Postprint: Cognitive Strategies in University Students' Online Collaborative Learning

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Abstract

[Purpose/Significance] Analyze dialogue texts in online collaborative learning among university students to identify the cognitive strategies they employ. [Method/Process] Based on an information retrieval course, online collaborative learning tasks were designed, and dialogue records of 30 students during task completion were collected and subjected to coding and analysis. [Results/Conclusions] In the process of online collaborative learning, university students most frequently applied intermediate-level analytical cognitive strategies, followed by low-level intuitive cognitive strategies, while high-level cognitive strategies were rarely applied. The study demonstrates that the application of intermediate- and high-level cognitive strategies is positively correlated with group learning effectiveness.

Full Text

Title and Abstract

The Cognitive Strategies of College Students in Web-Based Collaborative Learning

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Abstract: [Purpose/Significance] This study analyzes dialogue texts from college students' web-based collaborative learning to identify the cognitive strategies employed in collaborative learning. [Method/Process] Based on an information retrieval course, we designed web-based collaborative learning tasks, collected dialogue records from 30 students completing these tasks, and conducted coding and analysis. [Result/Conclusion] In the process of web-based collaborative learning, college students applied middle-level analytical cognitive strategies most frequently, followed by low-level intuitive cognitive strategies, while high-level cognitive strategies were rarely used. The research shows that the application of middle-level and high-level cognitive strategies is positively correlated with group learning effectiveness.

Keywords: web-based collaborative learning; cognitive strategies; content analysis; information behavior
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Introduction

With the rapid development of virtual communities and computer-supported collaborative technologies, users' information behaviors increasingly exhibit social and group-oriented tendencies. Collaborative information behavior has become increasingly common, attracting widespread attention from researchers both domestically and internationally, and gradually emerging as a new hotspot in information science [1]. Collaborative learning behavior is also a form of collaborative information behavior. Web-based collaborative learning refers to the process of using computer networks and multimedia-related technologies to establish a collaborative learning environment where learners discuss, interact, and cooperate on the same learning content to achieve a deeper understanding and mastery of the material [2].

The core of web-based collaborative learning is interaction among group members. Interaction enables knowledge sharing through different perspectives and constitutes the basic unit of activity for stimulating and creating shared knowledge [3]. Interaction is key to understanding the essence of collaborative learning and serves as an important basis for exploring collaborative learning patterns and grasping process changes [4]. Research has shown that interactive learning behavior is a critical factor affecting the quality of collaborative learning [5-6].

Research on interactive behavior in web-based collaborative learning has focused on three aspects: interactive behavior characteristics [7-8], interaction patterns [9-10], and member roles [11-12]. Tian Yongzhen [7] analyzed the interactive behaviors of learning communities on the Knowledge Forum platform using social network analysis and content analysis methods, examining participation levels, positions, core participants, and peripheral participants in the social networks formed through Knowledge Forum interactions. Liu Shufen [8] employed social network analysis to examine network density, centrality, and subgroups in three different periods of MOOC platform discussion communities in China, analyzing how these features evolved throughout the course. She also explored the relationship between interaction quality and academic performance from both quantitative and content perspectives, revealing characteristics and existing problems in online collaborative learning communities. X. Yang et al. [9] studied behavioral sequences in college students' knowledge construction processes through online collaborative translation activities, identifying three main interaction patterns: information sharing, inconsistency detection, and meaning negotiation. They compared high- and low-participation learners' behaviors, highlighting the significant role of social communication in cooperative learning. Li Yanyan et al. [10] analyzed the breadth, cohesion, reciprocity, and participation uniformity of social interactions in online collaborative learning groups, concluding that social interaction investment positively influences group learning performance. Wang Zhe and Zhang Pengyi [11] explored user roles and their behavioral and distribution characteristics in online knowledge collaboration among learning groups. D. Gasevic et al. [12] investigated the role of role assignment in collaborative knowledge construction, finding that explicit role assignment positively impacts learners' knowledge building and effectively promotes high-level group cognition.

