Journal of International Education and Development
2025, VOL. 9, NO. 3, 165-171
DOI: 10.47297/wspiedWSP2516-250033.20250903

Optimizing Cognitive Load in ESP Teacher Development: Designing Research and Teaching Activities in an AI-Driven Context

Chunyan Peng

Zhejiang Yuexiu University, Shaoxing, 312000, China

ABSTRACT

The rapid integration of artificial intelligence (AI) into education has reshaped pedagogical practices, yet its implications for specialized domains such as English for Specific Purposes (ESP) teacher development remain underexplored. This study addresses this gap by investigating how AI-driven teaching and research (T&R) activities can optimize cognitive load for ESP educators, who face unique challenges in balancing domain-specific content, language pedagogy, and technological adaptation. Grounded in Cognitive Load Theory (CLT), the research employs a phenomenological approach to analyze the experiences of 12 Chinese ESP teachers through semi-structured interviews, focus groups, and document analysis. Results reveal a three-phase adaptation trajectory: initial cognitive overload from technical unfamiliarity, iterative experimentation with AI tools, and eventual empowerment through structured training and redesigned T&R activities. Findings demonstrate AI's dual role in reducing extraneous load while fostering germane efforts, though outcomes varied across disciplines and institutional contexts. The study advances CLT by applying it to teacher cognition in technology-rich environments and proposes actionable strategies, including discipline-specific AI tools and collaborative professional development frameworks, to transform cognitive challenges into sustainable growth opportunities. These insights hold critical implications for ESP teacher training, AI design, and policy-making in the era of educational digitalization.

KEYWORDS

Cognitive Load Theory (CLT); Artificial Intelligence (AI) in Education; ESP Teacher Development; Teaching and Research (T&R) Activities; Phenomenological Approach

1 Introduction

English for Specific Purposes (ESP) teachers face multifaceted challenges in domain-specific language instruction, stemming from the complexity of content expertise and the diversity of student needs. First, ESP teaching demands not only strong language pedagogy skills but also mastery of specialized terminology and knowledge systems within specific disciplines, such as medical, legal, or business English. For instance, teaching medical English requires familiarity with extensive technical vocabulary, posing high professional demands on instructors (Hutchinson & Waters, 1987). Second, learners' increasingly diverse language proficiency levels, disciplinary backgrounds, and learning objectives necessitate tailored instructional adjustments, further challenging teachers' adaptability and instructional design capabilities (Belcher, 2006). Additionally, ESP emphasizes practicality, requiring teachers to integrate language skills with professional practice, which strains their access to pedagogical resources and innovation (Dudley-Evans & St John, 1998). These complexities often result in high cognitive loads for ESP teachers, underscoring the urgent need for effective support strategies.

The rise of artificial intelligence (AI) in education presents new opportunities and complexities for ESP instruction. Tools such as intelligent assistants, automated assessment systems, and personalized learning platforms are reshaping traditional teaching models (Luckin et al., 2016). While these technologies can streamline tasks like lesson preparation and student evaluation, their integration requires teachers to adapt to unfamiliar systems, potentially increasing cognitive burdens.

Cognitive Load Theory (CLT) offers a critical lens to understand how ESP teachers navigate these demands. CLT categorizes cognitive load into intrinsic, extraneous, and germane types (Sweller, 1988). Though traditionally applied to student learning, its principles are increasingly relevant to teacher training, particularly in balancing disciplinary expertise, pedagogical innovation, and technological adaptation. In this context, T&R activities emerge as vital pathways for enhancing ESP teacher competence, providing structured opportunities for skill refinement, reflective practice, and AI integration.

These dynamics raise critical questions: How can T&R activities be designed in AI-driven contexts to alleviate ESP teachers' cognitive load? Can AI tools reduce extraneous load (e.g., repetitive tasks) to free cognitive resources for germane efforts (e.g., creative pedagogy)? How do AI-generated resources, performance analytics, or research facilitation tools specifically support ESP teachers? Furthermore, what is the relationship between cognitive load management and teaching efficacy? Addressing these questions holds both practical and theoretical significance. Practically, this study aims to empower ESP teachers with actionable strategies for leveraging AI in professional development. Theoretically, it bridges gaps in understanding AI's role in ESP teacher cognition, offering insights into technology-mediated pedagogical transformation.

