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Development of a Coding Framework for Cognitive Engagement Based on Online Asynchronous Discussion

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Abstract: Online learning has broken the constraints of time and space, enhancing the quality and accessibility of higher education. However, real-time monitoring and effective assessment of learners' cognitive engagement within online learning environments present a major challenge. Due to variations across different learning contexts, general cognitive engagement coding frameworks increasingly reveal limitations in applicability, underscoring the need to develop context-specific frameworks. Therefore, this study adopts a grounded theory approach, analyzing 180 asynchronous discussion entries from six courses on the Chinese University MOOC. Through bottom-up coding, a three-level indicator system was established. Subsequently, the Delphi method was employed for validation, and the Analytic Hierarchy Process (AHP) was applied to determine indicator weights. The study also found that non-cognitive factors such as emotions and behaviors influence cognitive engagement, while the impact of interaction is somewhat diminished in this context.

Keywords: Online learning, asynchronous discussion, cognitive engagement, coding framework

1. Introduction

With the widespread adoption of asynchronous discussion in online learning and Massive Open Online Courses (MOOCs), the effective and scalable assessment of learners' cognitive engagement has become crucial (Peng et al., 2020). Cognitive engagement refers to a learner's willingness to make an effort to understand content and master skills (Huang et al., 2019). Asynchronous discussion forums serve as the primary space for interaction between learners and instructors (Almatrafi & Johri, 2019), and high-quality discussions have been shown to enhance learners' engagement and academic performance (Galikyan et al., 2021). However, existing cognitive engagement coding frameworks, such as the classic ICAP framework (Chi & Wyile, 2014), are often constructed in a top-down manner (Xu et al., 2023; Rivera et al., 2024). This approach leads to limitations such as coarse granularity (Liu, et al., 2022) and a lack of data-driven objectivity when applied to automated analysis, thereby restricting their practicality and accuracy. These frameworks demonstrate insufficient capability in distinguishing complex cognitive behaviors and struggle to adapt to large-scale, diverse online learning data.

To address this gap, this study aims to develop and validate a novel coding framework for cognitive engagement applicable to online asynchronous discussion contexts. Through a bottom-up grounded theory analysis of authentic MOOC discussion data (Strauss & Corbin, 1990), followed by validation via the Delphi method and weighting using the Analytic Hierarchy Process (AHP) to develop a more fine-grained and context-specific framework. This framework provides a more solid and objective benchmark for future automated cognitive engagement assessment systems, enabling more precise understanding of and support for learners' cognitive states.

2. Methods

This study analyzed 180 authentic asynchronous discussion posts from six diverse courses (covering humanities, social sciences, and STEM) on the Chinese University MOOC platform. A three-stage mixed-methods approach was employed. Firstly, grounded theory was applied, using three-level coding to generate the initial framework. This coding process was validated with substantial inter-coder reliability (Cohen's Kappa = 0.71) and continued until theoretical saturation. Next, two rounds of the Delphi method were conducted, inviting six experts in educational technology to anonymously revise and validate the framework until consensus was achieved. Then, based on expert judgments, the AHP was used to calculate the relative weights of all indicators, ensuring the framework possesses a robust internal structure.

3. The Coding Framework for Cognitive Engagement

The final output of this research is a multi-level coding framework for cognitive engagement. As shown in Table 1, the framework consists of 2 primary, 6 secondary, and 17 tertiary indicators, each with an assigned weight reflecting its relative importance. This fine-grained, multi-level structure enables a comprehensive and differentiated assessment of learners' cognitive engagement in asynchronous discussion, ranging from passive participation to deep knowledge construction.

Table 1. *Cognitive Engagement Coding Framework with Weights*

Primary indicators	Secondary indicators	Tertiary indicators	Description of the tertiary indicators
Multidimensional Orientation (0.326)	Emotional Express (0.130)	Grateful (0.033)	Express gratitude towards teachers and other learners
		Joyful (0.020)	Express joy that arises during the learning process.
		Hopeful (0.026)	Express hopes or aspirations regarding certain expectations.
		Moved (0.052)	A deep understanding and resonance with the statements or emotions of other learners.
	Information Consultation (0.196)	Transactional Consultation (0.078)	Questions regarding the course, system functionality, stability, compatibility, etc.
		Learning-related Consultation (0.117)	Questions regarding the accessibility and availability of learning materials.
Cognitive Orientation (0.674)	Passive (0.060)	Repetition (0.030)	The content of the comments is largely or entirely derived from others.
		Meaning-lessness (0.030)	The content of the comments is devoid of value.
	Active (0.129)	Declarative Statement (0.042)	Learners' direct responses or clear statements to questions or scenarios set by the instructor.
		Autonomous Expression (0.087)	Learners' ability to demonstrate independent thinking and autonomy during the learning process.
	Interactive (0.207)	Response (0.049)	Learners provide explanations or answers to questions posed by other learners.
		Reflection (0.060)	Learners adopt a critical stance toward the views of teachers or other learners.
		Support (0.029)	Learners understand or accept the viewpoints of other learners.
		Extension (0.070)	Building upon others' viewpoints or ideas to expand and elaborate, thereby enriching existing perspectives or proposing new insights or reflections.
	Constructive (0.278)	Transfer (0.071)	Learners apply existing knowledge or concepts to new contexts or fields.
		Application (0.094)	Learners apply newly acquired knowledge, theories, or concepts to real-world situations to support their viewpoints or explain phenomena.
		Output (0.113)	Learners propose original viewpoints, theories, or strategies in discussion.

4. Discussion and Conclusion

A key finding, emerging directly from our bottom-up, data-driven approach, is the significant role of "Multidimensional Orientation" (weight 0.326). Unlike traditional top-down models that often focus exclusively on purely cognitive indicators, our grounded framework reveals that non-cognitive factors, such as "Emotional Express" and "Information Consultation", are integral components of engagement in this online asynchronous context. This finding challenges a narrowly cognitive view and underscores the necessity of a more holistic assessment model.

Notably, within the core "Cognitive Orientation" dimension, "Constructive" activities (0.278) outweigh "Interactive" activities (0.207). This finding offers a significant, context-specific amendment to influential frameworks like ICAP, which often place a heavy emphasis on interaction. It suggests that in the asynchronous, time-displaced environment of MOOC forums, fostering individual knowledge construction (e.g., application, original output) may be a more critical pedagogical lever for enhancing deep cognitive engagement than simply promoting more interaction.

Future research will focus on validating this framework across larger, more diverse datasets to address potential sample bias and enhance its generalizability across various disciplines and learning contexts. This will ultimately provide a robust foundation for developing large-scale, automated cognitive engagement assessment tools through integration with natural language processing (NLP) models.

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