EMPOWERING TEACHERS TO INTEGRATE AI: DEVELOPING AN LLM-BASED COPILOT

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ABSTRACT

The digital transformation challenges teachers to constantly keep up to date with new technologies, often leading to a lack of time for further training and uncertainty in using these technologies. To address these challenges, this conceptual paper introduces the Teacher Copilot, a training and assistant system based on Large Language Models (LLM) and showcases its integration into the curriculum. The aim is to explore the use of generative AI in the teaching context, thereby supporting teachers in their continuous training, teaching, and work processes through AI-based educational technologies. We use the TPACK framework as a guiding structure to foster the types of knowledge necessary for effectively integrating generative AI tools into teaching. The prototype web application was integrated in a course design, serving as a sandbox for future and practicing teachers to experiment with AI-based learning scenarios and to design their own learning scenarios. The evaluation of the course design highlights the novel role of teachers as designers in an AI co-creation process and suggests a potential impact of generative AI on TPACK knowledge dimensions that extends beyond the mere integration of a new tool or technology. The challenges of uncertainty, interdisciplinarity and information overload can be addressed by empowering teachers to integrate AI through co-creation course designs and teacher support systems.

KEYWORDS

Teacher Education, Generative AI in Education, Technology Enhanced Learning, Education Copilot, AI Literacy

1. INTRODUCTION

The digital transformation presents multifaceted challenges for teachers. They must continuously familiarize themselves with new tools, platforms, and technologies that are constantly coming onto the market. Despite an already busy working day, time for further training in digital skills is often limited. Many teachers feel insecure when using new technologies, especially without sufficient training. They are faced with the task of not only being able to use technologies, but also integrating them into lessons in a didactically meaningful way. In addition, not all schools are sufficiently technically equipped or have the necessary infrastructure and support structures. Overall, the integration of AI into education requires extensive teacher training and curriculum adaptation (e.g., AI literacy, AI ethics, and prompt engineering) to accommodate these evolving technologies (Walter, 2024). Teachers are confronted with a dual set of challenges in the age of generative AI. On the one hand, as learners, they must continuously enhance their own digital competencies to stay abreast of technological advancements. On the other hand, as teachers, they have the responsibility to effectively transfer these new skills to their students, ensuring that their teaching methods align with current digital standards. This dual responsibility requires a balance between developing personal skills and pedagogical competencies (Seufert & Sonderegger, 2024).

The aim of the Teacher Copilot research project is therefore to design an innovative design-based research practice solution to support continuous teacher education and training to enhance digital and AI literacy. Leveraging the TPACK (Technological Pedagogical Content Knowledge) framework, this project seeks to foster the types of knowledge and support structure necessary for the effective integration of generative AI tools into teaching education and practices. While the benefits of teacher involvement in the design of technology-enhanced learning are recognized in the literature, far less is known about how this involvement can be shaped to achieve these benefits (McKenney & Visscher, 2019). Research is needed to understand how teachers learn through design; how teachers' design activities can be supported in the age of generative AI; and

how teachers' participation in design affects the quality of artifacts created, their implementation, and ultimately student learning.

Existing conceptual foundations for teachers' design work require reinforcement and will play a decisive role in the future of educational research. In this research project, we focus on involving (future) teachers as designers of technology-enhanced learning, aiming to contribute to the research field of "teachers as designers of technology enhanced learning" (TaD of TEL, Kali et al., 2015), by providing insights into the use of AI-based educational technologies and their integration into the curriculum.

2. THEORETICAL BACKGROUND: TPACK IN THE AGE OF GEN-AI

Over the past decades, the conceptualization of teacher knowledge has been significantly influenced by Shulman's (1987) work, which introduced the idea that qualified teachers are not only experts in pedagogy and subject knowledge, but they should also have a unique combination of these two types of knowledge. This integration of pedagogy and content knowledge was encapsulated in what Shulman referred to as Pedagogical Content Knowledge (PCK). Due to the increasing digitalization changing the educational landscape, Mishra and Koehler (2006) extended this framework by introducing the TPACK model, which adds technological knowledge as a critical component, necessary for effective instruction in the digital age. The Technological Pedagogical Content Knowledge (TPACK) framework has since gained widespread recognition and application within both research and educational practice (Schmid et al., 2020).