Historically, research on collaborative learning interaction analysis has shifted its focus from studying interaction processes to analyzing interaction content. However, research on the cognitive strategies embedded in interactions remains scarce. In fact, learning is an active and positive cognitive process [13]. In collaborative learning contexts, member interactions help learners complement each other's strengths, thereby promoting the improvement of individual cognitive structures and the enhancement of group cognitive levels [14]. Studying collaborative learning interaction behaviors from a cognitive perspective can reveal the core of the collaborative learning process and is therefore particularly important.

This study explores the application of cognitive strategies in college students' web-based collaborative learning to gain insights into complex interactive phenomena. Specifically, it addresses three questions: (1) What cognitive strategies exist in college students' web-based collaborative learning processes? (2) What cognitive characteristics are presented during collaborative learning interactions? (3) Does the application of cognitive strategies affect the final learning outcomes of groups?

2 Basic Theory

2.1 Cognitive Learning Theory

Cognition is the process by which the human brain processes externally input information, including cognitive activities such as perception, memory, thinking, and reasoning [15]. Perception involves the detection, discrimination, and recognition of external information input, including the interpretation and integration of sensory information. Memory is the process by which the brain encodes and stores perceived information and retrieves it when needed. Thinking is a complex, high-level skill that can fill knowledge gaps and represents a search process within problem spaces [16]. Reasoning involves drawing inferences from other information and requires focused thinking.

Information processing theory decomposes the cognitive process into multiple stages associated in certain ways, where each stage is essentially a unit that performs specific processing and operations on input information. Information is transmitted between these units and finally output as useful knowledge to guide individuals in problem-solving and learning completion. Based on information processing theory, the renowned American educational psychologist R. M. Gagné divided learning activities into eight stages [17]: (1) Motivation stage—motivation drives effective learning, and learning tasks, objectives, and contexts can all serve as learning motivations that generate learning expectations and stimulate learning activities; (2) Apprehending stage—learners focus on various stimuli related to learning objectives, that is, they selectively perceive information; (3) Acquisition stage—learners encode and store information, entering it into memory; (4) Retention stage—learners repeatedly process information, storing it as long-term memory; (5) Recall stage—learners use certain retrieval strategies, such as information retrieval, to activate stored knowledge; (6) Generalization stage—when facing new learning situations, learners apply existing skills and transfer stored knowledge; (7) Performance stage—this stage provides learners with opportunities to test learning effects and apply acquired knowledge, allowing them to demonstrate learning outcomes and prepare for subsequent learning; (8) Feedback stage—learners compare initial learning objectives and expectations with learning outcomes, and if they can meet expectations, their learning motivation is reinforced.

Cognitive psychologist Ausubel, based on differences in information processing levels, roughly divided learning activities into three types [18]: (1) Zero learning—neither mastering nor being able to apply relevant knowledge; (2) Rote learning—mastering relevant knowledge but being unable to apply it to solve problems; (3) Meaningful learning—not only mastering knowledge but also being able to apply it to solve problems and understand new knowledge. The hallmark distinguishing meaningful learning from rote learning is whether learners establish non-arbitrary and substantive connections between new knowledge and appropriate concepts already existing in their cognitive structures.

These theories suggest that collaborative learning should not allow students to remain at the low level of rote learning. Learners must generate their own cognitive models and personalized understandings based on existing knowledge and experience, and through conversation, enable each learner's thinking achievements to be shared by the entire learning group, thereby achieving meaningful learning.

2.2 Cognitive Strategy Theory

Cognitive strategies are a product of the continuous development of cognitive psychology, explaining learning phenomena from a cognitive psychology perspective. First proposed by American psychologist Bruner [19], they were defined as thinking processes in the discovery and problem-solving process. Subsequent scholars have provided various definitions, but all emphasize the ability to internally process and regulate information. Generally speaking, cognitive strategies in learning refer to internal mental activities organized and applied by learners themselves that guide and regulate learning activities.

