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Effects of Social Roles Rotation on the Cognitive Learning Process in Online Collaborative Conversation

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Abstract: Online collaborative conversation is one of the crucial approaches to promote students' collaborative skills and cognitive development. Students' social roles in collaborative learning have a key impact on the process of collaborative learning activities and the development of students' cognition. What are the differences in the cognitive structures and processes between rotated-role and fixed-role in students' groups? This paper explored this question by empirical research. The results of epistemic network analysis showed that the rotated-role groups had more high-level cognition and more complex cognitive structure, while the fixed-role groups had more management activities. In the rotated-role groups, the leaders can better mobilize the atmosphere, organize, and coordinate the cognitive processes of the team, to contribute more to the collaborative conversations. The cognitive depth and efficiency of fixed-role groups significantly decreased over time. These imply that in online collaborative conversation activities, role-rotation can be used to promote higher-order cognitive development, and fixed role can be used to improve management efficiency. Teachers should encourage team leaders to take on more cognitive activity organization and coordination tasks in online collaborative conversation activities. In the later stages of online collaborative conversation activities, teachers should strengthen intervention and support for fixed social role groups.

Keywords: social roles, collaborative learning, online collaborative conversation, epistemic network analysis

1. Introduction

Online collaborative conversation activities are widely used in online learning, since it can make up for the lack of communication between teacher-student and student-student. Students can share information, consult with each other, and eventually reach a consensus on a topic or complete a specific task through conversational interactions) [1]. However, online learning is difficult to achieve the desired learning performance [2]. Previous studies have pointed out that given social roles can promote collaborative activities, because social roles can better help learners to take on the roles that enhance the effectiveness and performance of collaboration can be enhanced [3–6]. Nevertheless, fixed-role approach also carries less freely in choosing activities and words [3]. Some researchers pointed out that the above risks can be avoided by changing learners' social roles during the learning process [7]. Furthermore, having too many script roles may bind students to highly specialized role functions and deprive them of opportunities to participate in various social and cognitive activities [4]. On the other hand, the group leader, as a central social role in collaborative learning activities, is very important for the development of collaborative learning activities [8, 9]. Therefore, in the absence of other roles, a leader might be an indispensable role for a group. Previous studies have shown that the learning behavior of team leaders is different from their peers and to be a group leader can increase behavioral engagement [10]. In addition, low-performing students should deserve equal opportunities to be a group leader [10], and it will be contributed to CPS development, such as cognitive process skills, if student's role was generated emergently [7]. However, there is no consistent conclusion on the impact of designated team leaders on a rotating basis on learners' cognitive processing.

To address this issue, this study focused on the impact of different organizational ways of team leader roles on learners' cognitive processes. This study conducted an empirical research to explore the differences in cognitive construct and cognitive moving over time of the fixed-role groups and rotating-role groups. The participants were sophomores who enrolled in the course "Database Principles and Techniques" of a university in China. The findings of this empirical study can provide an important reference for the organization and management of online collaborative conversation activities.

2. Literature Review

Aiming to gain an understanding of the current research related to the role of team leaders, this section reviewed the previous research related to social roles in collaborative learning and cognitive process analysis in collaborative learning conversation. Furthermore, epistemic network analysis (ENA) was introduced.

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2.1. Social roles in collaborative learning

