

From Digital Teaching Innovation to AI-Enhanced Learning Architectures: How Sustained Implementation Support Shapes Pedagogical Development in Higher Education

Paul Dölle¹ 

¹Centre for University Teaching, University of Bayreuth, Germany.

How to cite: Dölle, P. (2026). From Digital Teaching Innovation to AI-Enhanced Learning Architectures: How Sustained Implementation Support Shapes Pedagogical Development in Higher Education. In: 12th International Conference on Higher Education Advances (HEAd'26). Valencia, 15-18 June 2026. <https://doi.org/10.4995/HEAd26.2026.21794>

Abstract

Lecturers in higher education aim to implement digital and AI-enhanced teaching practices but often lack the operational capacity to do so. This study analyses how sustained student-based implementation support shapes pedagogical innovation and facilitates AI adoption in teaching. Based on 198 teaching innovation projects conducted between 2017 and 2026 at a German university, thematic content analysis and longitudinal comparison were used to identify shifts in pedagogical learning architectures. Projects were classified into three innovation levels: content-based digitalisation, interactive formative learning environments, and AI-enhanced adaptive learning designs. Results show an early predominance of interactive designs and a rapid transition towards AI-enhanced architectures from 2024 onwards. AI adoption emerged as a higher-order stage of pedagogical maturity, enabled by sustained implementation capacity rather than technological availability alone. The findings highlight student-based implementation support as a key institutional mechanism for continuous teaching innovation.

Keywords: digital teaching innovation, e-tutor programmes, AI in higher education, implementation support, competency-oriented learning

1. Introduction

Higher education institutions increasingly encourage lecturers to adopt innovative digital and AI-supported teaching practices to enhance student engagement, formative assessment, and competency-oriented learning. While the pedagogical potential of emerging educational technologies is widely acknowledged, their sustained integration into everyday teaching remains a persistent challenge. Many lecturers face time constraints, limited technical resources,

and insufficient implementation support, causing innovation initiatives to remain fragmented or short-lived (Røe et al., 2021).

Previous research has extensively explored individual digital tools, teaching methods, and AI applications in education (Crompton & Burke, 2023). However, less attention has been paid to institutional support structures enabling continuous and scalable implementation of teaching innovations. A systematic review by Zawacki-Richter et al. (2019) highlighted that empirical research on AI in higher education remains predominantly technology-centred, with a notable absence of studies investigating the role of educators and institutional support mechanisms in shaping meaningful integration. In particular, the role of trained student assistants as operational resources for pedagogical innovation has received limited systematic investigation, despite growing practical relevance.

To address this gap, a German university established a structured e-tutor support model in 2017, providing lecturers with sustained implementation capacity for digitally supported teaching development. Rather than focusing solely on technology adoption, the programme combines pedagogically grounded training of student assistants with project-based collaboration between e-tutors and lecturers. Over time, this model evolved to incorporate AI applications for formative feedback and assessment preparation.

This study analyses the long-term development, diffusion, and pedagogical impact of this support model based on 198 implemented projects (2017–2026). It addresses three research questions:

RQ1: How does sustained student-based implementation support build pedagogical innovation capacity over time?

RQ2: How does pedagogical maturity shape the progression from basic digitalisation to interactive and AI-enhanced learning architectures?

RQ3: How does increased implementation capacity facilitate the adoption of complex AI-supported learning designs?

2. Theoretical Framework

Research on educational innovation consistently highlights a gap between pedagogical intentions and practical implementation. While lecturers often demonstrate willingness to adopt innovative approaches, structural constraints frequently hinder sustained transformation (Røe et al., 2021). Innovation studies increasingly emphasise implementation capacity as a critical institutional condition enabling the translation of pedagogical ideas into realised learning designs.

Within organisational change research, innovation is understood as a cumulative capability-building process rather than isolated technology adoption. Rogers (2003) conceptualises innovation diffusion as a process in which early adopters initially drive change, while broader institutional participation follows once implementation barriers are reduced and operational frameworks become available. Early phases involve incremental experimentation that gradually builds professional competencies and institutional routines. This progressive maturation enables the subsequent integration of more complex technologies. From this perspective, advanced educational technologies such as AI represent a higher-order innovation stage building upon established interactive learning environments and formative practices (Crompton & Burke, 2023).

Research on the digital transformation of higher education teaching further supports this developmental perspective. Røe et al. (2021) identify pedagogical conceptions of teaching as a decisive factor in technology integration, noting that teachers with student-centred approaches are more open to purposeful use of digital tools. Longitudinal evidence suggests that pedagogical orientations shift progressively through sustained engagement with innovative teaching practices, reinforcing the view that technology integration is a gradual developmental process rather than a discrete adoption event.