2 Literature Review

2.1 Cognitive Load Theory (CLT)

Cognitive Load Theory (CLT), proposed by Sweller in the 1980s, has become a cornerstone of educational psychology, offering a critical framework for understanding and optimizing learning and teaching processes. The theory posits that human cognitive resources are finite, and excessive cognitive load impedes learning effectiveness (Sweller, 1988). CLT categorizes cognitive load into three types: intrinsic, extraneous, and germane. Intrinsic load arises from the inherent complexity of a task, such as the integration of disciplinary content and language pedagogy required of ESP teachers. Extraneous load stems from inefficient instructional design, such as redundant classroom instructions or overly complex tool interfaces. Germane load refers to the cognitive effort learners actively invest in integrating new and prior knowledge (Paas et al., 2003).

In educational practice, CLT has been widely applied to optimize learning material design—for instance, by breaking down tasks into manageable steps to reduce intrinsic load or by strategically combining multimedia resources to minimize extraneous load (van Merriënboer & Sweller, 2005). However, existing research predominantly focuses on managing cognitive load for students, while studies targeting teachers remain nascent. As designers and implementers of instructional activities, teachers' cognitive load not only affects their professional development but also indirectly impacts student learning outcomes. For example, research indicates that ESP teachers face "dual cognitive demands" when alternating between disciplinary content and language teaching objectives during lesson preparation, a process that risks intrinsic overload (Kalyuga, 2011). Despite these insights, systematic strategies to support teachers' cognitive load—particularly in highly specialized domains like ESP—remain underexplored.

2.2 Professional challenges for ESP teachers

The core challenge of ESP teaching lies in its interdisciplinary nature and goal-oriented approach. Unlike general English instruction, ESP requires teachers to deeply integrate language pedagogy with domain-specific knowledge, such as medical terminology or legal protocols (Dudley-Evans & St John, 1998). This dual mandate distinguishes ESP teachers from general language instructors and significantly amplifies their cognitive burden. During lesson preparation, teachers must research specialized topics, adapt materials to diverse learner backgrounds, and ensure alignment with real-world professional needs. In the classroom, they must fluidly explain complex concepts, facilitate technical discussions, and respond to students' immediate queries, further escalating cognitive demands. Empirical studies consistently identify these tasks as primary sources of cognitive overload, with ESP teachers frequently reporting difficulties in maintaining instructional coherence under such pressures (Belcher, 2006).

The proliferation of AI technologies in education has compounded these challenges, necessitating a deeper examination of how AI tools may alleviate or reshape ESP teachers' cognitive demands.

2.3 AI in education

The rise of artificial intelligence (AI) in education has introduced novel support mechanisms for ESP teachers, though its impact on cognitive load is bidirectional. Natural Language Processing (NLP)-driven tools, such as automated grammar checkers and intelligent tutoring systems (e. g., DeepSeek), can efficiently generate, evaluate, and adapt language materials, significantly reducing teachers' time spent on repetitive tasks (Holmes et al., 2019). For instance, automated assessment systems provide real-time analysis of student errors, liberating teachers from labor-intensive grading (Luckin et al., 2016).

However, AI integration may also impose new cognitive burdens. Teachers must learn technical workflows, adapt to tool-driven pedagogies, and even redefine their professional roles (e.g., transitioning from "knowledge transmitters" to "learning facilitators"). Such shifts may temporarily increase intrinsic load (Zawacki-Richter et al., 2019). Research suggests that without adequate training and cognitive scaffolding, teachers may experience "technostress" or "tool dependency," leading to imbalanced cognitive resource allocation (Selwyn, 2016). For example, overreliance on AI-generated lesson plans risks eroding teachers' instructional design autonomy, while technical glitches may disrupt workflows and generate additional extraneous load.

2.4 AI in T&R activity design

The design principles of T&R activities directly influence the distribution of teachers' cognitive load and the efficacy of professional development. Traditional models, such as lecture-based training or experience-sharing workshops, often fail to account for individual cognitive differences and contextual adaptability (Borg, 2010). Standardized training programs, for instance, may increase extraneous load through generic content or inhibit germane load by detaching from authentic teaching scenarios.

Recent studies advocate "cognitively friendly" T&R designs, such as modular task decomposition to reduce intrinsic load or collaborative learning to enhance germane load (Mayer, 2009). AI technologies further expand these possibilities: virtual T&R communities enable cross-institutional resource sharing, intelligent analytics generate personalized professional development pathways, and AI-powered simulated classrooms allow teachers to experiment with innovative strategies in low-risk environments (Bond et al., 2020).