The concept of social role originates from the role theory proposed by American social psychologist George Herbert Mead. According to Mead, a "role" is a person who is in a certain position and behaves according to his or her corresponding behavioral norms [11]. Different learners may take on different roles in the collaborative learning process, but leaders were likely to emerge regardless of the number of members in group and lead to better engagement [12]. The group leader plays an important role in the collaborative learning process. Previous research has pointed out that many different roles would emerge during a collaborative session, such as coordinator, inquirer, integrator, marginal, and facilitator [13]. The more functions the team leader assumes in the collaborative process, the more effective the collaborative process will be [14]. Therefore, the role of the team leader in the collaborative process is so crucial that cannot be ignored. In collaborative learning activities, group leaders are often generated in a certain way (e.g., appointed by the teacher, co-elected by the members of the group, etc.) and are relatively fixed in the learning activities to facilitate the management of the learning process. Previous studies have shown that group leaders engage in more participatory behavior than their peers [15], which means that the distribution of behavior among group members is not evenly distributed. Research has shown that a balanced distribution of leadership among group members can help facilitate successful collaborative activities [7]. Based on this finding, some researchers pointed out that it was possible to enhance the quality of collaborative learning by rotating group leaders among group members during activities [16]. Both ways of fixing leader and rotating leader are widely used in the organization of collaborative learning activities [10, 15, 17], but little researches have been done on the effects of these two organizational approaches on the collaborative learning process. Delving inside collaborative learning activities to explore the impact of these two organizational styles on the learning process helps to gain a deeper understanding of the operational mechanisms of collaborative learning activities. This can help teachers to better organize collaborative learning activities in groups.

In addition, understanding learners' cognitive processing processes is a key method for comparing the effects of different organizational approaches. Therefore, this article provides a review of existing cognitive processing analysis models.

2.2. Cognitive process analysis in collaborative learning conversation

Online collaborative conversations are an important form of learning activity in collaborative learning. In recent years, due to the impact of the development of mobile devices and COVID-19, online collaborative conversation activities have been widely used in online and blended learning to promote student-student communications, enhance their collaborative abilities, and help them better accomplish their learning tasks [1, 18]. The analysis of online collaborative conversation processes helps to gain a more in-depth understanding of learners' learning processes and cognitive states; therefore, researchers have proposed a large number of analytical models of cognitive processing in collaborative conversations. For example, Henri's analytical framework consisted of five dimensions and the cognitive dimension consists of five categories including elementary clarification, in-depth clarification, inference, judgment, and strategies [19, 20]. Gunawardena et al. [21] proposed a framework, which divided the collaborative cognitive processing into five phases, namely sharing/comparing of informa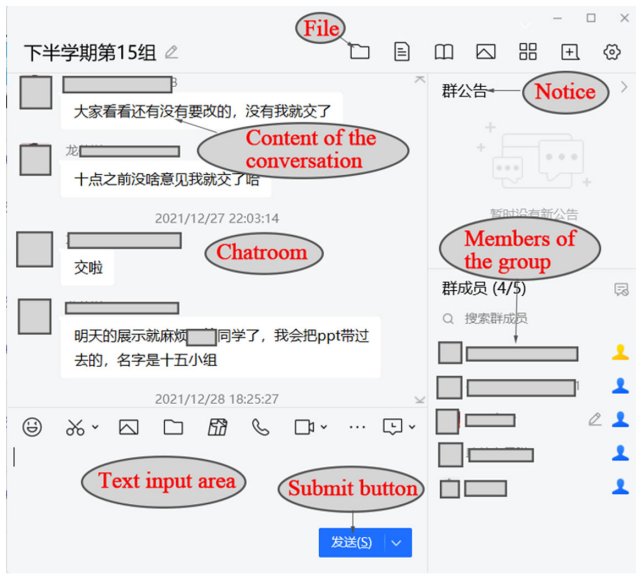tion, discovering and exploring the dissonance or inconsistency among ideas, concepts, or statements, negotiation of meaning/co-construction of knowledge, testing, and modification of proposed synthesis or co-construction, agreement statement(s)/applications of newly constructed meaning. Garrison et al. proposed the cognitive presence scheme based on the model of Community of Inquiry, mainly including triggering event, exploration, integration, and resolution [22]. The revised Bloom's Taxonomy has six key levels of cognitive processing, including remember, understand, apply, analyze, evaluate, and create [23]. These models analyze and describe students' cognitive processing in collaborative conversation from different perspectives, revealing the relevant characteristics of cognitive processing presented in different perspectives. However, in applying these models specifically, existing research has tended to focus on the number of times each element of cognitive processing occurs, ignoring the inter-transitions between the elements. The transitions among elements reflect the contextual relevance and temporal characteristics of cognitive processing and deeply reflect the progress and evolution. Therefore, this study intends to introduce the ENA method to model the associative relationships among the elements in the cognitive processing process by means of an adjacency matrix. By constructing the model network characteristics of the learners, we hope to better present the progression and evolution in the process of the learners' online collaborative conversations and to help the researchers gain a deeper understanding of the associative relationships and the interactions among the cognitive elements in the process of the online collaborative conversations.

