CSCanada
Canadian Social Science
Vol. 21, No. 6, 2025, pp. 1-4
DOI:10.3968/13937

ISSN 1712-8056[Print]
ISSN 1923-6697[Online]
www.cscanada.net
www.cscanada.org

Virtual Coworker and Intelligent Tutor: Research on AI Agent-Driven Innovation in Contextualized Teaching Models for Higher Vocational Education

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Received 11 August 2025; accepted 19 October 2025
Published online 26 December 2025

Abstract

Higher vocational education has long grappled with the structural dilemma of the schism between the "school field" and the "work field." Traditional skills training often prioritizes the replication of operational procedures while neglecting the complexity of social interactions inherent in professional scenarios. With the maturation of AI Agent technology empowered by Large Language Models (LLMs), a digital subject capable of simulating autonomous behavior, memory, and planning has become feasible. Grounded in social constructivism—specifically Situated Learning and Cognitive Apprenticeship theories—this paper proposes a dual-agent pedagogical model comprising a "Virtual Coworker" and an "Intelligent Tutor." This model aims to re-"contextualize" the learner's cognitive process by constructing a high-fidelity network of professional social relations. Through horizontal collaborative interaction and vertical expert guidance, it facilitates the transformation from mere knowledge acquisition to the generation of professional competency.

Key words: AI agent; Social constructivism; Situated learning; Higher vocational education; Virtual coworker

Chen, J. Y. (2025). Virtual Coworker and Intelligent Tutor: Research on AI Agent-Driven Innovation in Contextualized Teaching Models for Higher Vocational Education. *Canadian Social Science, 21*(6), 1-4. Available from: http://www.cscanada.net/index.php/css/article/view/13937
DOI: http://dx.doi.org/10.3968/13937

1. INTRODUCTION

Higher vocational education is characterized by a distinct career orientation. Its talent cultivation paradigm of "school-enterprise cooperation and work-integrated learning" (Jiang, 2009) dictates that the educational process cannot remain at the level of skills training but must essentially be a dual variation of individual socialization and professionalization. However, current vocational teaching practices face a severe predicament of "Decontextualization." Although technologies such as Virtual Reality (VR) and Augmented Reality (AR) have resolved issues regarding equipment attrition and high risks in training through high-fidelity simulation, they often fall into the trap of "technological rationality" that prioritizes objects over people: they construct a "sterile" operational space where physical attributes are highly simulated, but social attributes are stripped away.

In authentic occupational fields, problem-solving is never an isolated execution of algorithms but is embedded within complex networks of social relations. Workers must not only interact with machines but also collaborate with colleagues, communicate with superiors, and achieve goals through the "negotiation of meaning" amidst conflicts. As Vygotsky's sociocultural theory posits, higher psychological functions originate from social interaction (Gao, 2021). Lacking this social "scaffolding," students' skill acquisition remains at the operational level, making it difficult to internalize into professional literacy capable of coping with complex variables.

In light of this, Generative AI, particularly AI Agents possessing capabilities for autonomous planning, memory storage, and tool utilization, offers a new opportunity to reconstruct the "social context" of vocational teaching. Unlike the "environmental simulation" of traditional VR/AR and passive question-answering systems, AI Agents possess anthropomorphic Agency, characterized by autonomy, reactivity, proactivity, and sociality (Liu, et al.,

2024). This paper aims to explore the introduction of AI Agent technology to reconstruct the situational field of vocational teaching. By designing the dual roles of "Virtual Coworker" and "Intelligent Tutor," we seek to replicate authentic professional social relations in digital space, thereby exploring a new path for contextualized teaching aligned with social constructivist principles.

2. THEORETICAL PERSPECTIVE: METAPHORICAL RECONSTRUCTION OF LEARNING UNDER SOCIAL CONSTRUCTIVISM

2.1 Situated Learning and Legitimate Peripheral Participation

The theory of Situated Learning, proposed by Jean Lave and Etienne Wenger, argues that learning is not a static accumulation of knowledge concepts within an individual's brain, but a process of "Legitimate Peripheral Participation" (LPP) (Zhang, et al., 2005). Learners enter a "Community of Practice" and move from the periphery toward the center. Through interactions with "old-timers" and peers, they acquire the language, norms, and tacit knowledge of that community.