Building on these perspectives, this study conceptualises student-based implementation support as institutional innovation capacity enabling cumulative pedagogical maturation. The analysis examines how sustained operational support interacts with growing pedagogical sophistication to facilitate the transition from basic digitalisation towards AI-enhanced learning architectures.

3. Institutional Context and Methods

3.1 The e-tutor support model

The e-tutor programme was established at a German university as an institutional support structure enabling lecturers to implement digital and AI-enhanced teaching innovations. Projects are initiated through individual applications submitted by lecturers. Due to budgetary constraints, ten to fifteen e-tutor positions are supported per semester, selected based on pedagogical innovation potential, clarity of implementation concepts, and institutional breadth. Preference is given to first-time applicants to foster diffusion across faculties, consistent with diffusion principles emphasising broad participation over concentration among early adopters (Rogers, 2003).

Participating student assistants undergo a mandatory multi-day training combining higher education pedagogy with practical competencies in digital teaching technologies. Core training covers blended learning, flipped classroom approaches, and pedagogical design of digitally supported courses. Since 2023, optional modules address AI applications in teaching and

learning. Following training, structured project meetings between lecturer, e-tutor, and programme coordinator define objectives and implementation strategies. Continuous supervision and a final reflective meeting conclude each project cycle.

3.2 Data and analytical approach

Data sources include records of 198 implemented projects (2017–2026), thematic information from project applications, faculty-level participation statistics, and reflective reports produced by e-tutors since 2022.

A mixed-methods longitudinal framework was applied. Quantitative descriptive analyses mapped temporal trends and faculty participation patterns. Qualitative thematic content analysis of project applications and reflective reports identified dominant pedagogical functions of implemented innovations. Inductive coding captured recurring themes, which were subsequently classified into three pedagogical innovation levels reflecting increasing complexity: content-based digitalisation (Level 1), interactive formative learning environments (Level 2), and AI-enhanced adaptive learning architectures (Level 3). Longitudinal comparison across programme years enabled identification of developmental transitions. Selected AI-based projects were further analysed as illustrative cases.

These levels reflect increasing pedagogical complexity from content delivery to interactive regulation of learning and adaptive, dialogical learning processes, a progression widely acknowledged in research on digital and adaptive learning environments, where adaptive systems are positioned as more complex, pedagogically richer than basic digital content and interactive formats.

4. Results

The following results address the three research questions by examining institutional diffusion (RQ1), developmental shifts in pedagogical architectures (RQ2), and the conditions enabling AI adoption (RQ3).

4.1 Institutional diffusion

Between 2017 and 2026, 198 projects were implemented across all seven faculties, demonstrating broad institutional uptake. The highest numbers originated from law and economics (50 projects), followed by languages and literatures (32), humanities and social sciences (27), and natural sciences (24). This distribution indicates that the support model enabled innovation across diverse disciplinary cultures.

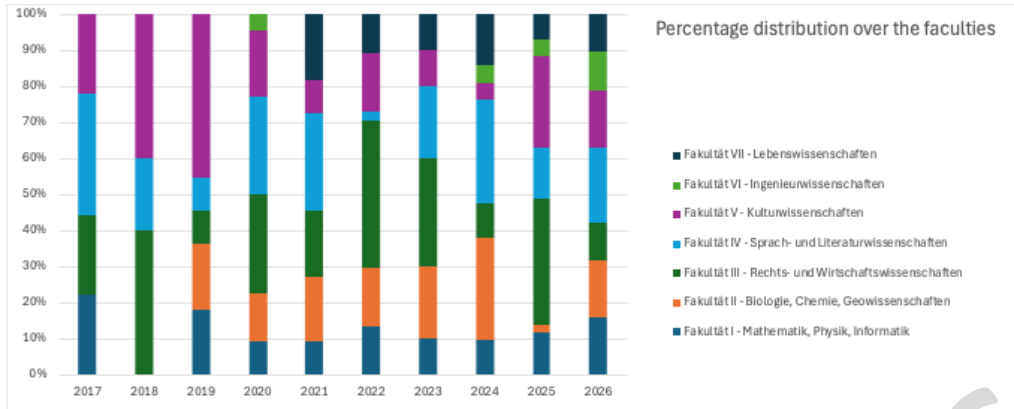


Figure 1: Percentage distribution of e-tutor projects by faculty. Source: own representation (2026)

Regarding temporal development, project numbers increased steadily, with a strong growth phase beginning around 2020. The highest annual output was reached in 2025 with 43 implementations, suggesting structural embedding within institutional teaching practices rather than short-term experimentation.