For example, AI-driven reflective platforms can automatically analyze classroom recordings to identify high-load phases and provide optimization suggestions, enabling teachers to pinpoint cognitive bottlenecks and enhance the precision of T&R activities.

Despite these advances, a critical gap persists in the literature: the lack of qualitative research on ESP teachers' cognitive load adaptation in AI-driven contexts. While quantitative studies have assessed AI's impact on student performance or teacher productivity, few delve into ESP educators' subjective experiences during this transition. Given their unique role at the intersection of language and disciplinary instruction—and the cognitive complexity introduced by AI integration—qualitative insights are essential to capture the emotional and intellectual dimensions of their adaptation journey. Existing research often overlooks factors such as teachers' perceptions of AI's role in T&R activities or contextual influences on their engagement. This gap constrains the development of targeted strategies for ESP teachers in AI-rich environments.

By foregrounding their voices, this study seeks to bridge this divide, elucidating how AI can transform cognitive challenges into opportunities for professional growth.

3 Methodology

This study adopted a qualitative research paradigm, anchored in a phenomenological approach, to deeply explore ESP teachers' subjective experiences of cognitive load and adaptation strategies within AI-driven T&R contexts. Phenomenology emphasizes uncovering the essential structures of phenomena through participants' lived experiences (Van et al., 2005), aligning with this study's focus on teachers' cognitive dynamics during technological integration. To enhance methodological rigor, narrative inquiry elements were incorporated, inviting teachers to reconstruct their journeys of technology adoption and professional growth through storytelling (Braun & Clarke, 2022). For instance, during interviews, teachers not only described manifestations of cognitive load but also recounted pivotal moments (e.g., initial struggles or breakthroughs with AI tools), revealing the emotional and intellectual evolution underlying their adaptation.

3.1 Participants and sampling

Twelve ESP teachers specializing in Business English from Chinese universities participated in the study. Purposeful sampling was employed, with selection criteria including: 1)Experience: At least three years of ESP teaching. 2)AI Usage: Active integration of AI tools (e.g., DeepSeek, ChatGPT, or discipline-specific platforms) into T&R activities within the past year. 3)Consent: Voluntary participation with signed informed consent forms.

Participants ranged in age from 28 to 45, with eight female and four male teachers. Their expertise spanned international trade, cross-cultural communication, and business negotiation. Sampling continued until data saturation—the point where new data no longer generated novel themes (Braun & Clarke, 2022).

3.2 Data collection

Data were collected using triangulation, a combination of in-depth interviews, focus groups, and document analysis. First, each teacher participated in 1-2 semi-structured interviews, each lasting 60-90 minutes. The interview questions centered on three core dimensions: (1) Perceptions of cognitive load (e.g., "What cognitive challenges arise when integrating AI tools?") ;(2) Experience of using AI tools (e.g., "What features significantly reduced your workload?") ; (3) Adaptation process (e.g., How do you balance technology use with cognitive resource allocation?") . The interviews were audio-recorded and transcribed verbatim, resulting in approximately 200 pages of text data. Second, two focus group discussions (5-6 participants per group) facilitated collective reflection on shared challenges (e.g., "Has AI altered your perception of the 'teacher's role'?") , and captured the collective experience behind individual differences (Nowell et al., 2017). Finally, teachers' design documents for T&R activities (e.g., AI-generated lesson plans, instructional reflection journals, and notes on technology use) were were collected to triangulate interview findings.

3.3 Data analysis

Data were analyzed using Thematic Analysis, following the six-stage process proposed by Braun and Clarke (2022): (1) Familiarization: repeated readings of the transcribed text and documentation; (2) Generation of Initial Codes: open coding of the data segments using NVivo 12 software (e. g., “Technology learning anxiety”, ‘tool dependency’, ‘cognitive resource redistribution’); (3) Theme construction: clustering related codes to form potential themes (e.g., ”turning point from overload to empowerment (3) Theme construction: clustering related codes to form potential themes (e.g., “from overload to the turning point of empowerment”); (4) Theme review: revising the structure and boundaries of the themes through team discussion; (5) Theme naming and definition; (6) Report writing.