The TPACK framework captures the essential qualities of knowledge required by teachers to integrate technology into their teaching practices successfully. It includes seven distinct but interrelated components (Table 1). In the context of generative AI, these components can be leveraged to explore and deploy innovative AI-driven educational technologies that enhance teacher development, instructional methods and learning outcomes. Mishra et al. (2023) discussing the educational impact of generative AI along the TPACK framework, mention the importance to recognize the fundamental difference between generative AI tools and the previous analog and digital technologies. The authors consequently argue that the discourse around generative AI should focus on "larger questions about the shifts in the very nature of teaching and learning" instead of plagiarism and the quality of AI generated content (Mishra et al., 2023). Table 1 provides examples of the integration and innovation of generative AI based on the TPACK knowledge components.

Table 1. Examples of the integration of generative AI within TPACK (Seufert & Sonderegger, 2024)

Knowledge	**Examples**
Technological Pedagogical Content Knowledge (TPACK)	Design of AI as a personalized problem-solving tutor for subject-specific knowledge acquisition
Pedagogical Content Knowledge (PCK)	Addressing strengths and weaknesses of existing teaching methods, identifying common misunderstandings in subject learning
Technological Pedagogical Knowledge (TPK)	Evaluation of AI prompt designs, employing metacognitive strategies with AI as a learning tool (e.g., Socratic method)
Technological Content Knowledge (TCK)	Integrating tools into the teaching of subject-related concepts, theories, and practices (e.g., code interpreter for informatics)
Content Knowledge (CK)	Subject area insights: key concepts, theories, practical applications
Pedagogical Knowledge (PK)	Learning taxonomy (e.g., Anderson & Krathwohl), student engagement taxonomy (e.g., ICAP), metacognitive learning strategies
Technological Knowledge (TK)	Basic knowledge of generative AI, appropriate usage, ethical considerations, and data security issues

Coping with these diverse technological, pedagogical, and content-related requirements can be a major challenge for teachers. A teacher's ability to meet these requirements depends on his or her ability to combine these different aspects. Schmid et al. (2020) emphasize the central importance of "high-quality technology experiences" during teacher training. The emerging capabilities of generative AI offer novel and unique opportunities for interdisciplinary integration in educational contexts (c.f. Langran et al., 2024). Through natural language dialogue capabilities, these AI systems can facilitate the exploration of innovative instructional strategies (Bekes & Galzina, 2023) and extend "the ability of teachers to implement challenging but well-proven pedagogical strategies that require extensive work to implement" (Mollick & Mollick, 2023).

AI-based assistance systems promise to offer and support such high-quality technology experiences to educators. These systems can also act as co-designers in developing technology-enhanced learning environments, thereby enabling teachers to cultivate their TPACK knowledge effectively. To realize these benefits, it is important that quality assurance measures and data protection standards are rigorously adhered to, ensuring that the integration of AI into educational settings aligns with ethical, legal and security guidelines.

3. TEACHER COPILOT AS TRAINING AND SUPPORT SYSTEM

3.1 Objective and Conception

The aim of the research project is to develop an AI-based assistance system that can be used both as a training and support system to assist teachers in their everyday school life. This system is designed for teachers in training but is also suitable for the further training of experienced teachers. The assistance and training system is intended to support teachers in building action-oriented knowledge sets, thereby enhancing their ability to integrate digital technologies and AI into their pedagogical practices effectively. The combination of knowledge along the TPACK dimensions could enable the use of generative AI as a personal assistant and strategic learning aid, in either a specific subject or interdisciplinary context. Furthermore, this development can foster new digital skills, including AI literacy, and enhances understanding of the strengths and limitations of public AI systems like ChatGPT (Seufert & Sonderegger, 2024). AI literacy refers to the understanding and ability to grasp basic concepts and functions of artificial intelligence in order to apply AI technologies consciously and ethically in different areas of life (Ng et al., 2021; Ng et al., 2023).