C. E. Weinstein categorized cognitive strategies into five types: rehearsal strategies, elaboration strategies, organizational strategies, comprehension-control strategies, and affective strategies [20]: (1) Rehearsal strategies are mechanical learning methods aimed solely at memory, where learners focus attention on learning materials through repetition; (2) Elaboration strategies refer to the process of connecting new information with existing old knowledge for meaningful memory—the more connections established, the more retrieval cues available, and the more meaning assigned to new information. These strategies typically include summarization, analogy, and explanation; (3) Organizational strategies involve generating hierarchical networks of concepts and identifying paradigms between concepts. Learners using these strategies divide learning materials into sections and then abstract the structure of the material; (4) Comprehension-control strategies involve consciously controlling and adjusting strategies used in learning with task objectives as guidance, such as pursuing further information searches for unclear issues, checking understanding and learning progress through self-questioning, and reflecting on learning gains; (5) Affective strategies involve maintaining learning attention and eliminating irrelevant emotions by regulating one's own emotions to ensure effective task completion. M. H. Dembo [21] argued that beyond these five strategies, problem-solving strategies should also be included in cognitive strategies—using appropriate methods to solve different problems and transferring knowledge to different scenarios. J. M. O'Malley and A. U. Chamot further refined cognitive strategies into 15 sub-strategies [22].

In collaborative learning, continuous interaction with others generates cognitive conflicts and viewpoint collisions, helping learners develop multiple cognitive strategies to address different learning situations. Therefore, studying learners' application of cognitive strategies in collaborative learning environments can help us understand learners' knowledge transformation processes.

3 Research Methods

3.1 Experimental Design

This experiment was based on a third-year undergraduate "Information Retrieval" course, with collaborative learning tasks exploring the latest developments in specific topics within the information retrieval field. Using a web-based collaborative learning model, students were required to conduct collaborative learning on the Scientific Research Online Platform (http://www.escience.cn/). Group members could upload literature, original documents, or other information resources to a shared collaborative space, post comments and viewpoints in discussion forums, freely reply to each other, and jointly complete learning tasks to produce group outcomes.

Since web-based collaborative learning was a new model, 30 students were ultimately selected to participate based on personal willingness. They shared the same educational background and had learned the basic principles and techniques of information retrieval before the experiment. During the experiment, they explored cutting-edge topics in information retrieval through collaborative learning. There were five learning themes: (1) Automatic question-answering systems; (2) Improving information retrieval through user behavior analysis; (3) Application of cognitive psychology in information retrieval; (4) Online community-based search; (5) Emerging topic identification and prediction. The 30 students were divided into 5 groups of 6 members each through free combination. Groups 1 and 5 each consisted of 1 male and 5 female students, while Groups 2, 3, and 4 consisted entirely of female students. Each group selected one theme for in-depth study, with no duplicate selections among groups. The experiment lasted 4 weeks (October 31, 2018–November 28, 2018), culminating in group presentations and submission of learning reports.

3.2 Data Collection and Communication Content Encoding

This study's data were derived from user collaborative learning logs recorded on the Scientific Research Online Platform (http://www.escience.cn/). Researchers collected collaborative learning data from each group, including document upload records, document reading records, and group discussion (posting and replying) records. This study focused on analyzing dialogue texts from the web-based collaborative learning process—specifically, learners' posts and replies in discussion forums (with each post treated as one text unit). First, invalid texts such as blanks or punctuation-only entries were removed. Then, social texts unrelated to learning themes (e.g., "When is the report due?") were further excluded, retaining 403 valid theme-related texts from the 30 participants. The statistics of valid dialogue texts for each group are shown in Table 1 .

Based on cognitive learning and cognitive strategy theories, this study conducted content analysis on the collected 403 valid texts. First, Group 1's dataset was selected for pre-coding, dividing text units and annotating their cognitive strategies. Cognitive strategies were developed through discussion between two researchers, with categories added, deleted, or adjusted based on C. E. Weinstein's cognitive strategy classification according to the characteristics of collaborative learning communication, making the coding results more suitable for this study. The cognitive strategies from Group 1 were refined and summarized to obtain coding categories, forming a coding table that defined each category and described the content of cognitive strategies. Two coders divided and coded the remaining groups' communication texts according to the coding table, revised the coding table, and discussed inconsistent coding results until consensus was reached. The final coding table and results are shown in Table 2 .