For example, the theme “AI’s Dual Impact on Cognitive Load” encompassed subthemes such as “initial adaptation burdens” and “long-term efficiency gains,” illustrated by contradictions in teacher narratives (e.g., “At first, AI felt like an extra burden, but after three months, I couldn’t teach without it”). Reflective memos were maintained throughout to document analytical decisions and potential biases, enhancing credibility (Tracy, 2024).

3.4 Ethical considerations

Ethical considerations were integrated throughout the research process. First, the study protocol was reviewed by the ethics committee of the host institution (approval number: IRB-2024-ESP-AI-01) to ensure compliance with the principles of the Declaration of Helsinki. Participants signed an informed consent form, which clearly informed them of the purpose of the study, the use of the data, and their right to withdraw. Second, all audio recordings and text data were anonymized, code names (e.g., T1-T12) were used in place of real names, and sensitive information (e.g., names of institutions, student information) was deleted or blurred in transcription. In addition, the researcher used active listening and non-judgmental feedback strategies during the interviews to avoid making value judgments about participants' experiences (Bhattacherjee, 2021). At the end of the data analysis, preliminary findings were returned to some participants through Member Checking to confirm the accuracy of their representations and to correct possible misunderstandings (Flick, 2022).

4 Results

Through thematic analysis of interviews, focus groups, and supplementary materials, the researcher observed a complex adaptation process among ESP teachers as they navigated AI-driven T&R activities. This journey began with pronounced cognitive overload, evolved through experimentation, and culminated in empowerment, mediated by individual and contextual factors.

4.1 Initial cognitive overload

Prior to AI adoption, participants universally reported feeling overwhelmed by cognitive demands, primarily stemming from technical unfamiliarity and time constraints. Teachers specializing in medical and business English emphasized the added strain of mastering new technologies alongside domain-specific content. For example, a medical English teacher stated:

> "I'm already struggling to keep up with the latest medical research. Learning a new tool felt impossible at first."

Focus group discussions echoed this sentiment, revealing that pre-existing workloads and limited technical literacy exacerbated perceived burdens. Teachers described AI as a “double-edged sword”—initially perceived as an additional task rather than a solution. These narratives established a baseline of cognitive saturation, setting the stage for subsequent adaptation efforts.

4.2 Adaptation through trial and error

As teachers began integrating AI tools, their adaptation process unfolded through cautious experimentation and iterative problem-solving. Many initially employed AI for discrete tasks, such as automated lesson planning or student feedback analysis, to alleviate prior pressures. A business English teacher noted:

> "Using AI for case studies cut my prep time in half."

However, this phase was marked by challenges: technical glitches (e.g., erroneous AI-generated assessments), steep learning curves, and occasional disillusionment. One participant recalled:

> "The first time I used AI to grade essays, half the feedback was inaccurate. It took longer to fix than grading manually!"

To mitigate these issues, teachers developed adaptive strategies, such as peer collaboration in focus groups or incremental tool mastery (e.g., starting with basic features before advancing to complex functions). These efforts aligned with findings on technology adoption in education (Chen et al., 2022). Despite initial frustrations, this phase planted seeds of optimism, as teachers gradually recognized AI's potential to streamline workflows.

4.3 Empowerment through training and design

A critical turning point emerged when structured support mechanisms enabled teachers to transform cognitive overload into empowerment. Professional development programs played a pivotal role. A medical English teacher shared:

"After attending AI workshops, I stopped seeing tools as obstacles. They became allies."

Redesigned T&R activities further facilitated this shift. For instance, AI-driven tasks like classroom simulations or data-informed research projects allowed teachers to reallocate cognitive resources from administrative tasks to creative pedagogy. One participant enthused:

"Real-time student analytics let me adjust lessons instantly. It's liberating!"

Focus group data corroborated these sentiments, with teachers reporting reduced stress, heightened efficiency, and renewed job satisfaction—findings consistent with studies on technology-enhanced teacher agency (Huang & Chen, 2023). These results underscore how external support and intentional design catalyzed cognitive reconfiguration.

4.4 Individual and contextual variability

The adaptation trajectory varied significantly across participants, shaped by individual traits and institutional contexts. Younger, tech-savvy teachers embraced AI rapidly, leveraging its functionalities enthusiastically. In contrast, older teachers adopted a more cautious approach, requiring extended adaptation periods—a pattern aligning with generational technology adoption trends (Akyıldız & Ahmed, 2021).

