Cunningham-Nelson et al., 2019)—was hindered by inconsistent formatting and insufficient system alignment. This fragmented experience limited students' ability to engage deeply, suggesting that AI-based chatbots need to provide not just content, but also cognitive and metacognitive support.

A recurring theme across educators' reflections was the tension between standardisation and flexibility. While standardisation is essential to ensure content quality and coherence—especially in foundational topics such as risk and cost management—excessive rigidity may undermine the adaptive potential of chatbots. Effective content design should balance both needs: standardisation for pedagogical robustness, and flexibility for personalization and responsiveness. As highlighted in recent literature (Wollny et al., 2021; Winkler and Soellner, 2018a, 2018b), the most impactful chatbots are those that combine modular, validated content with personalised learning pathways enabled by AI.

Standardising the presentation of materials is necessary to enrich the learning experience, provide clarity and help students navigate the content effectively. Materials should be concise, well-structured, and broken into manageable parts. This will improve perceived quality and consistency, creating a more accessible learning process. Yet, a degree of adaptability remains necessary to meet diverse learner needs.

The trials also showed the PMTutor's role as a supplementary learning tool. When integrated into existing course structures, it offered value as a flexible, self-paced resource. Students appreciated the opportunity to revisit content and reinforce learning independently, aligning with principles of self-regulated learning (Dahri et al., 2024). However, the limited interaction between students and instructors during chatbot use raised concerns about diminishing the social and dialogic dimensions of learning, particularly in collaborative and reflective contexts. This finding alignes with broader critiques of digital education that caution against over-reliance on automation at the expense of human connection (Holmes and Porayska-Pomsta, 2022).

Despite these integration challenges, educators who applied the PMTutor generally claimed that it effectively engaged students, motivating them to spend more time on learning activities than anticipated. One teacher noted, "It was online teaching, but it was never difficult to get the students to use the tutor; they seemed well-motivated to spend perhaps 1 h doing an exercise with the tutor." This aligns partly with an assessment of student motivation using Keller's ARCS model (Keller, 1987). Students found the PMTutor relevant and felt confident using it. However, they reported neutral attention and low satisfaction with the application. This aligns with students' reflections on the PMTutor's interface, which was perceived as lacking flexibility, navigation ease, and engaging design.

The PMTutor provided a valuable self-paced learning experience; students had control over their learning speed and got essential feedback. However, some educators expressed concerns over the limited interaction between students and teachers during chatbot use, a shift from traditional teacher-led interactions.

Finally, educators pointed to a lack of clear implementation strategies. The pedagogical potential of PMTutor was occasionally underutilised due to insufficient guidance on how to effectively embed it into different course formats. This gap suggests a need for detailed instructional design guidelines, including use cases, timing, and alignment with learning outcomes—especially in contexts aiming to transition from passive to active learning models (Ang, Afzal and Crawford, 2021).

5.2. *Design guidelines*

Building on the reflections gathered from educators and the lessons emerging from trial implementation, this section formalises a set of design guidelines to support the integration of educational chatbots like PMTutor into project management teaching in higher education (basic and intermediate-level PM education at the university and high school level). These guidelines, reported in Table 3, are grounded in empirical findings and pedagogical theory and are intended to serve as a practical reference for instructors seeking to align chatbot use with learning objectives, learner profiles, and instructional formats. They distinguish between individualised use for foundational knowledge acquisition and collaborative use for advanced application and discussion and are complemented by general recommendations for course-level integration.

The pedagogical guidelines presented in Table 3 illustrate how PMTutor can be flexibly integrated into project management education to address different learner needs and contexts. For less experienced learners, such as undergraduates and adult students in continuing education, the chatbot functions primarily as a personalised, self-paced environment for reinforcing basic knowledge. In these cases, PMTutor enhances confidence and relevance by enabling targeted review of specific topics, supporting homework and formative assessment, and providing a structured entry point into project management concepts. The possibility to revisit content independently lowers barriers to engagement and helps learners consolidate foundational competences at their own pace.