The six coding categories are explained as follows:

(1) **Intuitive Cognitive Strategy**: This can be further divided into three subcategories: "information-seeking questioning," "simple sharing," and "excerpting." The essence of this strategy is the perception of intuitive

information—activities generated without deep thinking or analysis after learners read information shared by others or uploaded literature. "Information-seeking questioning" occurs when learners, after encountering learning content, have questions and directly pose problems that come to mind, seeking help from other members to supplement their own cognition. "Simple sharing" and "excerpting" involve only introducing core content or copying from learning materials without personal thinking processes, remaining at the level of original text.

(2) **Memory Cognitive Strategy**: This can be divided into three subcategories: "existing resources," "concept narration," and "rehearsal." "Existing resources" indicates learners' attention to external linked information such as relevant resource links, bibliographies, and content sources. "Concept narration" indicates learners' attention to important concepts and attempts to extract them. "Rehearsal" of article content involves organizing new information based on selective attention, reflecting learners' understanding and memory of new information. This behavior helps maintain sustained attention and facilitates the transfer of short-term memory to long-term memory.

(3) **Analytical Cognitive Strategy**: This can be divided into three subcategories: "discussion questioning," "expressing viewpoints," and "comparative evaluation." "Discussion questioning" involves learners questioning others' viewpoints or posing open, worthwhile questions after in-depth analysis. "Expressing viewpoints" refers to learners replying to others' questions or supplementing others' viewpoints with arguments and explanations. Based on analyzing authors' writing purposes and research conclusions, learners identify article highlights or reference-worthy aspects, explain them with evidence, and recommend them to group members to advance group learning progress. "Comparative evaluation" reflects learners' in-depth reading and analysis of articles, comparing different articles or viewpoints, evaluating advantages and disadvantages, and providing evidential analysis.

(4) **Associative Cognitive Strategy**: This can be divided into two subcategories: "association" and "reflection." "Association" builds a bridge from old knowledge to new knowledge for learners, incorporating new connections into their knowledge networks and changing existing cognitive structures. The essence of associative cognitive strategies is integrating new information into existing cognitive structures and making them interrelated, collecting scattered, isolated knowledge into a whole and forming an interlocking knowledge network in the mind. Such networks facilitate learners' ability to mobilize information from any node to solve different problems. "Reflection" refers to learners combining new knowledge to reflect on whether previous experiences, thoughts, or methods have deficiencies or require improvement. In collaborative learning, learners explain new knowledge based on previous knowledge and personal think-

ing practices, improving their own knowledge construction while bringing new inspiration to other group members and enhancing others' cognition. This strategy often involves high-order cognitive processes such as reasoning and critical thinking, representing an embodiment of efficient learning ability.

(5) **Focused Cognitive Strategy**: This refers to conducting targeted in-depth searches for literature or problems. It is primarily problem-solving oriented, launching a high-level journey to explore the "unknown world." Problem-solving requires learners to conduct in-depth searches for relevant information to find solutions, often occurring when learners face new knowledge or problems that cannot be explained or conflict with existing knowledge reserves after association and reflection. "Focused searching" requires learners to accurately identify core keywords for retrieval and filter search results.

(6) **Expansive Cognitive Strategy**: This involves proposing suggestions or problem solutions based on existing knowledge or literature, and flexibly transferring and applying knowledge. Expansive cognitive strategies require not only active thinking ability but also flexible information utilization skills. While fully learning new knowledge, learners can think beyond the inherent ideas, research procedures, or applicable contexts of inspirational articles to propose new problem-solving methods or flexibly apply knowledge to new situations.

