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Metacognition Centered Project-Based Learning Design for Human-AI Collaborative Skills Training

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Abstract: The article explores the impact of digital transformation on the labor market, emphasizing the importance of human-AI collaborative abilities in the digital age. According to new trends in human-AI collaboration, metacognitive skills, human-AI communication abilities, and ethical responsibility will become the three core competencies. The article highlights that Project-Based Learning is an effective method for developing these capabilities. Project-Based Learning promotes self-reflection, effective communication, and ethical judgment skills in students through real-world contexts and inquiry-based learning. Furthermore, the article elaborates on incorporating metacognitive training into PjBL design to enhance students' learning outcomes and adaptability, equipping them for future work environments. By embedding these elements into educational practices, the article argues that students will be better prepared to navigate the complexities of working alongside AI in various professional settings.

1. Background

Digital transformation has profoundly reshaped the occupational structure of the global labor market through automation and technological innovation [1]. Firstly, it has led to a reduction in low-skilled and repetitive jobs, as these tasks are more easily replaced by machines and algorithms. Meanwhile, the demand for high-skilled and creative professions has increased, as these roles require complex human thinking and innovative capabilities. Additionally, digital transformation is also giving rise to emerging industries and professions, particularly in the fields of technology, data science, and online services. In order to adapt to these changes, workers need to continuously enhance their skills, especially their human-AI collaborative abilities, to remain competitive in the digital economy.

2. Human-AI Collaboration

In this paper, human-AI collaborative (HAC) ability refers to the capability of humans and AI systems working together to solve complex problems [2]. There are two key points to note: First,

collaboration means elevating AI to the role of a team member [3], rather than merely using it as a tool to complete specific tasks as was done in the past. As the intelligence level of AI increases, it can take on tasks in areas where it excels, thus emphasizing the importance of this collaborative relationship. Second, HAC differs from human-human collaboration. In the human-AI dynamic, humans remain in a leading role and are responsible for the outcomes of problem-solving.

Considering these aspects, the core elements of human-AI collaborative abilities must include metacognitive skills, human-AI communication capabilities, and ethical responsibility. Metacognitive skills enable humans to self-reflect and regulate their cognitive processes, which is crucial for understanding and managing interactions with AI systems. Human-AI communication capacity emphasizes effective interaction between humans and AI, including clear expression and comprehension, ensuring that both parties can share information and work together. Ethical responsibility involves moral guidelines, accountability, and behavioural norms within the HAC process, ensuring that the application of technology aligns with societal values and promotes sustainable development. These three aspects collectively build a HAC framework.

3. Metacognition

Metacognition, in essence, refers to the process of "thinking about one's own thinking," involving the awareness and understanding of one's cognitive processes [4].

The fundamental elements of metacognition include metacognitive knowledge and metacognitive regulation. Metacognitive knowledge encompasses declarative knowledge (awareness of one's cognitive capabilities), procedural knowledge (knowledge of how to implement strategies), and conditional knowledge (understanding when and why to apply certain strategies). Metacognitive regulation, on the other hand, involves planning (setting goals and selecting strategies), monitoring (awareness of understanding and task performance), and evaluating (assessing the effectiveness of strategies and processes) [5].

Metacognition is pivotal to the enhancement of HAC capacities [6], as it enables individuals to reflect upon and optimize collaboration and task distribution with AI systems. Individuals with metacognitive awareness can clearly identify the limitations of both AI and themselves, thereby establishing effective mental models and behavioural frameworks [7], appropriately relying on AI, and engaging in effective communication. Furthermore, metacognition aids individuals in considering ethical responsibility in decision-making, leading to more judicious choices.

4. Project-based Learning

Project-based learning (PjBL) is defined as a student-centred instructional approach grounded in three constructivist principles: learning is context-specific, learners actively engage in the learning process, and they achieve their goals through social interaction and knowledge sharing [8]. PjBL is regarded as a specific type of inquiry-based learning, where the context for learning is provided through authentic problems and practices, leading to meaningful learning experiences. The uniqueness of PjBL lies in its ultimate production of a "concrete artifact," which represents students' new understanding, knowledge, and attitudes regarding the issue under investigation.

In relation to the characteristics of HAC abilities, PjBL is an exceptionally effective training method. Firstly, the complexity of PjBL problems necessitates the complementary strengths of humans and AI, effective communication, iterative feedback, and rational task allocation. Particularly when AI lacks contextual understanding, humans need to share information with it, posing a challenge to human-AI communication abilities. Secondly, PjBL, as an inquiry-based learning approach, requires humans to possess metacognitive skills to reflect on and understand not only themselves but also the operations of human-AI teams. The requirement to deliver a final

artifact in PjBL also demands ethical responsibility and judgment. In contrast, theoretical instruction is inadequate in cultivating HAC, as it typically relies on passive learning, emphasizing the transmission and memorization of knowledge while neglecting practical application and interaction, thus limiting students' development in cognitive and executive capacities.