To ensure the adaptability and feasibility of ENA methods, this article reviewed the relevant research on cognitive network analysis methods in the following section.

2.3. ENA

ENA is based on the theory of epistemic frames, which holds that behaviors and activities are external manifestations of internal epistemic [24]. Shaffer et al. [25] view the learning process as a pattern of connections between knowledge, skills, habits of mind, and other cognitive factors that characterize communities of practice. This view is widely recognized by scholars and argues that analyzing the correlations between factors is critical to the understanding of learning [26]. In light of this, Shaffer et al. [26] deepened and proposed ENA based on traditional behavioral pattern analysis. Based on the theory of epistemic frames, ENA uses a dynamic network model to characterize and analyze the network relationships among learners' epistemic elements. It can quantitatively analyze the textual records produced by learners during the online interaction process, forming a dynamic network model to characterize the correlation structure between learners' cognitive elements and further characterize learners' cognitive traits. ENA models the connections between elements by quantifying the co-occurrence of elements in a conversation, generating a weighted network of co-occurrences and a visualization of the associations for each unit of analysis in the data. In addition, ENA analyzes all networks simultaneously, resulting in a set of networks that can be compared visually and statistically [27, 28]. In this study, learners' online collaborative conversation data were the external carrier and important embodiment of their cognitive processes in collaborative learning activities, which deeply reflected their coordination, cooperation, and in-depth cognitive processing to achieve certain knowledge construction goals. Therefore, ENA is very suitable for analyzing the data in this study to explore the differences in the cognitive characteristics of learners' online collaborative conversations under different social roles organization.

Figure 1
The interface of QQ platform

2.4. Research questions

To investigate the effects of social role on cognitive processing in online collaborative conversation, the following research questions were identified in this study:

- RQ1: What was the cognitive processing of groups in online collaborative sessions between rotated-role groups and fixed-role groups?
- RQ2: What were the functions of the group leaders in the cognitive processing of the rotated-role groups and fixed-role groups?
- RQ3: What were the developmental pattern of cognitive processing over time in rotated-role groups and fixed-role groups?

3. Methodology

To address the above research questions, this study conducted empirical research, collected collaborative conversation data, and then analyzed their cognitive processes by ENA. The specific research design, participants, and coding table are shown below.

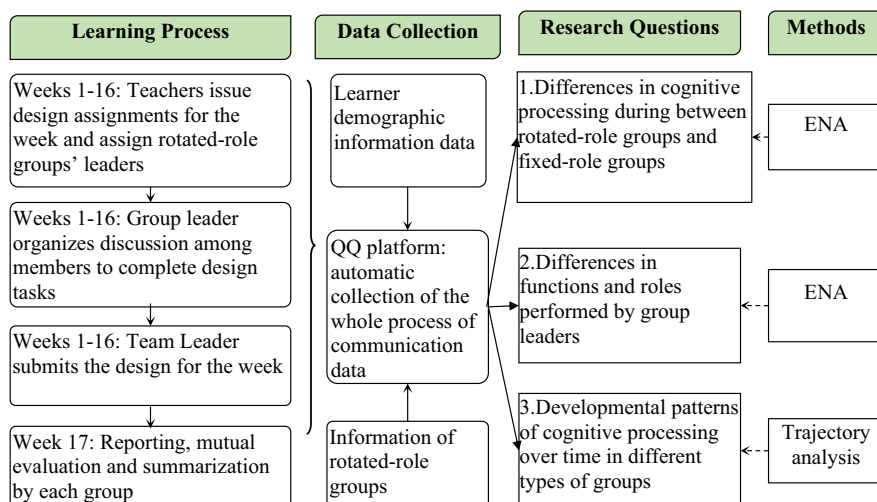### 3.1. Research design and data collection