In traditional digital teaching, the computer acts as a "transmitter of various knowledge." Under the framework constructed in this paper, the AI Agent is no longer a retrieval interface for a knowledge base but a "community member" with a social identity, capable of perceiving the environment and executing corresponding actions (Xu, et al., 2021). The interaction between student and Agent is no longer an exchange of human-machine commands but a social engagement based on professional identities. This engagement endows the learning process with "situatedness," allowing knowledge to be dynamically constructed within application scenarios.

2.2 Dynamic Remeasurement of the Zone of Proximal Development (ZPD)

Vygotsky's concept of the "Zone of Proximal Development" defines the gap between a student's current level and the potential level achievable under adult guidance or in collaboration with more capable peers (Ma, et al., 2004). Traditional ZPD intervention relies on the acute observation of human teachers, which is difficult to implement precisely in large-scale classroom settings.

AI Agents, with their powerful context understanding and real-time data processing capabilities, can act as that "more capable peer" or "guide." Crucially, LLM-based Agents can perceive students' emotional shifts (Liu, et al., 2024), logical discontinuities, and skill bottlenecks, thereby dynamically adjusting intervention strategies—ranging from direct scaffolding to intentional "feigning of weakness" to stimulate student reflection. This dynamism transforms the ZPD from a static interval into a fluid, personalized interaction field.

3. MODEL CONSTRUCTION: A CONTEXTUALIZED TEACHING SYSTEM BASED ON DUAL-AGENT ARCHITECTURE

Based on the theoretical logic, this study proposes a dual-Agent collaborative teaching model. This model is not a mere accumulation of technology but a digital mapping of the authentic "apprentice-coworker-master" triangular relationship in the workplace.

3.1 Role One: "The Virtual Coworker" Horizontal Collaboration and Perturbation

In the real workplace, peer interaction constitutes most of the communication. The design goal of the "Virtual Coworker" Agent is not to provide standard answers but to simulate a "colleague" with a specific personality, skill level, and even flaws.

· **Functional Positioning:** It serves as the student›s partner in virtual tasks, possessing an independent Behavior Tree and long-term memory.

· **Interaction Logic:** It may offer constructive suggestions during collaboration, commit errors due to «carelessness,» or even display «emotions» due to uneven task distribution. For instance, in automotive repair training, the Virtual Coworker might hand over the wrong wrench or propose a hypothesis for a malfunction that seems plausible but is actually incorrect.

· **Pedagogical Significance:** This design aims to force students to abandon blind faith in authority, verify the coworker›s behavior through critical thinking, and correct deviations through communication and coordination. This embodies the «social negotiation» in social constructivism—truth is not preset but dialectically generated in interaction.

3.2 Role Two: "The Intelligent Tutor" — Vertical Metacognitive Scaffolding

Distinct from the "eye-level" perspective of the Virtual Coworker, the "Intelligent Tutor" Agent represents a "core member" or "expert" in the community of practice.

· **Functional Positioning:** It monitors the entire task flow but does not easily intervene in specific operations. It focuses on the student›s Metacognitive Strategies.

· **Interaction Logic:** The Intelligent Tutor intervenes when the student and Virtual Coworker reach an impasse or when a safety error is imminent. Its intervention follows the «modeling-coaching-fading» principle of cognitive apprenticeship. Initially, it guides student thinking through Socratic Questioning; as student ability improves, its intervention frequency decreases until it remains merely an observer.

· **Data Insight:** The Intelligent Tutor also assumes the role of an evaluator. It analyzes not the correctness of the final result, but the decision-making path, information retrieval capability, and communication efficiency with the coworker during the problem-solving process.

3.3 Scene Generator: Generative Task Flow

The foundation of dual-Agent operation is a dynamically generated environment. Leveraging Generative AI, the teaching system no longer relies on fixed scripts. For example, in nursing education, the system can randomly generate a case of a virtual patient with "poor compliance and sudden complications." The Virtual Coworker (nurse partner) may make operational errors due to panic, while the Intelligent Tutor (head nurse) observes, providing guidance only at critical moments. This non-deterministic situation maximizes the reproduction of the complexity of real work.