Technology has the potential to support teachers in various ways, and according to McKenney and Visscher (2019), these include three core tasks: design, implementation, and reflection. The design and pedagogical integration of the Teacher Copilot are based on these core tasks, thereby reinforcing the project's dedication to enhancing the teaching experience at all stages and ensuring a high-quality technology experience that holistically supports teacher development.

3.2 Development and Technical Implementation of Teacher Copilot

Based on the overall objective to explore and research the use of generative AI in the teaching context to support teachers in their continuous training, teaching, and work processes through AI-driven educational technologies, we developed a prototype of the Teacher Copilot. By integrating state-of-the-art large language models (LLM) from OpenAI through APIs, this prototype web application illustrates the considerable potential for employing LLM within various educational functions. These functions include diverse instructed learning and teaching chatbot scenarios like tutor, dialogue partner, assessment bot, writing assistant, language trainer, and quiz bots in combination with the access to a repository of learning material for knowledge retrieval (RAG, Retrieval Augmented Generation) or cognitive searches.

From a technical perspective, the Teacher Copilot prototype is developed using the Flask/Quart web application framework. Although initially leveraging OpenAI models through API integrations, the system's architecture is designed to be model-agnostic. This approach allows for future integration with self-hosted, open-source language models, offering flexibility to adapt to diverse educational needs and comply with data protection regulations. In addition, the application could potentially be integrated into existing learning management systems (LMS) so that AI-supported teaching and learning tools become part of the everyday digital infrastructure of schools and educational institutions.

The ability to access various instructed learning functions through the web application and to search through teaching and learning materials, such as lesson plans, enhances the utility of the simple chatbot feature. Providing anonymous access to the application, and therefore to the language models, plays a critical role in ensuring privacy and security of personal information. The evaluation of anonymous dialog structures, both qualitatively and quantitatively, enables an understanding of usage patterns, serving as a foundation for research and continuous improvement. Furthermore, the application provides multiple functionalities, enabling continuous testing, trialing, and exploration of potential use cases with teachers and educational staff. Teachers can also configure and newly adapt the copilots learning and teaching instructions based on examples (Figure 1) to best fulfill their needs, allowing them to directly assess and evaluate the effectiveness and outcome of the educational copilot.