Disciplinary differences also mediated experiences. Business English teachers praised AI's analytical capabilities (e.g., market trend simulations), while medical English teachers criticized tools' inability to grasp clinical terminology. One participant lamented:

"The AI kept misinterpreting medical jargon. I spent hours correcting outputs."

Institutional resources further influenced outcomes. Teachers at well-funded universities benefited from robust training and infrastructure, whereas those at smaller institutions faced systemic barriers. A participant from a rural college noted:

"We lacked both training and technical support. It felt like we were left behind."

These variations highlight that while the transition from overload to empowerment was a shared directional trend, its pace and quality depended on personal adaptability and environmental affordances.

5 Discussion

The findings of this study illuminate a discernible trajectory among ESP teachers in adapting to AI-driven T&R activities, a process interpretable through the lens of CLT. CLT posits that cognitive load comprises three dimensions: intrinsic (task complexity), extraneous (inefficient design), and germane (meaningful knowledge integration) (Sweller et al., 1998). Initially, teachers grappled with heightened extraneous load—stemming from technical unfamiliarity and time constraints—which compounded their existing cognitive demands. Over time, however, structured training and redesigned T&R activities reduced this extraneous burden, enabling teachers to reallocate cognitive resources toward germane efforts, such as innovating pedagogical strategies or refining discipline-specific content. This transition from overload to empowerment aligns with CLT's premise: minimizing extraneous load while fostering germane engagement enhances cognitive efficacy. These results suggest that AI, when strategically integrated, can transform cognitive challenges into catalysts for professional growth.

This study both extends and challenges prevailing narratives about AI's role in teacher development. While existing research predominantly highlights AI's capacity to enhance efficiency or student outcomes in general education (Chen et al., 2022; Wang & Zhang, 2020), such studies often overlook teachers' subjective experiences, particularly in specialized domains like ESP. By foregrounding ESP teachers' voices, this work addresses a critical gap, demonstrating how AI alleviates extraneous load (e.g., automating repetitive tasks) while amplifying germane efforts (e.g., fostering pedagogical creativity)—a finding that resonates with Huang and Chen's (2023) emphasis on training efficacy. However, the study also complicates overly optimistic views of AI by revealing tangible barriers, such as tool inaccuracies or disciplinary mismatches, which are seldom documented in broader surveys (Hong & Guo, 2025). These insights underscore the necessity of contextualized, teacher-centered approaches to AI integration.

The findings offer actionable strategies for ESP teachers, institutions, and policymakers: 1)Integrate AI Training into Professional Development: Structured workshops can mitigate initial adaptation burdens, as evidenced by teachers who transitioned from resistance to proficiency post-training. 2)Design Discipline-Specific AI Tools: Tailored solutions (e.g., medical terminology-aware systems) are critical to address domain-specific challenges and reduce extraneous load. 3) Foster Collaborative T&R Communities: Peer-driven knowledge sharing, as observed in focus groups, can accelerate problem-solving and reduce feelings of isolation. 4)Prioritize User-Centric AI Design: Tools must balance automation with teacher autonomy to prevent over-reliance and preserve pedagogical agency. These recommendations align with Liu et al.' s (2021) call for AI systems that augment—rather than replace—teacher expertise, ensuring technology serves as an enabler rather than a disruptor.

While this study provides rich qualitative insights, several limitations warrant caution. The small, regionally specific sample (12 teachers from Chinese universities) limits generalizability to broader ESP contexts, such as vocational training or under-resourced institutions. Reliance on self-reported experiences introduces potential recall inaccuracies or socially desirable responses (Peel, 2020). The cross-sectional design captures adaptation snapshots but not longitudinal dynamics, such as how cognitive load evolves over years of AI use.

To advance this research, future studies should prioritize expanding participant diversity by engaging ESP teachers across disciplines (e. g., law, engineering) and institutional contexts (e. g., rural schools, vocational training centers), ensuring findings reflect broader educational realities. Mixed-methods approaches—combining qualitative narratives with quantitative metrics such as cognitive load scales, time-tracking data, and student performance indicators—could triangulate insights and enhance validity. Longitudinal designs are critical to map how teachers' cognitive strategies and AI tool usage evolve over years, capturing adaptive trajectories beyond initial adaptation phases. Additionally, cross-cultural comparisons (e. g., contrasting Eastern and Western pedagogical systems) would elucidate how cultural and institutional factors shape AI integration. These directions collectively aim to refine our understanding of AI's role in teacher cognition and inform equitable, sustainable support systems for ESP educators globally.