Overall, low-level cognitive strategies (Categories 1 and 2) refer to learners simply expressing personal ideas or superficial evaluations about materials uploaded by peers. Communication at this level remains shallow. Middle-level cognitive strategies (Categories 3 and 4) indicate that learners, based on understanding and analysis, provide in-depth thinking, questions, and suggestions about learning content through evaluation, association, and reflection. High-level cognitive strategies (Categories 5 and 6) represent learners deepening their knowledge understanding through continuous exploration and thinking during collaborative interactions, achieving knowledge transfer and application, and reaching deep collaboration. The three levels of cognitive strategies progress from shallow to deep, expressing learners' cognitive levels from superficial to profound.

4 Research Results

4.1 Characteristics of Cognitive Strategies in Web-Based Collaborative Learning

Based on the coding table, we conducted content analysis on dialogue data from the five learning groups, obtaining statistical data on cognitive strategies used in collaborative learning, as shown in Table 3 . The results show that middle-level cognitive strategies accounted for over half of all applications (53.72%), low-level cognitive strategies ranked second (42.5%), and high-level cognitive strategies were rarely used (only 4.23%). Regarding individual cognitive strategies, analytical strategies were most frequently used (44.87%), followed by intuitive strategies (35.61%). Associative and memory strategies accounted for 5%-10%, while focused and expansive strategies did not exceed 3%.

(1) **Analytical cognitive strategies were most frequently used**, reflecting college students' cognitive habits. Reading is an important learning method for college students, who are adept at interpreting literature through summarization, comparison, and other means. In collaborative learning, learners can identify specific literature highlights to alert peers and pose worthwhile questions. For example, learner G4:S1 asked: "The overlapping community algorithm mentioned in the article first converts to non-overlapping communities and then weights the results, which consumes considerable resources. Are there other methods to optimize this aspect?" Analytical cognitive strategies demonstrate learners' thinking and processing of learning content, indicating improved cognitive levels.

(2) **Intuitive cognitive strategies accounted for over one-third** of applications, with interactions such as "information-seeking questioning," "simple sharing," and "excerpting" appearing frequently in group dialogues. Especially during early project phases and when first discussing an article, learners easily pose superficial conceptual questions or copy important content they believe is valuable to share with group members. For instance, learner G5:S1, regarding a literature piece they uploaded, stated: "This paper summarizes three existing research methods domestically and internationally: citation analysis-based methods, content word analysis methods based on text mining, and hybrid methods combining citation analysis and content words." However, copying or simple Q&A involves low-level information processing and does not change the cognitive levels of speakers or other members. The extensive use of intuitive cognitive strategies in collaborative learning reflects some learners' misunderstanding of collaborative learning, possibly viewing it as a process of individually collecting materials and finally summarizing information.

(3) **Associative cognitive strategies accounted for 8.85%** of applications. The application of associative strategies demonstrates learners' full integration of new knowledge with their existing knowledge reserves, representing an important means of meaningful learning. For example, learner G1:S3 proposed: "I think this article provides a good research direction because we learned earlier in our information architecture course that most users tend to encounter information serendipitously, with only a small proportion obtained through active searching. Users develop vague information needs that gradually become clarified through continuous serendipitous encounters." The application of associative strategies requires not only certain knowledge reserves but also awareness and ability to construct knowledge networks. The low proportion of associative strategy applications may be due to insufficient knowledge reserves requiring instructor guidance, or weak awareness of actively building knowledge connections.

(4) **Memory cognitive strategies accounted for 6.44%** of applications. Memory is not simple copying but extracting important concepts from learned content and rehearsing core article content in one's own understandable language to explain to peers. For example, learner G5:S5 extracted an important concept: "Bibliographic coupling: the more identical references two articles cite, the more similar their topics." Learner G5:S3 rehearsed article content: "This article uses machine learning methods, with full article texts as analysis objects, employing the LDA topic model for clustering articles (with multiple topic distributions), and finally manually consulting the thesaurus to represent topics with thesaurus terms as much as possible." In learning, memory strategy application is a process of knowledge internalization and foundation for building personal mental models. In collaborative learning, learners more often share original text summaries than employ rehearsal strategies. This may be due to weak awareness of knowledge internalization or concerns that their rehearsal may not be as clear as original summaries.