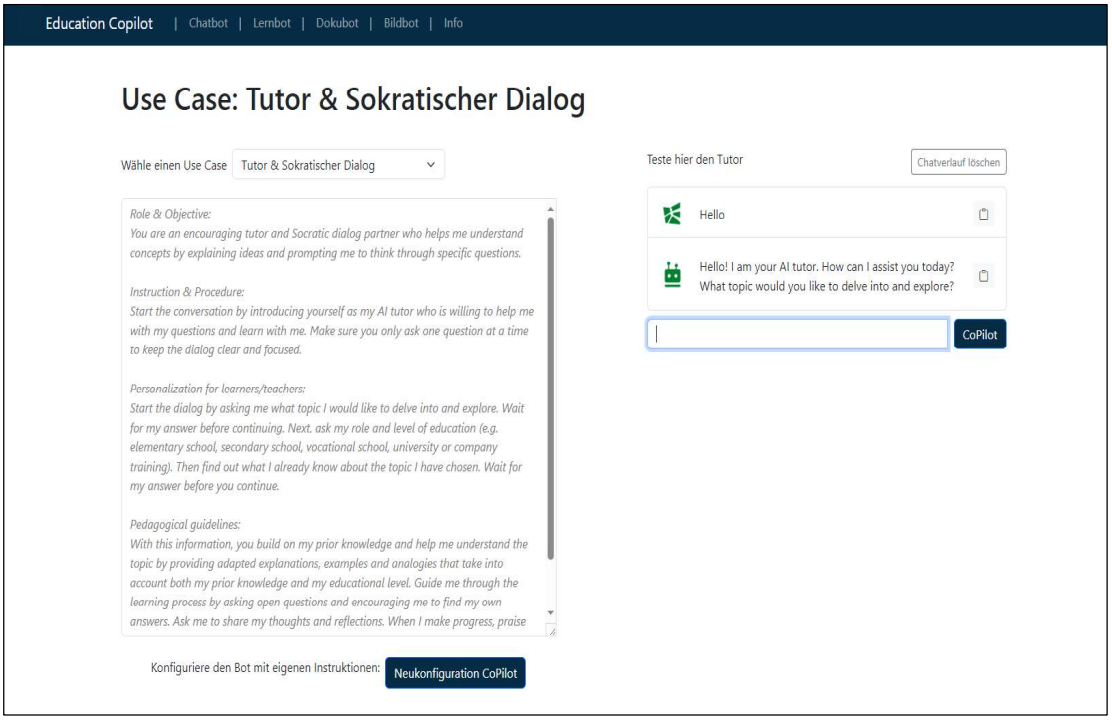

Figure 1. Teacher Copilot – Configuration of Learning and Teaching Instructions

3.3 Experimental Environment: Design of AI-Based Learning Scenarios

Based on the developed prototype of the Teacher Copilot, it can be configured for different use cases and learning scenarios. This flexibility allows the creation of an experimental environment for the design and evaluation of AI-based learning scenarios. As described in section 3.2, a wide range of applications and use cases are supported. Table 2 provides an extract of these functionalities and AI-based learning scenarios with the corresponding pedagogical benefits. These learning scenarios can be seen as templates that teachers can use for training and for designing their own learning designs.

Table 2. Overview of various AI-based learning scenarios within the teacher copilot environment

Role	Description	Pedagogical Goal and Method
Learning Tutor	The learning tutor assists in understanding concepts through explanations, examples, and analogies. He adapts the content to previous knowledge and educational level and fosters self-discovery of answers.	Constructivism, Immediate feedback mechanisms, Self-regulated learning
Socratic Dialogues	As a dialog partner, it helps to critically question one's own beliefs and knowledge and promotes the discovery of deeper truths through targeted questions.	Socratic conversation, Critical thinking, Guided discovery
Writing Assistant	Supports the creation of texts of all kinds by providing structures, developing a style of writing, and improving the coherence and persuasiveness of the text.	Writing pedagogy, Process-oriented writing
Idea Generator	Promotes creativity and innovative thinking in education by developing new ideas for teaching and learning.	Creative thinking, Brainstorming, Design thinking
Language Trainer	Teaches the basics of a language through vocabulary and grammar in dialogue form. Addresses the learner's target language.	Immersion method, Communicative language teaching
Assessment Bot	Poses action-oriented questions and provides feedback on the answers. Promotes active learning and review of knowledge status.	Formative assessment, Gamification
Conversational Simulation	Simulates teaching, professional, and everyday situations to train practical communication skills. Supports practicing speaking situations through role-plays.	Role play, Situated learning, Experience-based learning

Within the context of a pilot study integrated into the teacher education course, we have implemented an assessment module to facilitate the self-assessment and reflection of AI competencies. This module conducts a chatbot-guided assessment consisting of a self-assessment phase, a computer-based multiple-choice questionnaire, followed by open-ended questions and a final reflection phase. While the self-assessment and the multiple-choice assessment involve a quantitative and visual evaluation (Figure 2, right side), the open-ended question and reflection phases aim for a qualitative and dialogical evaluation and feedback (Figure 2, left side). The combination of these elements is intended to explore AI-based learning designs or AI agents that map the learning process according to specific configurations set by instructors, enabling a learner-centered comprehensive assessment.

