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THEMATIC PAPER: APPRENTICESHIP

Generative artificial intelligence in vocational education and training: A framework for sustainable teacher competence development

Christian Schmitt*, Alexandra Brutzer*

Faculty of Agricultural, Nutritional and Engineering Sciences, University of Bonn, Bonn 53115, Germany

ABSTRACT

This study examines the development of a four-hour advanced teacher training program designed to equip vocational education and training (VET) educators with the technological, ethical, and operational competencies required to integrate Generative artificial intelligence (AI) into lesson planning and resource creation. Grounded in a design-based research framework, the training balanced theoretical modules on AI functionalities, data protection, multimedia applications, and the future development of AI with hands-on exercises in prompt engineering, aided by a scaffolded prompt library. The prompt library was iteratively refined based on feedback from three VET teachers before implementation. Key findings from the training, attended by 52 participants, indicate that teachers experienced marked improvements in designing effective prompts and critically assessing AI capabilities, as reflected in their self-assessments and overall positive feedback. Qualitative insights highlighted the prompt library's practical utility while also revealing a need for more extensive hands-on practice and structured guidance during collaborative work sessions.

Key words: generative artificial intelligence, prompt-engineering, teacher training

INTRODUCTION

The proliferation of generative artificial intelligence (GenAI) has the potential to reshape educational landscapes, offering tools for personalized learning and resource creation (Watson & Shi, 2024; Zhai, 2024). GenAI refers to a class of machine learning models capable of creating novel content—including text, images, audio, and video—by learning patterns from vast datasets, thereby enabling the synthesis of creative and contextually relevant outputs. In Germany, most vocational education and training (VET) teachers instruct apprentices, and GenAI can help develop for example introductory scenarios and subject-specific informational materials. Teachers must not only grasp the technical foundations of GenAI but also address its ethical and operational intricacies, thereby developing the competencies needed to guide apprentices in responsibly and efficiently applying AI (Zhang *et al.*, 2024). As a key policymaker in German education, the Kultusministerkonferenz (KMK) emphasizes that both educators and learners need to acquire a thorough understanding of large language models (LLMs) along with the nuances of prompt-tuning (KMK, 2024). Moreover, the KMK advocates for a rapid, systematic, and research-informed expansion of teacher training offerings to ensure a didactically sound and ethically grounded integration of AI.

In response to these imperatives, the present study investigates an advanced, post-initial advanced training program for VET teachers, hypothesizing that

***Corresponding Author:**
Christian Schmitt, Faculty of Agricultural, Nutritional and Engineering Sciences, University of Bonn, Bonn 53115, Germany. Email: christian.schmitt@uni-bonn.de.
Alexandra Brutzer, Faculty of Agricultural, Nutritional and Engineering Sciences, University of Bonn, Bonn 53115, Germany. Email: brutzer@uni-bonn.de.
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sustainable competency development requires educators to fully comprehend and internalize GenAI by applying it in their own professional context. Accordingly, the training is designed to equip teachers with skills to integrate GenAI into lesson planning and preparation, leveraging its effectiveness in generating high-quality teaching materials, as demonstrated by Küchemann *et al.* (2023). This approach aims to foster competencies to ultimately meet the evolving needs of apprentices in an AI-driven future. Inspired by the Dagstuhl Declaration (German Informatics Society, 2016), the curriculum integrates theoretical content (*e.g.*, AI functionalities, ethics) with practical activities (*e.g.*, hands-on AI exploration, context-sensitive prompts).

A valuable resource in our training program is the prompt-library, a scaffolded tool that merges Schulhoff *et al.*'s (2024) systematic prompting techniques with VET-specific templates, based on a master's thesis on prompt engineering in VET lesson planning (Schmitt, 2024). It supports teachers in effective prompt creation, technological fluency, and practical competence, addressing prompt formulation challenges. Although its development is briefly summarized here, our primary focus remains on the overall design and evaluation of the training program.

METHODS AND RESEARCH DESIGN

The training program was developed and iteratively refined using a design-based research (DBR) methodology, enabling continuous cycles of design, implementation, evaluation, and revision (Schmiedebach & Wegner, 2021). This four-hour advanced training, offered as a post-initial program for VET teachers in Germany, comprised modules on technological fundamentals (Vasudevan *et al.*, 2022; Zhou, 2021), limitations such as AI hallucinations (Rawte *et al.*, 2016), socio-cultural and data protection aspects, and application-oriented components focusing on prompt engineering. As a practical tool for the hands-on working phase, a concise prompt library was integrated into the program. Developed based on theoretical insights in prompt-engineering (Schmitt, 2024; Schulhoff *et al.*, 2024) and refined through qualitative feedback from three German VET teachers, the prompt library served to support teachers in formulating effective prompts during lesson planning.