(5) **Focused and expansive cognitive strategies were rarely used (4.23%).** Focused strategies reflect learners' targeted in-depth searches for problems. Learner G1:S4 focused on search behavior research methods to explore new methods and applications: "I noticed that literature found by everyone uses methods like clickstream logs and questionnaire surveys, but eye-tracking is also a good method, so I found this article and another recently uploaded one." Learners conduct information retrieval due to new needs arising from problems, supplementing knowledge through cycles of deep searching and problem discussion to fill cognitive gaps and improve group cognitive levels through continuous interaction. Another example is learner G1:S5, who proposed new ideas based on user attribute concepts mentioned in a music retrieval article: "Considering user context and query context can return more targeted results. For example, if you've been searching for insomnia treatment recently, it may indicate you're anxious and irritable. If you query a certain topic at this time, the system should return more concise or easily cognizable (e.g., charts or videos) relevant documents, or even something humorous." Overall, the rare use of high-level cognitive strategies indicates insufficient learner exploration and innovation abilities, which in this experiment also relates somewhat to the difficulty of learning themes.

To compare differences in the six cognitive strategy categories across the five groups, Figure 1 [Figure 1: see original paper] presents each group's application patterns using bar charts and radar charts. Figure 1(a) shows the frequency of each group's application of the six cognitive strategies. Group 1 applied the most strategies across five categories (except memory), while Group 2 showed the opposite pattern, applying the fewest strategies across five categories (except memory). Groups 3-5 fell in between. Figures 1(b)-1(f) display relative proportions using radar charts. Groups 1 and 4 showed similar radar patterns, with analytical strategies presenting the highest proportions (47.85% and 58.42%, respectively) and focused and expansive strategies accounting for approximately 6%. Groups 3 and 5 also showed similar patterns, with intuitive strategies presenting the highest proportions (51.43% and 49%, respectively), followed by analytical strategies (38.57% and 37%, near 40%), and then associative strategies (7.14% and 6%). Groups 3 and 5 applied focused and expansive strategies very rarely (0% and 2%). Group 2 was unique, with intuitive strategies (47.5%) far exceeding analytical strategies (27.5%), memory strategies accounting for the highest proportion among all groups (17.5%), and no high-level cognitive strategies applied.

Figure 2 [Figure 2: see original paper] compares the application of high-, middle-, and low-level cognitive strategies across the five groups. Groups 1 and 4 applied middle-level strategies most frequently, approximately twice as often as low-level strategies, with about 6% high-level strategies. Groups 3 and 5 applied low-level strategies most frequently, with low-level strategy applications about 10% higher than middle-level strategies. Group 2, while lacking high-level strategies, applied low-level strategies about twice as frequently as middle-level strategies.

4.2 Impact of Cognitive Strategy Application on Learning Outcomes

Collaborative learning effectiveness was evaluated by the course instructor based on group presentations and submitted learning reports, using criteria including completeness, richness, and standardization. Group scores from Group 1 to Group 5 were 92, 82, 85, 90, and 84, respectively. To further explore the correlation between cognitive strategy application and group learning effectiveness, we conducted correlation analyses between group scores and total dialogue counts, total cognitive strategy applications, and applications of the three cognitive strategy levels. Results are shown in Table 4 .

Table 4 Correlation Analysis Results Between Different Indicators and Group Scores

Indicator	Pearson Correlation	Significance
Total cognitive strategy uses	0.776	0.392
Low-level cognitive strategy uses	0.860*	0.123
Middle-level cognitive strategy uses	0.948*	0.061
High-level cognitive strategy uses	0.921*	0.514

Note: indicates significance at the 0.05 confidence level.*

College students' collaborative learning, from literature collection to learning report production, is a complex process, but the essence of collaborative learning is interaction. Interaction research should focus not only on interactive behaviors, patterns, and individual role functions but, more importantly, on the cognitive depth achieved during communication. Based on cognitive theory, this study analyzed dialogue texts from college students' web-based collaborative learning from a cognitive strategy perspective, identifying six cognitive strategies across three levels: intuitive, memory, analytical, associative, focused, and expansive.