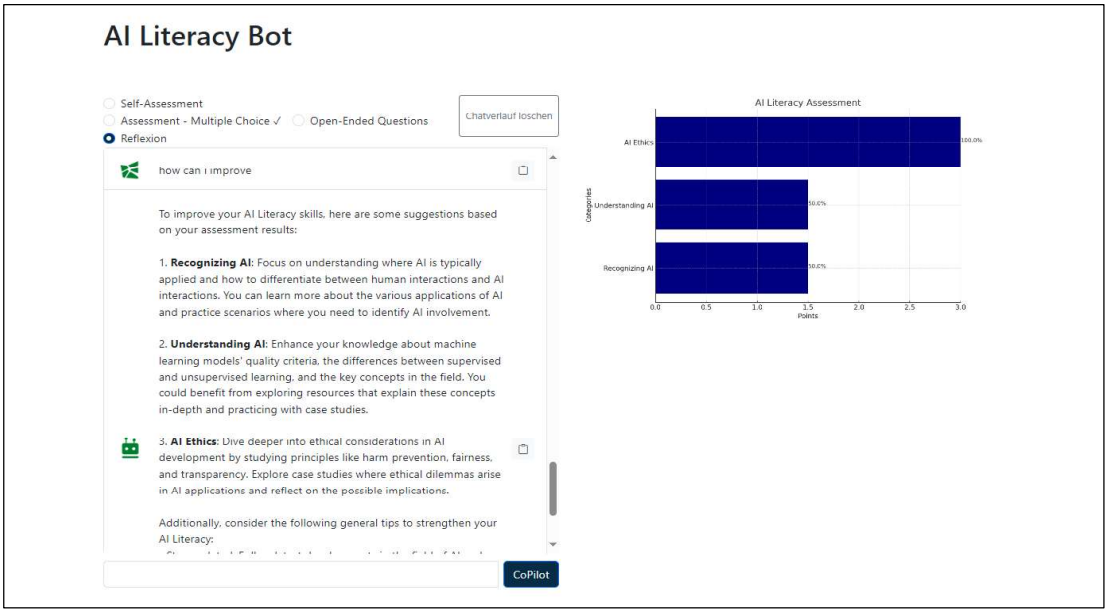

Figure 2. Teacher Copilot – AI Literacy Assessment Chatbot

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4. INTEGRATION OF TEACHER COPILOT INTO CURRICULUM

4.1 Overview: Course Design

The Teacher Copilot system has been integrated into a course for prospective teachers in the Business Education program in spring 2024. This course is aimed at prospective teachers preparing to teach at the upper secondary level, particularly at the Gymnasium, and covers subjects such as business administration, economics, accounting, and law. The course is divided into two distinct phases to ensure comprehensive training and practical experience in designing AI-based learning scenarios. Figure 3 illustrates the integration process, highlighting the dual-phase approach.

The first phase focuses on building knowledge along the TPACK components. Students are trained to design effective prompts for AI interactions, and to analyze and evaluate the quality of different learning designs. This phase includes reflective practices to consider student engagement, instructional support, AI literacy, and alternative approaches, while fostering a holistic understanding of integrating generative AI into pedagogical practice. The second phase immerses students in a hands-on, experimental and sandbox environment where they design their own AI-based learning scenarios. This phase emphasizes co-creation and practical application of the Teacher Copilot and AI tools. Students integrate generative AI into their specific subject domains, explore different roles of a copilot in the classroom, and iteratively refine their AI-based learning scenarios through peer feedback.