For more advanced learners, such as graduate students or those enrolled in specialised modules, PMTutor proves most effective when embedded in group activities and case-based learning. Here, the chatbot is not a substitute for classroom interaction but a scaffolding tool that supports discussion, ensures factual accuracy, and frees up classroom time for higher-order tasks such as analysing complex project scenarios. This mode of use is strongly linked to attention and satisfaction, as learners benefit from interactive, peer-driven exchanges while using the chatbot as a shared resource. Beyond these specific contexts, the general integration guidelines highlight the importance of embedding PMTutor into course planning, aligning activities with clear learning objectives, and framing interactions in ways that motivate participation (e.g., graded tasks or enrichment opportunities). These guidelines position PMTutor as a versatile learning infrastructure that can enhance both individual mastery and collective exploration in project management education.

6. Discussion

This study contributes to the growing debate on how artificial intelligence is reshaping project management education, particularly in relation to personalised learning and student motivation. While prior research has emphasised the importance of competences and learning processes for effective project practice (Medina and Medina, 2015; Geraldi and Söderlund, 2018), little attention has been given to the role of AI-based tools in supporting these dimensions.

This paper contributes to this debate by reporting on an international, multi-phase project in which a rule-based educational chatbot—PMTutor—was developed and tested across four European

Table 3
Pedagogical design guidelines for integrating PMTutor into project management education.

Guideline	Target group	Key applications	Illustrative examples	Linked ARCS dimensions
1. Individual use for personalised learning and basic content reinforcement	Undergraduate students; adult learners in continuing education	- Personalised review and practice of PM topics- Formative assessment and homework- Introduction to basic concepts	"Students can use it to train specific content; if they don't understand something in class, they can use the tutor to practise that topic.""It is useful for teachers to use it for homework, to train the content.""In an undergraduate course, the PMTutor can be helpful when going through the basics."	Confidence, Relevance
2. Group work for advanced learning and case studies	Graduate-level students; advanced modules	- Support for collaborative case study work- Facilitation of classroom dialogue- Feedback-driven peer learning	"For case studies, it gives better benefits to use it in groups, and there will be more scope for discussion.""Then there will be much more time, e.g., for real cases and interactions with companies.""That would add the important dimension of learning with others."	Attention, Satisfaction
3. General integration guidelines	All learner levels and contexts	- Early integration into course design- Objective-driven use- Motivational framing	Integration during planning to clarify purpose and scope.Mapping activities to learning goals.Using chatbot interactions for graded work, preparation, or enrichment.	All four ARCS dimensions (holistic alignment)

countries. The chatbot evolved during the project in response to technological advances, including the release of ChatGPT in late 2022, which prompted a shift toward integrating generative AI capabilities into the tool. Our findings align with (Kuhail et al., 2023b) who show that the majority of current educational chatbots are still rule-based and constrained by static dialogue structures. However, this landscape is evolving quickly: over one-third of students now regularly use ChatGPT in their studies, and more than half express positive attitudes towards AI-based educational tools (Stöhr, Ou and Malmström, 2024). Importantly, this enthusiasm is accompanied by elevated expectations for usability, flexibility, and interface quality.

The integration of generative AI into PMTutor marked a significant shift in both technological architecture and pedagogical potential. While this move responded to evolving learner expectations and offered more flexible, context-aware responses, it also introduced new challenges. From a pedagogical perspective, the inclusion of GPT-3/4 raised concerns about alignment with learning goals, control over instructional content, and the risk of students relying on AI-generated responses without critical engagement. Ethically, the use of generative models required careful handling of transparency, as well as clarification that generated content may contain inaccuracies. Technologically, the hybrid model (rule-based + LLM) posed data governance issues—particularly regarding user inputs processed via external APIs. These considerations highlight the importance of framing generative AI as a pedagogical assistant under the guidance of educators, not as a substitute for instructional design. As outlined in the UNESCO (2023) guidelines, AI in education should reinforce human agency, support inclusivity, and be integrated with transparency and purpose.

In our study, students exhibited a generally positive attitude towards PMTutor and showed increased motivation when using the tool, particularly when it was integrated into their learning routines. This confirms earlier findings (Minichiello et al., 2022) showing that well-structured online environments and meaningful feedback mechanisms contribute to perceived support and motivation in digital learning contexts. However, students also demonstrated low tolerance for tools that fail to meet expectations, underlining the importance of a smooth, adaptive, and engaging user experience.

