Kashihara, A. et al. (Eds.) (2024). Proceedings of the 32nd International Conference on Computers in Education. Asia-Pacific Society for Computers in Education

Students' Verbal Interaction Patterns in Computer-Supported Collaborative Learning: The Role of Individual Preparation

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Abstract: This study explores students' verbal interaction dynamics in two computer-supported collaborative learning (CSCL) environments: immediate collaboration and individual preparation (IP) followed by group collaboration. Although verbal interactions are not always central to all CSCL designs, they are critical in contexts that emphasize face-to-face or synchronous communication, where they facilitate negotiation, idea sharing, and collaborative knowledge construction. By applying content analysis and lag sequential analysis (LSA), this study examined the verbal interaction behavioral sequences of students in both conditions to understand how IP influences collaborative dynamics. The findings highlight the crucial role of IP in enhancing collaborative dynamics, suggesting that well-structured preparatory activities can significantly improve group interaction efficiency. This research contributes valuable insights for refining CSCL instructional strategies, emphasizing the need to balance structured preparation with opportunities for spontaneous interaction to optimize collaborative learning outcomes. By managing distractions and maintaining task focus, educators can create more effective collaborative learning environments.

Keywords: Individual Preparation, Collaborative Learning, Computer-Supported Collaborative Learning, Behavioral Patterns

1. Introduction

Collaborative learning, where learners work together towards shared goals, has been widely recognized as an effective educational approach (Wilczenski et al., 2001; Wray, 2009). This process encourages the active exchange of ideas in a socially supportive environment, fostering diverse contributions and enhancing collective problem-solving. However, merely grouping students does not inherently lead to effective collaboration. Research indicates that without proper structure and guidance, collaborative learning may not result in enriched interactions or improved learning outcomes (Johnson & Johnson, 1999; Barron, 2003).

In the context of Computer-Supported Collaborative Learning (CSCL), verbal communication plays a crucial role, particularly in synchronous or face-to-face settings. It serves as the primary medium for negotiation, idea sharing, and co-construction of knowledge (Hmelo-Silver & Barrows, 2008; Mercer, 2004). The quality of verbal interactions— marked by questioning, explanation, and feedback — significantly influences cognitive processing and collaborative outcomes (Stahl et al., 2006).

One promising strategy to enhance collaboration is Individual Preparation (IP), a pedagogical approach rooted in the Preparation for Future Learning (PFL) framework (Bransford & Schwartz, 1999). IP allows learners to process instructional materials independently before engaging in group activities, thereby establishing a foundation that enhances the effectiveness of subsequent collaboration (Chen et al., 2022; 2023; Mende et al., 2021; Tan et al., 2021). Studies suggest that IP can address common challenges in groupwork, such as uneven participation and superficial engagement, by ensuring that all participants enter the collaborative phase with a well-developed understanding of the content (Noroozi et al., 2013; Tsovaltzi et al., 2015; Lyu et al., 2023). However, IP is not without its challenges. Some studies have noted that while IP can lead to more structured interactions, it may also cause rigidity in thought processes, making individuals less open to alternative perspectives during collaboration (Mende et al., 2021; Tsovaltzi et al., 2015). Thus, it is crucial to balance structured preparation with opportunities for dynamic, spontaneous interaction to foster both critical evaluation and flexibility in group settings.

Given these considerations, this study aims to address the following research question: Are there differences in verbal behavioral sequences during collaboration when IP is provided prior to the collaboration activity as compared to immediate collaboration?

2. Methods

2.1 Experimental Design & Data Collection

Ethical approval was obtained from the university's Institutional Review Board. 18 university students, aged 21 to 40, were recruited for this study. To minimize interpersonal dynamics, participants were paired with unfamiliar partners to form dyads. In a single session, dyads completed the control and experimental conditions in a randomized order. The control condition involved immediate collaboration, while the experimental condition included 2 minutes of individual preparation (IP) followed by 5 minutes of collaboration. During IP, participants independently generated ideas in their individual workspaces and reviewed their partner's work, without verbal communication. In the collaboration phase, they shared an ideation column, discussed ideas verbally, and collaboratively typed their descriptions. Participants used individual computers to access a shared task interface, completing product ideation tasks that involved designing multifunctional everyday items. The interface provided four prompts ('customer traits,' 'outlook,' 'function/technology,' and 'materials,') to further facilitate the product description process.

Audio recordings of the collaborative phases were transcribed using Whisper, an automatic speech recognition tool. Two researchers independently reviewed and cross-checked the transcriptions against the original audio recordings to ensure high transcription accuracy. Discrepancies were resolved through discussion, providing a reliable representation of participants' interactions for further analysis.