Data collection instruments for the training program included: (1) a competence grid capturing self-assessed competencies in four dimensions—embedding AI in lesson planning, critical analysis of AI, structured prompt-engineering, and reflection/ethics—using five levels adapted from Dreyfus & Dreyfus (1980), administered pre- and post-training; and (2) a validated evaluation questionnaire for advanced teacher training (Bezirksregierung Düsseldorf, 2018). All self-assessments and evaluation questionnaires were completed by the participating VET teachers of the training program. Qualitative data were analyzed *via* Mayring's (2011) content analysis, and quantitative responses were processed using median calculations appropriate for ordinal data.

RESULTS

An evaluation was conducted using two instruments: a 5-level competence grid (with 1 indicating the lowest competency and 5 the highest) to assess self-rated skills in four dimensions, and an overall training evaluation on a 4-point scale (with 1 as the lowest and 4 as the highest. The competence grid measured changes pre- and post-training, while the evaluation captured participants' overall impressions of the training's various aspects. The training was attended by 52 participants and took place at a large German vocational college. Responses that were unclear or incomplete were removed from the dataset before analysis.

Data from the self-assessment reveal significant improvements in self-assessed competencies: the median for Embedding AI in Lesson Planning increased by one level (from 2 to 3), while both critical analysis of AI's capabilities and prompt engineering showed a remarkable increase of two levels (from 1 to 3, Table 1). Reflection/ethics also improved by one level (from 1 to 2). These results indicate that participants felt notably more competent, particularly in analyzing AI's capabilities and in applying prompt engineering strategies.

Table 1: Results of the self-assessment competence grid (Scale: 1-5)

Dimension	*n*	Median pre	Median post	Δ Median
Embedding AI in lesson planning	46	2	3	+1
Critical Analysis of AI's capabilities	44	1	3	+2
Prompt-engineering	45	1	3	+2
Reflection/Ethics	42	1	2	+1

AI, artificial intelligence

The overall training evaluation yielded median ratings between 3.0 and 4.0, with particularly high scores for competence expansion and organization (both rated 4.0, Table 2). These ratings reflect strong overall satisfaction with the training content, its practical relevance, and its alignment with school practices. Qualitative feedback further supports these findings. Participants praised the

practical applicability of the training materials and the clear presentation of diverse AI models. They especially valued the prompt library during the hands-on phase, noting its role as a practical tool that enabled them to develop effective prompts for lesson planning. However, several participants remarked that the working phase was too brief and recommended that future sessions reduce the theoretical content to allow more structured and extended practical work, particularly to support less experienced teachers through smaller group formats or additional instructional support.

Table 2: Overall training evaluation ratings (Scale: 1-4)

Category	*n*	Median rating
GenAI knowledge	48	3.5
Competence expansion	51	4.0
Applicability	49	3.0
Alignment with school practice	49	3.0
Consideration of needs	46	3.0
Methodological delivery	49	3.0
Practical training	50	3.0
Quality of materials	49	3.0
Participant engagement	50	3.0
Fulfillment of expectations	50	3.0
Organization	50	4.0

GenAI, generative artificial intelligence.

It is important to acknowledge that the observed competence gains were based solely on self-assessment, which may be influenced by self-fulfilling prophecy effects; moreover, the limited sample size and single-session focus constrain the generalizability of these findings. Nonetheless, these results provide a robust foundation for further iterative development of the training framework, ensuring that VET educators are increasingly equipped to integrate generative AI tools responsibly and effectively into their instructional practice.

CONCLUSION

The findings suggest that even a short, four-hour training—supported by a prompt library—can yield competence gains among VET educators, particularly in prompt engineering and critical analysis of GenAI's capabilities. By integrating technological, socio-cultural, and application-oriented content, the program provides a framework that empowers VET educators to harness GenAI for instructional planning and to better support GenAI competency development in apprentices. These insights are also planned for integration into the initial phase of teacher education. While the prompt library proved useful, feedback indicated the practical phase should be extended for more hands-on experience. Future iterations should prioritize expanding practical components while maintaining theoretical foundations. Despite limitations in self-reported data and a single-session study, the findings offer valuable insights into improving teacher training frameworks, ensuring VET educators are better prepared for AI's evolving role in education.

DECLARATIONS

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The author has no conflicts of interest to declare.

Data availability statement
Data used to support the findings of this study are available from the corresponding author upon request.

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