The potential of educational chatbots to support personalised learning is increasingly recognised (Winkler and Soellner, 2018b; Hwang and Chang, 2021; Wollny et al., 2021). Our findings support this perspective: PMTutor was particularly effective for basic content reinforcement and low-stakes practice, especially in individualised settings. However, the chatbot showed limitations in guiding complex, open-ended problem-solving, suggesting that it currently works best as a supplementary tool rather than a standalone tutor in advanced scenarios.

This study also contributes to the broader discourse on blended learning, where chatbots serve as bridges between face-to-face and online instruction. In line with (Driscoll, 2002; Vaughan, 2007; Bonk and Graham, 2012, 2012), we found that chatbots like PMTutor offer benefits such as flexibility, on-demand support, and increased time-on-task. Teachers valued its capacity to extend engagement beyond the classroom and enhance students' self-directed learning. When integrated thoughtfully, chatbots can thus facilitate a pedagogical shift from passive reception to active construction of knowledge, supporting both formative assessment and learner autonomy.

In the context of project management education, these findings are particularly relevant. Preparing future project leaders requires not only technical knowledge but also soft skills, reflective capacity, and adaptive thinking. Chatbots can support this shift by offering scalable, interactive learning opportunities. As Konstantinou et al. (2023) argue, digitalisation calls for a redefinition of the educator's role—from knowledge gatekeeper to learning facilitator. Similarly, the notion of "human-dominant AI" proposed by Clegg and Sarkar (2024) suggests that AI tools should complement rather than replace traditional academic functions, enabling more personalised and dynamic learning experiences while preserving the value of human guidance.

However, integrating AI tools into established curricula is not without challenges. As noted by Kasneci et al. (2023) the adoption of large language models requires clear pedagogical strategies that emphasize critical thinking, source verification, and responsible use. Moreover, as our findings suggest, a reduction in teaching workload cannot be assumed. Instead, educators need support, training, and community dialogue to make informed decisions about when and how to adopt these technologies effectively and ethically.

6.1. Implication for theory

This study contributes to the theoretical discourse in project management by positioning AI-powered educational chatbots as enablers of capability development for future project professionals. In project studies, scholars have long emphasised the importance of competences and learning processes for effective project practice (Ramazani and Jergeas, 2015; Geraldi and Söderlund, 2018). Our findings add to this conversation by showing how artificial intelligence based tools can foster personalised and scalable learning experiences that respond to the increasing demand for reflexivity, adaptability, and lifelong learning in project-based work. In doing so, the paper extends the PM education literature on digital and AI-enabled student-centred approaches by providing an empirically grounded account of how AI tools—operationalised here through a chatbot—translate into concrete mechanisms for capability formation in project management.

Specifically, the study illustrates how such tools support capability formation in project management by (i) personalising learning paths in response to individual student needs, (ii) facilitating continuous practice and feedback outside traditional classroom boundaries, and (iii) enhancing learner autonomy and engagement. In this sense, the contribution lies both in confirming the potential of AI for scalable and adaptive education (Maier and Klotz, 2022; Ingason and Eskerod, 2024), but also in detailing how these affordances materialise in practice and translate into the development of core project management competences.

By analysing students' perceptions of motivation and usability, the study highlights how AI-driven tools can reinforce key project management competences, particularly in terms of autonomy, confidence, and engagement in learning processes. These dimensions are aligned with broader project management debates on the formation of professional identity and the cultivation of dynamic capabilities that allow project managers to thrive in uncertain and complex environments (Medina and Medina, 2015; Davies, Dodgson and Gann, 2016; Davies and Brady, 2016). We theorise a micro-mechanism whereby personalization increases perceived relevance and self-efficacy, which in turn supports the consolidation of foundational PM competences and the maturation of professional judgement. In this sense, educational chatbots should be understood not merely as technological artefacts, but as instruments that shape how project knowledge is constructed, internalised, and transferred.