Overall, middle-level cognitive strategies were most frequently applied, while high-level strategies were rarely used. Most communication remained at the memorization and comprehension levels, with low awareness of active in-depth exploration and transfer innovation. Some students stopped short of high-order thinking activities, without fully exercising their cognitive abilities. These conclusions align with research by Liang Yunzhen et al. [23] and Li Yi et al. [24]. To promote deeper collaborative learning among college students, fully leverage the complementary advantages of collaborative learning, and achieve the condensation and sublimation of collective wisdom, this study proposes the following recommendations:

5 Discussion and Recommendations

5.1 Role Positioning Strategy to Enhance Responsibility Awareness

When learners are unclear about their specific roles in discussions, they tend to actively pose questions and rely on others for answers. Research shows that role assumption positively impacts online discussions and promotes the development of learners' metacognitive abilities regarding online discussion strategies and learning behaviors [25]. Therefore, clarifying learners' role positioning in group knowledge construction during the early stages of collaborative learning will help them question, dialogue, and challenge, thereby enhancing group communication and interaction.

5.2 Learning Guidance Strategy to Promote Deep Cognition

The correlation analysis results in Table 4 show no significant correlation between total dialogue counts or total cognitive strategy applications and group scores, indicating that frequent interaction does not necessarily produce good collaborative results. Among the three cognitive strategy levels, middle-level and high-level strategy applications showed positive correlations with group scores, demonstrating that higher-level cognitive strategies help improve group cognitive levels and produce high-quality learning outcomes. This partially confirms earlier discussions: higher-level cognitive strategies better help learners internalize knowledge, build connections between knowledge, elevate learned knowledge to application and innovation levels, and thereby improve learning effectiveness and group collaborative learning outcomes.

The purpose of collaborative learning is to promote learners' in-depth discussions around themes. However, due to insufficient knowledge reserves, learners easily deviate from topics, making it difficult to sustain discussion breadth and depth [26]. If instructors provide deep guidance or prompts for learners' thinking and discussions, they can greatly facilitate rich connections between target knowledge, effectively promoting learners' transition from middle-level to high-level cognition and reducing superficial engagement [27].

5.3 Diversified Evaluation Strategy to Guide Deep Learning

Since learners are unclear about their participation and contribution levels throughout collaborative learning, they cannot timely detect and adjust their status. Research shows that constructing an innovation- and quality-oriented diversified evaluation system with visual feedback can, to some extent, promote online deep interaction among learners [28]. Therefore, adding technical support to provide real-time visual feedback on individual activity levels and content quality will give learners clearer self-awareness, prompting reflection on learning status, adjustment of learning behaviors, and ultimately enhancing the enthusiasm and depth of interactive discussions.

This study currently only collected and analyzed dialogue texts from collaborative groups on web platforms. However, online data cannot comprehensively and authentically reflect the cognitive strategies of college students participating in collaborative learning. In future work, we will collect offline group dialogue texts through audio recording for comparative analysis.

References

[1] Zhang Li. User collaborative information behavior and library information services from a social network perspective [J]. Library and Information Service, 2012, 56(7): 49-53.

[2] Xie Shuxiao, Li Jingpei. Construction and application of a problem-based collaborative learning model in network environments [J]. e-Education Research, 2002(8): 44-47.

[3] Yilmaz R, Yilmaz FGK, Cakmak EK. The impact of transactive memory system and interaction platform in collaborative knowledge construction on social presence and self-regulation [J]. Interactive Learning Environments, 2017, 25(8): 949-969.

[4] Zheng Lanqin. Reflection on interaction analysis methods in collaborative learning [J]. Modern Distance Education Research, 2013(5): 91-99.

[5] Liu Meimei. Research on the impact of interactive behavior on knowledge creation ability in Knowledge Forum [D]. Wuhan: Central China Normal University, 2019.

[6] Zheng B, Warschauer M. Participation, interaction, and academic achievement in an online discussion environment [J]. Computers & Education, 2015, 84: 78-89.