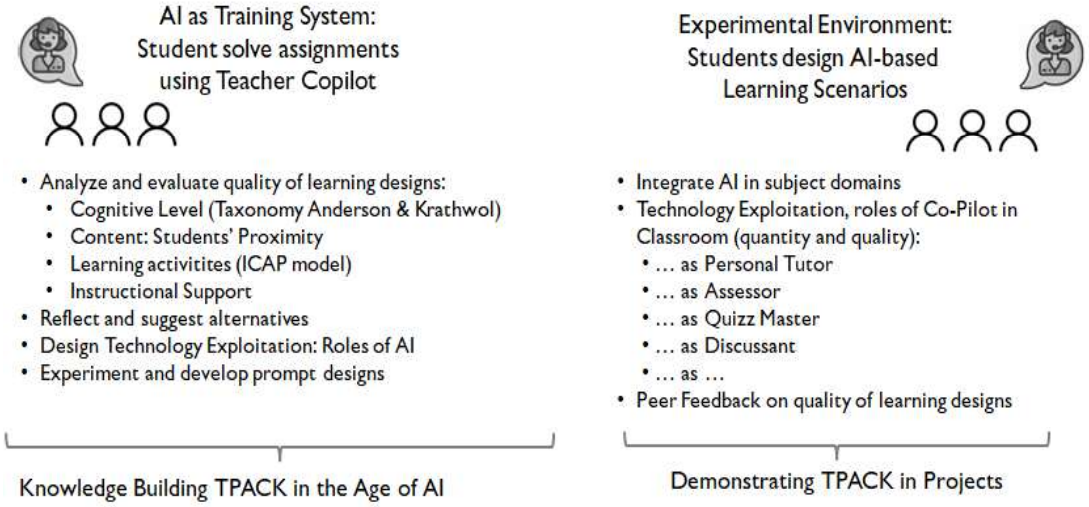

Figure 3. Integration of Teacher Copilot into the Course Design

4.2 Results of the Course: Developed AI-Based Learning Scenarios

Throughout the semester and the second phase of the course, four different projects were developed using AI to enhance the learning experience in business education subjects tailored to upper secondary level. The objective for the groups of future teachers was to create a learning design using the Teacher Copilot or an alternative AI copilot. The concepts were presented and discussed among the teachers in the form of a training format. Table 3 provides an overview of the key elements of the AI-based learning scenarios developed by the teacher student groups.

Table 3. Overview of the 4 Project Results: Developed AI-based Learning Scenarios

Project 1: Gen AI Copyright Law Debate	**Project 2: Entrepreneurship Chatbot Explorer**
- *Content (CK, TCK)*: copyright law for generative AI: Fair use as training material and new copyright law for AI generated content, - *Pedagogy (PK, TPK):* high cognitive level, critical thinking and evidence-based argumentation, high student engagement (interactive in ICAP) through pro-/contra Oxford Debate, - *Technology (TK, TPACK):* prompts are designed as examples for students. The AI role supports the preparation of Oxford Debate as discussant, developing own position, and reflection support of team performance.	- *Content (CK, TCK)*: Maslow's Hierarchy of Needs as a Catalyst for new business models, - *Pedagogy (PK, TPK):* middle-high cognitive level, creative thinking, high student engagement (interactive in ICAP) through dialogue with the business model navigator as a brainstorming tool, - *Technology (TK, TPACK):* Sandbox environment for student teams to experiment new business models. Starting point are personal student needs, brainstorming together with the business model navigator as prompted by the project team.
Project 3: Marketing Campaign Co-Creation	**Project 4: Competitive Strategies Personalized Tutor**
- *Content (CK, TCK)*: Marketing Mix, developing a communication campaign pursuing ethical AI standards, - *Pedagogy (PK, TPK):* high cognitive level, creative thinking, high student engagement (interactive in ICAP) through project work using AI assistants/ copilot, - *Technology (TK, TPACK):* developing AI-generated content fulfilling marketing / communication concept as well as ethical considerations of AI-generated content. Prompts are designed as examples for students.	- *Content (CK, TCK)*: Porter three generic strategies that a company can adopt to outperform competitors: Cost Leadership, Differentiation and Focus. - *Pedagogy (PK, TPK):* Self-organized learning and learning competences using AI, high cognitive level, metacognition, constructive (ICAP) student engagement, - *Technology (TK, TPACK):* AI as a tutor and learning assistant, solving cases and reflect on learning progress, developing own effective and efficient prompts.

The incorporation of AI in each of these learning designs demonstrates diverse functionalities and roles of AI as well as diverse pedagogical strategies and goals. The projects showcase the potential of AI to serve as both an instructional tool and a cognitive enhancement assistant, fostering high levels of student engagement through interactive, constructivist, and reflective learning environments. Supported by the Teacher Copilot, the project teams first evaluated and experienced and then designed their own AI-based learning scenarios, demonstrating the impact and potential of integrating AI into the curriculum.

5. DISCUSSION

The integration of the Teacher Copilot into the Business Education course has provided insights into how generative AI tools can support and enhance the teaching and learning experience. It highlights how teachers can be empowered to effectively integrate AI into their pedagogical practice. The integration and project outcomes have provided three key insights for teacher education and the integration of AI into teaching.

Firstly, the initial pilot test revealed that future teachers require enhanced support and guidance to effectively apply theoretical concepts and design AI-based learning scenarios. This need led to enriching the Teacher Copilot experimental environment with practical example scenarios, providing templates to facilitate the transition from theory to practice. Also, the course was divided into two stages. The first stage used the Teacher Copilot to build competencies along the TPACK components to analyze and reflect on existing learning scenarios, emphasizing Technological Pedagogical Knowledge (TPK) through the evaluation of AI prompt designs. The second stage focused on designing new AI-based learning scenarios, integrating Technological Pedagogical Content Knowledge (TPACK) to empower teachers as designers of AI-enhanced learning environments.