5. Project-based Learning Design

The design process of PjBL typically involves identifying the theme and learning objectives, presenting a driving question that can engage students' interest, and breaking down the project into different phases to guide students through step-by-step completion. Throughout this process, it is essential to provide ample resources and technical support, project guidance or other roles (which can be performed by the teacher), timely feedback, and finally, arrange for students to present and share their results. After the project's conclusion, it is crucial to conduct a summary reflection to improve future PjBL design and implementation.

When designing PjBL for HAC, special attention should be given to metacognitive training. This means incorporating training for metacognitive knowledge and metacognitive regulation at appropriate stages of the project.

The following presents a case study to illustrate a typical instructional design.

5.1. Case Project Overview

Students will collaboratively design a market survey questionnaire for a campus coffee shop with the assistance of AI.

5.2. Case Project Objective

The essential objective is to enhance HAC skills through working alongside AI.

5.3. Case Driving Question

"How can we design an effective market survey questionnaire to help the campus coffee shop better understand students' needs and preferences?"

5.4. Case Project Structure

The following Table 1 indicates the project structures, as well as a scoring paper for each student. Students fill in their self-assessment (Metacognition) scores and document the content of their interactions with AI and other human roles. If difficulties arise, an observing teacher can assist in recording this information.

An iterative self-evaluation is scheduled to make students aware that they may have biases in their self-perceptions. This process also aids students in genuinely mastering information from their collaboration with AI, rather than simply glossing over it. The quality of the tasks completed by students reflects their level of understanding and mastery of knowledge and skills. If this level differs significantly from their self-evaluation scores, it indicates a relatively low metacognitive level. Students can initiate dialogue with AI at any time or consult human roles, such as teachers, clients, or relevant individuals. Whether and how effectively students initiate these dialogues will serve as observational criteria for evaluating their communication abilities with AI and their level of ethical responsibility.

Table 1: PjBL design for HAC training

Phrase	Task	Pre-Self-assessment Score [0-10]	Optional action of talking with AI	Optional action of talking with human roles	Post-Self-assessment Score [0-10]
Preparation	To understand the basic concepts, categories, applications etc.				
	To collect context information, requirements from customers				
Design	To understand design methods, process, criteria				
	To design a questionnaire with AI together				
Testing	To understand how to test a survey				
	To understand how to analyse a survey				
	To execute a data analysis on a survey				
Implementation	To understand how to implement a formal survey				
Reporting	To understand how to write marketing investigation report				
	To write the final report with AI				

5.5. PjBL Assessment

Based on the scores in Table 1 and observations of the students, teachers can conduct a comprehensive assessment of the students from the following three aspects, as shown in Table 2.

Table 2: PjBL / HAC Assessment

Student ID	Metacognition score [0-10]	Human-AI communication score [0-10]	Ethical responsibility score [0-10]
1			
2			

6. Conclusion and Future Research

Based on the definition of HAC abilities, elements of metacognition, and the instructional characteristics of PjBL, this paper innovatively designs a metacognition-centred PjBL approach to train HAC. Its distinguishing feature is the incorporation of two iterative self-evaluations to enhance metacognitive levels throughout the various phrases of PjBL. This design can be extended to

various application scenarios, including but not limited to AI+writing, AI+painting, and AI+programming. By improving their metacognitive abilities, students are likely to collaborate more effectively with AI, continually enhance communication in HAC, and foster individual ethical responsibility.

Cultivating HAC abilities is a highly promising direction. This study will continue to implement the aforementioned instructional methods in the college, gathering more feedback from teachers and students to optimize PjBL design and evaluation methods. With accumulated experience, the development of a corresponding training system could potentially be launched, offering resources to anyone seeking to improve their HAC skills.

References

[1] Kolade, O., & Owoseni, A. (2022). Employment 5.0: The work of the future and the future of work. Technology in Society, 71, 102086.

[2] Memmert, L., & Bittner, E. (2022). Complex problem solving through human-AI collaboration: literature review on research contexts. Proceedings of the 55th Hawaii International Conference on System Sciences, 378-387.

[3] Siemon, D. (2022). Elaborating team roles for artificial intelligence-based teammates in human-AI collaboration. Group Decision and Negotiation, 31(5), 871-912.

[4] Lai, E. R. (2011). Metacognition: A literature review. Always learning: Pearson research report, 24, 1-40.

[5] Nelson, T. O., & Narens, L. (1994). Why investigate metacognition? In J. Metcalfe & A. Shimamura (Eds.), Metacognition: Knowing about knowing. Cambridge, MA: The MIT Press, 1-25.

[6] Sidra, S., & Mason, C. (2024, June). Reconceptualizing AI Literacy: The Importance of Metacognitive Thinking in an Artificial Intelligence (AI)-Enabled Workforce. In 2024 IEEE Conference on Artificial Intelligence (CAI) (pp. 1181-1186). IEEE.

[7] Cabrera, Á. A., Perer, A., & Hong, J. I. (2023). Improving human-AI collaboration with descriptions of AI behavior. Proceedings of the ACM on Human-Computer Interaction, 7(CSCW1), 1-21.

[8] Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. Improving schools, 19(3), 267-277.