[7] Tian Yongzhen. Research on interactive behaviors of learning communities in Knowledge Forum [D]. Jinan: Shandong Normal University, 2017.

[8] Liu Shufen. Evolution analysis of social network structure and knowledge construction levels in online collaborative learning [D]. Jinhua: Zhejiang Normal University, 2019.

[9] Yang X, Li J, Xing B. Behavioral patterns of knowledge construction in online cooperative translation activities [J]. The Internet and Higher Education, 2017, 36: 13-21.

[10] Li Yanyan, Peng Yu, Kang Jia, et al. Analysis model construction and application of group learning engagement in online collaborative learning [J]. Chinese Journal of Distance Education, 2020(2): 40-48, 77.

[11] Wang Zhe, Zhang Pengyi. User roles and behaviors in online knowledge collaboration among learning groups [J]. Library and Information Service, 2018, 62(7): 77-87.

[12] Gasevic D, Adesope O, Joksimovic S, et al. Externally-facilitated regulation scaffolding and role assignment to develop cognitive presence in asynchronous online discussions [J]. The Internet and Higher Education, 2015, 24: 53-65.

[13] Keiichi T. Bruner's theory of cognitive development [A]// Wright JD. International encyclopedia of the social & behavioral sciences, 2nd ed. Amsterdam: Elsevier, 2015: 880-885.

[14] Wang Ya. Research on the design and implementation of online learning activities based on group cognition [D]. Jinhua: Zhejiang Normal University, 2019.

[15] Liang Ningjian. Contemporary Cognitive Psychology [M]. Shanghai: Shanghai Education Press, 2014.

[16] Francis G, Galotti KM. Cognitive psychology in and out of the laboratory [M]. 5th ed. Thousand Oaks, CA: SAGE Publications, 2014.

[17] Gagné RM. The Conditions of Learning and Theory of Instruction [M]. Translated by Pi Liansheng, et al. Shanghai: East China Normal University Press, 1999.

[18] Wang Huilai. The guiding significance of Ausubel's meaningful learning theory for teaching [J]. Journal of Tianjin Normal University (Social Science Edition), 2011(2): 67-70.

[19] Bruner JS, Goodnow JJ, Austin GA. A study of thinking [M]. New York: Wiley, 1956.

[20] Weinstein CE. Assessment and training of student learning strategies [A]// Schmeck RR. Learning strategies and learning styles. New York: Plenum, 1988: 291-316.

[21] Dembo MH. Applying educational psychology in the classroom [M]. 5th ed. New York: Longman, 1994.

[22] O'Malley JM, Chamot AU. Learning strategy in second language acquisition [M]. Cambridge: Cambridge University Press, 1990.

[23] Liang Yunzhen, Zhu Ke, Zhao Chengling. Empirical research on collaborative problem-solving learning activities promoting interaction depth [J]. e-Education Research, 2017, 38(10): 87-92, 99.

[24] Li Yi, Shi Xiaoli, He Shawei. Analysis of social interaction quality in network asynchronous interaction environments—Taking online courses for continuing education as an example [J]. Modern Distance Education, 2020(4): 35-42.

[25] Chen Jing. Research on the impact of role assumption on college students' online discussion participation in CSCL environments [D]. Jinhua: East China Normal University, 2018.

[26] Li Haifeng, Wang Wei. Construction of online learning communities from a social systems theory perspective [J]. China Educational Technology, 2018(6): 77-85.

[27] Zheng Lanqin, Liang Miao. Empirical research on the impact of teacher guidance on collaborative learning effectiveness [J]. e-Education Research, 2014, 35(8): 89-94.

[28] He Xiaojuan. Research on the process and strategies of collaborative learning interaction in distributed learning environments [D]. Jinhua: Zhejiang Normal University, 2019.

Author Contributions

Liu Ping: Conceived research ideas, guided experimental design, coded data, revised paper.
Wang Zhaoyang: Collected, coded, and analyzed data, wrote initial draft, revised paper.
Ni Jiangxue: Conducted literature review, analyzed data, revised paper.

Note: Figure translations are in progress. See original paper for figures.