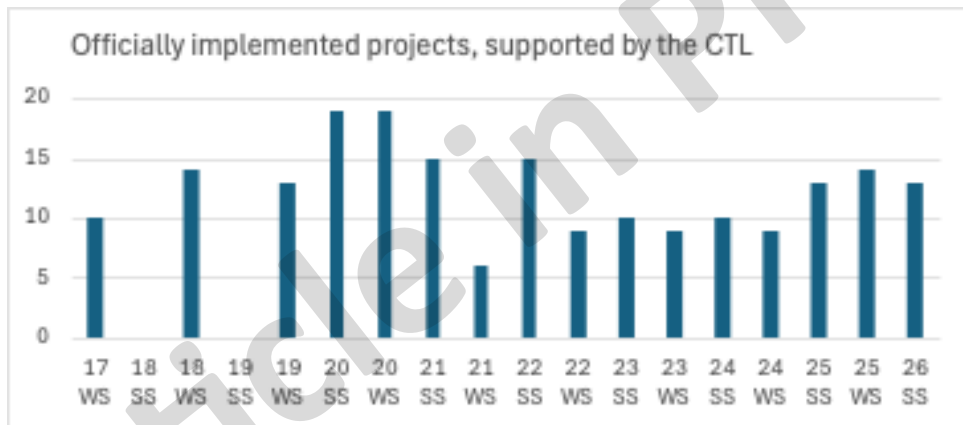


Figure 2: Number and growth of e-tutor projects since 2017

4.2 Predominance of interactive designs

Interactive formative learning environments (Level 2) constituted the dominant architecture across all years, accounting for approximately 60% of implementations. Content-based digitalisation (Level 1) represented only 14%. This indicates that lecturers consistently sought to transform learning processes rather than merely digitise existing materials.

The most frequently addressed categories were LMS-based course structures (131 occurrences), interactive assessment formats (131), video-based materials (75), peer feedback (66), and

flipped classroom designs (46). Qualitative documentation further revealed that several initially tool-oriented ideas were transformed into pedagogically grounded designs through collaboration with e-tutors, highlighting the mediating role of implementation support.

4.3 Transition to AI-enhanced architectures

A pronounced shift towards AI-enhanced learning architectures (Level 3) emerged from 2024. Prior to 2023, AI played virtually no role. From 2024, Level 3 projects expanded rapidly, accounting for 57% of implementations in 2024, 56% in 2025, and 58% in 2026. Concurrently, Level 2 proportions decreased, indicating not replacement but progression towards more complex designs building upon established formative environments.

This transition coincided with the broader availability of generative AI technologies. However, the rapid integration within pedagogically complex designs suggests that prior interactive learning environments and sustained implementation capacity constituted critical enabling conditions.

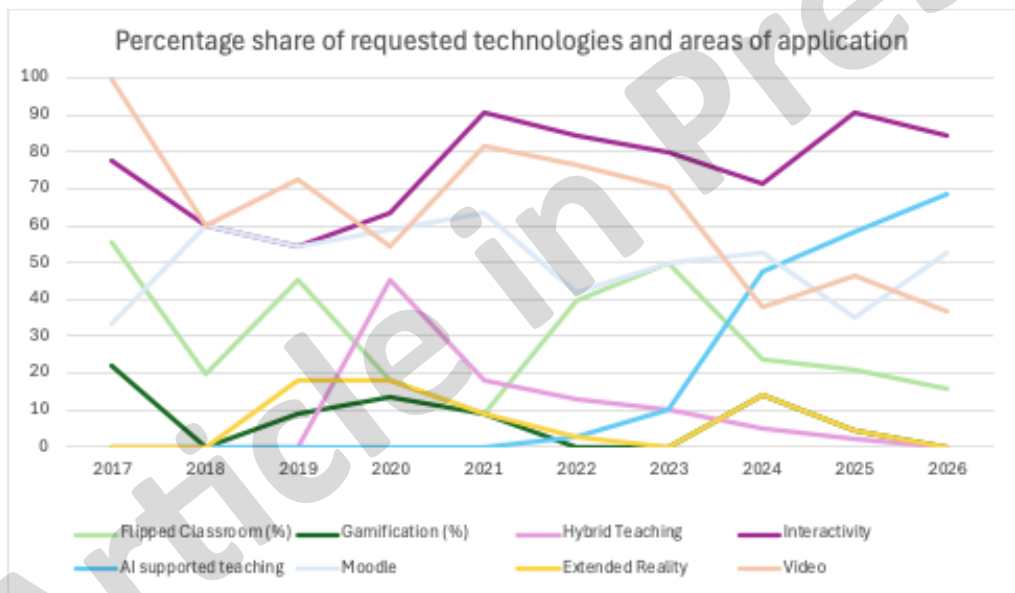


Figure 3: Percentage distribution of implemented digital and AI-supported teaching innovation categories across programme years (2017–2026).