This study reveals that AI's impact on ESP teachers is neither uniformly positive nor inherently disruptive. Rather, its value lies in how it is strategically embedded within supportive ecosystems. By reducing extraneous load and nurturing germane engagement, AI can empower ESP teachers to transcend cognitive saturation and embrace their roles as innovators at the intersection of language and discipline. However, this potential hinges on context-sensitive design, continuous professional support, and a commitment to amplifying teachers' agency in the AI era.

About the Author

Chunyan Peng was born in Xinyang, China, in December 1979. She is currently an Assistant Professor of English Language at Zhejiang Yuexiu University, where her research focuses on American literature and language pedagogy, with a particular emphasis on integrating literary analysis into second-language teaching.

References

[1] Akyıldız S. T., & Ahmed K. H. (2021). An overview of qualitative research and focus group discussion. International Journal of Academic Research in Education, 7(1), 1-15.

[2] Belcher D. (2006). English for specific purposes: Teaching to perceived needs and imagined futures in worlds of work, study, and everyday life. TESOL Quarterly, 40(1), 133–156.

[3] Bhattacherjee A. (2021). Social science research: Principles, methods, and practices (3rd ed.). Global Text Project.

[4] Bond M., Marín V. I., Dolch C., Bedenlier S., & Zawacki-Richter O. (2020). Digital transformation in German higher education: Student and teacher perceptions and usage of digital media. International Journal of Educational Technology in Higher Education, 17(1), 1–20.

[5] Borg S. (2010). Language teacher research engagement. Language Teaching, 43(4), 391–429.

[6] Braun V., & Clarke V. (2022). Thematic analysis: A practical guide (2nd ed.). SAGE Publications.

[7] Chen X., Li J., & Zhang Y. (2022). The impact of AI-driven tools on language teachers' workload and efficiency. Journal of Educational Technology, 38(4), 567–582.

[8] Dudley-Evans T., & St John M. J. (1998). Developments in English for specific purposes. Cambridge University Press.

[9] Eatough V., & Smith J. A. (2017). Interpretative phenomenological analysis. The Sage handbook of qualitative research in psychology, 193-209.

[10] Flick U. (2022). The SAGE handbook of qualitative research design. SAGE Publications.

[11] Holmes W., Bialik M., & Fadel C. (2019). Artificial intelligence in education: Promises and implications for teaching and learning. Center for Curriculum Redesign.

[12] Hong X., & Guo L. (2025). Effects of AI-enhanced multi-display language teaching systems on learning motivation, cognitive load management, and learner autonomy. Education and Information Technologies, 1-35.

[13] Huang L., & Chen Q. (2023). AI-enhanced teacher training: Personalization and its effects on professional development. Teaching and Teacher Education, 119, 103856.

[14] Hutchinson T., & Waters A. (1987). English for specific purposes: A learning-centred approach. Cambridge University Press.

[15] Kalyuga S. (2011). Cognitive load theory: How many types of load does it really need? Educational Psychology Review, 23(1), 1 – 19. https://doi.org/10.1007/s10639-010-9132-6

[16] Luckin R., Holmes W., Griffiths M., & Forcier L. B. (2016). Intelligence unleashed: An argument for AI in education.

[17] Mayer R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press.

[18] Nowell L. S., Norris J. M., White D. E., & Moules N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. International Journal of Qualitative Methods, 16(1), 1–13.

[19] Paas F., Renkl A., & Sweller J. (2003). Cognitive load theory and instructional design: Recent developments. Educational Psychologist, 38(1), 1–4.

[20] Peel K. L. (2020). A beginner's guide to applied educational research using thematic analysis. Practical Assessment Research and Evaluation, 25(1).

[21] Sweller J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285.

[22] Sweller J., & van Merriënboer J. J. G. (2005). Cognitive load theory and complex learning: Recent developments and future directions. Educational Psychology Review, 17(2), 147–177.

[23] Selwyn N. (2016). Is technology good for education? Polity Press.

[24] Tracy S. J. (2024). Qualitative research methods: Collecting evidence, crafting analysis, communicating impact. John Wiley & Sons.

[25] Van Merriënboer J. J. G., & Sweller J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. Educational Psychology Review, 17(2), 147–177.

[26] Wang Q., & Zhang L. (2020). AI adoption in education: Cognitive load and teacher readiness. Computers & Education, 155, 103934.