At the same time, the study advances theoretical work on the digitalisation of project management (Jonasson and Ingason, 2022; Konstantinou, Nachbagauer and Wehnes, 2023; Ingason and Eskerod, 2024). The integration of chatbots into project management education illustrates how digital technologies are reshaping pedagogical practices and, in turn, the competences of future project leaders; this finding is in line with the extant research on digital education and technology-enhanced learning, which highlights the role of AI-driven tools in fostering active engagement, personalised learning pathways, and the development of higher-order skills necessary for thriving in complex project environments (Jääskä et al., 2022; Ingason and Eskerod, 2024). We characterise this shift as a move toward a "digital project pedagogy", in which human–AI arrangements act as capability-building infrastructures linking curricular bodies of knowledge to individual learning pathways (Lewin, Cranmer and McNicol, 2018). This perspective also clarifies boundary conditions: chatbots are most theoretically salient as scaffolds for basic knowledge reinforcement and reflective practice, rather than as substitutes for advanced, open-ended problem-solving.

6.2. *Implication for practice*

This study offers several practical takeaways and pedagogical guidelines for educators and institutions seeking to adopt educational chatbots effectively. First, chatbots like PMTutor work best when integrated into existing course structures—not as replacements for teaching, but as tools to support and extend learning, especially in self-paced or blended environments. To be effective, their implementation must be guided by clear pedagogical goals and supported by proper training for educators. Second, user experience matters: students respond positively when the interface is intuitive, flexible, and responsive. Investing in usability and adapting to students' expectations is crucial. Moreover, while generative AI brings new opportunities for personalised learning and content support, it also requires transparency about limitations, especially in terms of accuracy and data handling. Finally, the successful use of chatbots depends on continuous refinement. Collecting student feedback, aligning chatbot features with learning objectives, and encouraging cross-functional collaboration between educators and developers can help ensure that these tools remain useful, engaging, and educationally sound.

7. Limitations and conclusions

This study makes several contributions to AI-supported education. It presents a practice-oriented account of chatbot development using Action Design Research (ADR), showing how a rule-based system evolved into one enhanced with GPT-3. The empirical analysis, guided by Keller's ARCS model, offers insights into how chatbots impact learner motivation across diverse student groups. The study also outlines pedagogical design guidelines for both individual and collaborative learning, helping educators integrate chatbot technology into project management curricula. Finally, it addresses ethical, technical, and instructional challenges, contributing to the ongoing discourse on responsible AI use in higher education.

Despite the promising findings, several limitations should be acknowledged. First, although ADR provided a robust framework to iteratively co-design and refine the chatbot with both researchers and practitioners, the choice of setting (pilot implementations in specific PM courses) may affect the generalisability of the findings. To mitigate this, we employed triangulation across multiple data sources (surveys and observations) and ensured transparency in documenting the design cycles through detailed reporting of iterations, design rationales, and students feedback; this enhanced reliability and validity. Second, while the study focused on students' perceptions of motivation and perceived learning, we did not include direct measures of cognitive performance (e.g., knowledge gain comparisons or cognitive load analysis). Future studies could address this gap by integrating objective metrics and longitudinal evaluations. Third, the qualitative and survey-based data are context-dependent, which may limit external validity. We mitigated this by including multiple cohorts and institutional settings, yet broader cross-institutional studies are needed to confirm the transferability of the results.

Looking ahead, future research should explore strategic pathways for AI-related research in project management education. This includes investigating how AI-enabled tools can be embedded into capability development frameworks for project professionals, studying their role in cultivating dynamic capabilities and professional identity in project-based contexts, and examining the ethical and governance challenges of AI adoption in educational programmes. Comparative studies across institutions and cultures, integration with industry-based training initiatives, and exploration of hybrid human–AI pedagogical models could provide a richer understanding of how digital technologies reshape the competences of future project leaders.

CRediT authorship contribution statement

Helgi Thor Ingason: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kirsi Aaltonen:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Atli Snaer Asmundarson:** Software. **Thordur Vikingur Fridgeirsson:** Investigation, Conceptualization. **Daniel Huemann:** Software. **Martina Huemann:** Writing – review & editing, Investigation, Conceptualization. **Jaakko Kujala:** Methodology, Conceptualization. **Hannele Lampela:** Writing – original draft, Investigation, Conceptualization. **Mauro Mancini:** Conceptualization. **Costanza Mariani:** Writing – review & editing, Investigation, Data curation, Conceptualization. **Claudia Ringhofer:** Data curation, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

While preparing this work, the authors used ChatGPT to help develop the text and Grammarly to improve the flow and grammar of the text. After using these services, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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