4.4 AI-supported case implementations

Recent projects illustrate how the support model enabled advanced AI-based learning scenarios. An AI-based oral examination simulator with an interactive avatar was e.g. deployed in marketing and health economics courses, facilitating over 300 structured dialogue sessions in which students practised disciplinary argumentation with adaptive feedback. These designs

operationalised dialogical learning, adaptive feedback, and simulation of authentic assessment situations. In parallel, an AI-supported feedback system was introduced for academic writing processes, integrating teacher oversight so that instructors could review and pedagogically guide both student inputs and AI-generated responses. The system enabled scaffolded formative feedback and reflective learning processes under teacher supervision. These cases demonstrate how e-tutor support expanded feasible pedagogical designs beyond what individual lecturers could realise alone.

5. Discussion

The findings indicate that AI adoption in higher education teaching is not primarily driven by technological availability alone. Instead, it emerged as the outcome of cumulative pedagogical development enabled by sustained implementation capacity. From the earliest programme phases, lecturers predominantly pursued interactive formative designs rather than basic digitalisation, suggesting innovation readiness may be higher than commonly assumed. However, willingness alone proved insufficient; trained student-based support functioned as a critical enabler by reducing operational barriers and translating pedagogical intentions into practical architectures.

Over time, interactive environments established a pedagogical foundation for increasingly sophisticated designs. The rapid transition towards AI-enhanced architectures from 2024 did not represent a sudden shift but a progression within a mature innovation ecosystem. Once generative AI became practically applicable, it was integrated into existing formative structures, expanding reflective learning processes and assessment-oriented scenarios. This supports the interpretation that pedagogical maturity constitutes a necessary precondition for meaningful AI adoption, aligning with the view that advanced technologies build upon rather than replace established pedagogical practices (Rogers, 2003; Crompton & Burke, 2023).

The e-tutor model's role extends beyond technical assistance. The systematic transformation of tool-oriented concepts into pedagogically grounded designs highlights implementation support as pedagogical mediation. E-tutors operated as catalysts ensuring alignment between technological possibilities and learning objectives. This mediating function resonates with findings that student-centred pedagogical orientations are a key driver of meaningful technology integration (Røe et al., 2021). Institutionally, these findings underscore the value of investing in sustained implementation capacity rather than isolated technology initiatives.

The diffusion across faculties further suggests that implementation capacity can bridge disciplinary differences in teaching innovation. Once operational barriers are reduced, lecturers from diverse academic cultures appear equally capable of engaging with complex learning designs. This observation is consistent with Rogers' (2003) proposition that the rate of innovation adoption depends more on systemic conditions than on individual predispositions.

Taken together, this study contributes to higher education innovation research by demonstrating that AI adoption in teaching is best understood as a developmental outcome of pedagogical maturity combined with sustained implementation support. This perspective addresses the gap identified by Zawacki-Richter et al. (2019), who called for more educator-focused and longitudinal research on AI in higher education. Rather than treating AI integration as a standalone technological challenge, institutions should conceptualise it as the culmination of a broader capability-building process.

6. Limitations and Future Research

Several limitations should be noted. First, the programme attracted lecturers with demonstrated interest in pedagogical development; the sample does not represent baseline institutional adoption. Second, project classification was based on documented goals and reports rather than direct observation or learning outcome measurement. Third, the emergence of AI designs coincided with broader technological developments; causal relationships cannot be established within this design. Fourth, the study does not directly assess learning outcomes. Future research should explore cross-institutional comparisons, examine long-term impacts on student competencies, and investigate how different forms of pedagogical mediation influence innovation sustainability.

References

- Crompton, H., & Burke, D. (2023). Artificial intelligence in higher education: the state of the field. *International Journal of Educational Technology in Higher Education*, 20(1), 22. <https://doi.org/10.1186/s41239-023-00392-8>
- Pelánek, R. Adaptive Learning is Hard: Challenges, Nuances, and Trade-offs in Modeling. *Int J Artif Intell Educ* 35, 304–329 (2025). <https://doi.org/10.1007/s40593-024-00400-6>
- Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). Free Press.
- Røe, Y., Wojniusz, S., & Bjerke, A. H. (2021). The Digital Transformation of Higher Education Teaching: Four Pedagogical Prescriptions to Move Active Learning Pedagogy Forward. *Frontiers in Education*, 6, 784701. <https://doi.org/10.3389/feduc.2021.784701>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39. <https://doi.org/10.1186/s41239-019-0171-0>