2.2 Coding Scheme

Numerous coding schemes have been developed to analyze interaction patterns in collaborative verbal communication (Chung et al., 2013). Notably, Gunawardena et al. (1997) introduced the Interaction Analysis Model (IAM), which examines the social construction of knowledge in computer-mediated conferences. IAM categorizes interaction into five stages: sharing and contrasting information, exploring cognitive dissonance, negotiating and co-constructing knowledge, testing syntheses, and affirming new knowledge, making it a valuable tool for understanding how learners collaboratively build understanding. Building on the IAM framework, Wang et al. (2020) developed a verb-centric coding scheme for synchronous online collaborative learning, focusing on three dimensions: academic relevance, social connectivity, and off-topic behaviors. Our study adapts Wang's framework to align with our focus on task completion and interaction dynamics, rather than solely higher-level knowledge construction. This adaptation allowed us to capture nuanced student interactions and gain insights into their collaborative behaviors and communication patterns. The detailed coding framework is outlined in the appendix Table 1.

In analyzing dialogues within collaborative learning, participants typically follow a turn-taking communication model. Researchers used a predefined coding framework (Table 1) to encode each turn within the dialogue, identifying interaction behavior patterns. The unit of analysis was the individual turn, coded according to predefined categories. To ensure reliability, Cohen's Kappa was calculated across all groups, resulting in an average value of 0.894, indicating substantial agreement between the two coders (Landis & Koch, 1977).

2.3 Lag Sequential Analysis (LSA) for Verbal Discourse

A pattern of behavior refers to the sequential relationship between coded discussion contents, determined by calculating the statistical significance of a behavior sequence (Wang et al., 2020). In this study, GSEQ 5.1 was used for Lag Sequential Analysis (LSA) to assess the significance of behavioral patterns exhibited by dyads under different conditions. GSEQ 5.1 calculated the frequency of each behavioral type in succession and the adjusted residuals (Z-scores) for transitions between behaviors. Behavioral transitions were considered significant if the Z-score exceeded 1.96 (Bakeman & Gottman, 1997). We then depicted behavior transition diagrams for all statistically significant sequences.

3. Results & Discussion

3.1 Behavioral Distribution

Table 2 (see Appendix) presents the frequencies of the codes displayed by all students in two conditions. Due to varying behavior counts across conditions, we focused on the frequency percentages of the behaviors instead for meaningful comparisons. Overall, the control condition exhibited higher frequencies in offering ideas or help (A1), responding to information or questions (A3), and irrelevant content (A9). Conversely, the experimental condition showed slightly higher frequencies in checking or reporting the progress of the learning task (A8) and leading task coordination or guiding group actions (A7).

It is noted that higher frequencies of certain behaviors reflect their prevalence in each condition. For instance, the higher frequency of A1 (offering ideas or help) and A3 (responding to information or questions) in the control condition suggests that these students were more actively engaged in these specific types of interactions. Similarly, the experimental condition's higher frequency in checking or reporting the progress of the learning task (A8) and leading task coordination or guiding group actions (A7) indicates a greater focus on monitoring and guiding the collaboration process. The lower frequency of irrelevant content (A9) in the experimental condition suggests that individual preparation might have contributed to students being more focused and on-task during collaboration. However, the identical frequencies of discovering uncertainties or spotting unclear contents (A6) in both conditions imply similar levels of exploratory behavior in identifying and addressing areas of confusion.

3.2 Sequential Analysis Results

As frequency data alone may not fully capture the influence of IP, we further examined behavioral sequences using GSEQ 5.1 software to assess the statistical significance of these sequences. A Z-score exceeding 1.96 indicates a significant relationship between behaviors ($p < 0.05$) (Bakeman & Gottman, 1997). The control condition yielded 10 significant sequences, while the experimental condition displayed 8 (Tables 3 & 4, see Appendix). Behavioral transition diagrams were constructed from these significant sequences for a clearer presentation of the results (Figure 1). In both conditions, frequent bidirectional interactions between A1 (Offer) and A4 (Agree) were observed, suggesting efficient information exchange. The transition from A3 (Respond) to A2 (Ask) also emerged consistently, indicating that responses often led to further inquiries. Additionally, a self-loop in A6 (Discover) was present in both conditions, reflecting a continuous cycle of identifying and addressing uncertainties.