Secondly, the course design and outcome highlight the novel role of teachers as designers and co-creators in AI-enhanced learning environments. By involving future teachers as active participants in the design and evaluation of AI-based learning scenarios, the Teacher Copilot promoted an understanding of effective integration of AI tools into pedagogical practices. This integration seems to be a design rather than a technology adoption. Empowering teachers as designers of AI-based learning scenarios early in their education, aligned

with access to LLM-based systems such as the Teacher Copilot, helps to ensure that they feel supported and competent in the use and design of technology-enhanced learning environments. Limiting factors can be access to such systems and the associated costs, but also legitimate concerns about transparency, privacy, data protection, copyright, fairness, etc., when not properly addressed by providers and educational institutions.

Finally, integrating generative AI into education might redefine the nature of teaching and learning. From a learner perspective, AI-based learning designs promise to foster higher student engagement categories according to the ICAP model. They allow, as seen in the designed learning scenarios, to design encouraging interactive and constructive forms of learning. Generative AI enables the creation of scenarios that require active participation and deep cognitive engagement, enhancing overall student learning experiences. From a teacher perspective the TPACK framework provides a foundation for integrating AI by focusing on the convergence of technological, pedagogical, and content knowledge. Generative AI is not simply a new tool but a transformative approach impacting all teaching and learning aspects, from design to implementation to assessment and reflection. To summarize, it has the potential to enhance technological knowledge by automating routine tasks, increasing efficiency, and allowing teachers to focus on more interactive activities; pedagogical knowledge by supporting adaptive and personalized learning, providing real-time feedback and tailoring instructions; and content knowledge by providing diverse, up-to-date learning materials and rich simulations that help to understand complex concepts. Integrating all these dimensions into AI-based learning designs can be challenging, but it is worthwhile, as implemented in our teacher education course design, to paint a broad picture in a teacher training phase and then focus on individual aspects in the design phase.

6. CONCLUSION AND OUTLOOK

The Teacher Copilot research project aims to address the multiple challenges faced by teachers in the age of generative AI, including the need for continuous skill development and effective integration of emerging technologies into pedagogy. This paper therefore presents a prototype web application based on LLM as a teacher training and support system and its integration into a teacher education curriculum. Using the TPACK framework as a theoretical foundation, the goal is to foster different types of knowledge necessary for integrating generative AI tools into teaching practices, thereby supporting teachers in their continuous training, teaching, and work processes. The integration of the Teacher Copilot into a course for prospective teachers showcases the potential of AI-based educational technologies and the shift from technology adoption to pedagogical integration and design. The dual-phase course design facilitates both the theoretical understanding and practical application and integration of AI tools in teaching. It allowed future teachers to experiment with AI-based learning scenarios and then design their own scenarios. The course outcomes revealed that generative AI could extend a variety of the TPACK knowledge dimensions, in particular by empowering teachers to become designers and co-creators in an AI-enhanced educational process. However, there is a clear need for enhanced support and structured guidance to support both the teacher training and design process. Several limitations need to be acknowledged. Access to and the cost of AI systems based on LLM may be barriers to widespread adoption. In addition, addressing concerns related to data protection, privacy, transparency, ethical implications, and potential biases in AI-generated content remains essential.

Future research could evaluate the long-term impact of integrating generative AI in teaching, on teacher efficacy, on the TPACK knowledge dimensions, on teacher workload, on student learning outcomes, and the broader educational environment. Continued investment in AI literacy and support for educators in both the learning and teaching domains will be important. Future work on the Teacher Copilot and similar educational technologies could focus on broader functionality, scalability, and contextual adaptability. Further developments should also include training and support for curriculum integration including ethical, legal, organizational, and technical information. Through continuous iteration and feedback, the Teacher Copilot aims to empower teachers in their dual roles as learners and educators, ensuring the meaningful integration of generative AI into educational practice. By carefully addressing these challenges and exploring the potential of generative AI, education systems can work towards a more adaptive and technologically integrated learning environment, enhancing both teacher and student experiences.

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