3.4 Operating Mechanism: From "Command Interaction" to "Negotiation of Meaning"

The core of this model lies in changing the nature of human-computer interaction. Traditional CAI (Computer-Assisted Instruction) is linear: System poses question -> Student answers -> System grades. In contrast, interaction under the dual-Agent model is reticular and cyclical.

Table 1
Contrasting Interaction Mechanisms Between Traditional Digital Teaching and Dual-Agent Contextualized Teaching Systems

Interaction Dimension	Traditional Digital Teaching	Dual-Agent Contextualized Teaching	Theoretical Correspondence
Interlocutor	Interface, Item Bank	Intelligent Agent with Social Role	The Other
Content	Determinate Knowledge Points	Indeterminate Problem-Solving Process	Negotiation of Meaning
Error Handling	Instant Correction, Deduction	Tolerance of Error, Feedback via Consequences	Trial & Error, Reflection
Knowledge Form	Explicit Knowledge	Tacit Knowledge & Process Knowledge	Embodied Cognition

Under this mechanism, the student first receives a task (e.g., precision component machining). They must discuss the process route with the "Virtual Coworker." If the route proposed by the student carries hidden dangers, the coworker may question it or follow blindly (depending on the coworker's settings). During machining, if parameter deviations occur, the Intelligent Tutor will not alert directly but will observe whether the student can identify the problem through the coworker's feedback (e.g., the coworker complaining that "the sound is wrong"). This mechanism forces students to mobilize multimodal sensory and comprehensive judgment rather than rote memorization of operating procedures.

4. PRACTICAL VALUE AND REFLECTION ON LIMITATIONS

4.1 Pedagogical Value: Reshaping the Path of Professional Literacy Generation

The greatest value of the model proposed in this study lies in enhancing the effectiveness and efficiency of "soft skills" training in higher vocational education. Through gaming with the "Virtual Coworker," students acquire not only hard skills but also implicit professional qualities such as communication, collaboration, conflict management, and responsibility sharing. As an all-weather, tireless practice partner, the AI Agent greatly expands the temporal and spatial boundaries of situated learning, making large-scale personalized "apprenticeship" possible.

4.2 Limitations and Ethical Challenges

Naturally, we must view this technological application with prudence.

· **Hallucination Risk:** AI Agents may generate plausible but incorrect information («hallucinations»). In high-stakes teaching fields like medicine or chemical engineering, such misleading information can be fatal (Zhao, et al., 2023). Therefore, strict Retrieval-Augmented Generation (RAG) and expert review mechanisms must be introduced into the Agent architecture.

· **Alienation of Emotional Interaction:** Although Agents can simulate human emotional feedback, this remains a mimicry generated by algorithms. Long-term interaction with virtual subjects may lead students to underestimate the complexity of real human social interaction, or even cause psychological discomfort associated with the «Uncanny Valley» effect.

· **Algorithmic Bias and Discrimination:** If Agent role settings are based on biased training data, they may inadvertently reinforce gender stereotypes or concepts of power inequality in the workplace (Bi, 2023). This requires educators to conduct strict ethical alignment during the model fine-tuning stage.

5. CONCLUSION

Technology is not merely a tool; it simultaneously reshapes our understanding of "learning" itself. Introducing AI Agents into contextualized higher vocational teaching is not a simple digital substitution for the traditional apprenticeship system, but an innovation of the educational paradigm based on social constructivism. By ensuring the dual presence of the "Virtual Coworker" and "Intelligent Tutor," we construct a digital community of practice capable of social tension.

In this community, knowledge is no longer a static stock but a flow dynamically generated amidst

collaboration, conflict, and reflection. Despite facing dual challenges of technology and ethics, this exploration undoubtedly provides a highly potential path for solving the persistent ailment of the disconnect between "learning and using" in higher vocational education. Future research should further focus on the optimization of multi-agent collaborative mechanisms and the evaluation of long-term empirical effects, with the aim of allowing intelligent technology to truly empower the comprehensive development of human beings.

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