Distinctive behavioral patterns also emerged in each condition. In the control condition, significant self-loops in A5 (Negotiate) and A6 (Discover) reflected a collaborative environment focused on critical evaluation and clarification. Additionally, a notable sequence from A7 (Lead) to A4 (Agree) indicated spontaneous leadership and consensus-building, while frequent occurrences of A5 (Negotiate) suggested extensive discussion and revision. In contrast, the experimental condition showed significant self-loops in A7 (Lead) and lower Z-scores in A6 (Discover), indicating a shift to a more structured, task-oriented approach post-IP. The transition from A6 (Discover) to A2 (Ask) suggested that participants typically expressed uncertainties before seeking help, and a self-loop in A7 (Lead) implied a tendency toward self-guidance in task coordination, potentially activating prior knowledge.

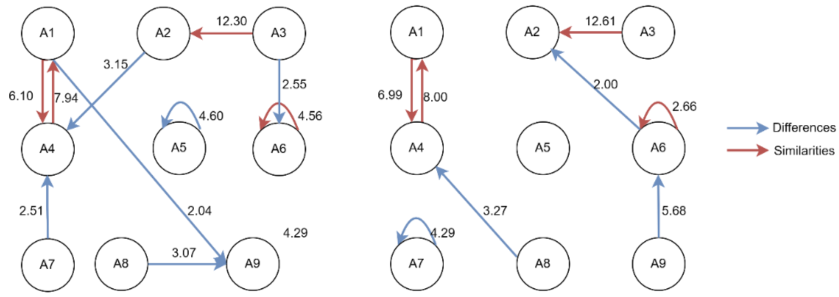

Figure 1. Behavior transition diagram of Control Condition$_{(left)}$ and Experimental Condition$_{(right)}$

4. Conclusion

This study provides insights into how individual preparation (IP) influences verbal interaction patterns in CSCL environments. Comparing the control and experimental conditions revealed both common and distinct behaviors. Contrary to previous research suggesting that idea negotiation increases with IP (Chen et al., 2022, 2023; Lyu et al., 2023; Tan et al., 2021), this study found more frequent negotiation (A5) and discovery of uncertainties (A6) in the control condition instead, indicating that immediate collaboration task facilitated more spontaneous idea exchange and critical evaluation (Hou et al., 2015).

In contrast, the experimental condition showed a more structured approach, as evidenced by the significant self-loop of A7 (Lead task coordination) and a lower Z-score for A6 (Discover), indicating that IP encouraged students to coordinate for consensus building (Chen et al., 2022). In clarifying uncertainties during the IP phase, participants could engage in more directive and task-oriented interactions, reducing the need for prolonged negotiation. The bidirectional exchanges between A1 (Offer) and A4 (Agree) reinforced a positive reinforcement cycle, building confidence and validating contributions, thereby fostering further idea sharing (Chi & Wylie, 2014). These findings suggest that IP can lead to more efficient collaborative processes, aligning with previous research that highlights how IP enables learners to better understand instructional material and engage in more meaningful exchanges during collaboration (Tan et al., 2021; Chen et al., 2022).The transition from A6 (Discover) to A2 (Ask) in the experimental condition suggests a proactive approach to overcoming knowledge gaps through inquiry. However, attributing this transition solely to the IP phase requires caution, as further evidence is needed to confirm this linkage. The findings overall indicate that IP can enhance the efficiency of collaborative interactions, though the specific mechanisms through which IP influences behavior warrant further investigation.

These results emphasize the importance of designing learning experiences that balance structured preparation with opportunities for spontaneous, dynamic interaction. Effective CSCL design should incorporate both structured preparation, which streamlines and focuses collaboration, and elements that encourage organic negotiation and critical evaluation for a well-rounded learning experience. Facilitators should consider designing activities that promote leadership and task coordination among students, as demonstrated by the significant self-loop of A7 in the experimental condition. Additionally, encouraging bidirectional exchanges, such as offering and agreeing (A1 and A4), can create a positive reinforcement cycle that builds confidence and promotes further idea sharing. Activities requiring mutual validation and constructive feedback can further enhance this dynamic.

Overall, while IP can effectively streamline collaboration, it must be balanced with the dynamic negotiation processes inherent to immediate collaboration. This research contributes to the development of pedagogical strategies that maximize the potential of IP in guiding collaborative learning within CSCL environments. By understanding the complementary roles of structured preparation and dynamic interaction, educators can create more effective collaborative learning experiences.

Acknowledgements

This study was funded by National Institute of Education (NIE), Nanyang Technological University (NTU), Singapore (RS 1/22 CWL) and administered by NIE, NTU. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NIE, NTU. The study was approved by the NTU IRB (IRB approval number: IRB-2022-210).

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