The data were collected in accordance with the human subjects' guidelines and principles. Before conducting data collection, we stated the purpose of the study to the students, as well as the possible risks and benefits. Students' private information and all of their rights were protected under the Institutional Review Board of the University.

To answer the research questions of this study, an empirical study was carried out on the course "Database Principles and Technology" offered by the Educational Technology subject of a university in East Asia which cultivates pre-service teachers. The purpose of the course was to train students to master the design, creation, management, and application of database. During the course, the instructor assigned a series of tasks about developing database: independently select an application system, design a database for the application system, including the conceptual model, the schema, the external schema, the internal schema, the integrity mechanism, and the security mechanism of the database, to ensure that the database meets the third normalization form. This task was carried out throughout the course over a period of 17 weeks, with each week's specific task corresponding to the content of that week's lecture.

The learners' collaboration and communication were all conducted on Internet. Semi-instant tool Tencent QQ was chosen as the communication platform to support online collaborative conversations, and the interface of QQ platform is shown in Figure 1. All the groups built their own QQ groups for intra-group collaborative discussions. The instructor also joined each group's QQ group so as to monitor and guide the learners' collaborative communications. After completing all the course learning and tasks, all the chat records of each group were exported as the data source of this study. The research design is shown in Figure 2.

As shown in Figure 2, in the teaching of weeks 1 to 16, the teacher would first announce the database design tasks of the week and alert the leaders of the social rotated-role groups to work in the week; then each group would discuss the tasks of the week under the organization of the leader and collaborate to complete the corresponding design

Figure 2
Research design

tasks and form the design manuscript. The leaders of the groups were needed to submit the corresponding design manuscript to the homework platform within the stipulated time. In the 17th week, each group reported on the assignments. They evaluated each other and then summarized and reflected on the assignments. At the end of the course, the teacher and the teaching assistant collected all the conversation records of all the groups in the QQ platform as the core data of the cognitive processing of the groups. After preprocessing (i.e., the system messages were deleted), there were 13604 messages analyzed. Furthermore, the leader roles information of the groups' students was also as the data source of this study.

3.2. Participants

A total of 28 third-year undergraduate university students were enrolled in the course, including 23 females and 5 males. All learners were freely grouped into four-person groups, containing seven groups in total. Three of the groups were randomly chosen as role-fixed groups (i.e., the group leader was fixed to be one person throughout the learning process), and the remaining four groups as rotating-role groups (i.e., all group members took turns to be the group leader during the learning process). The main tasks of the group leaders are as follows: organizing the group members to complete the database design tasks assigned by the teacher, collaborating with members' time to participate in the collaborative tasks, and submitting the design manuscripts to the assignment platform.

3.3. The coding scheme of cognitive processing in online collaborative conversation

For providing an in-depth analysis of the cognitive processing of online collaborative conversations, it was necessary to construct an appropriate coding scheme to analyze conversation content. Although the classic Gunawardena's five-stage model [21] and the Garrison's four-stage model [22] provided an in-depth portrayal of the cognitive processing of collaborative conversations, they did not address the organization of collaborative learning activities, which was not conducive to an in-depth analysis of the organization, management, and socialization of collaborative learning activities brought about by changes in social roles in this study. Therefore, this study adopted the content analysis coding scheme based on the collaborative knowledge construction process [29]. The coding scheme of learners' online collaborative conversation data was carried out from multiple dimensions, such as cognitive processing, management, and socialization in the process of collaborative conversation, so as to understand the learners' cognitive process in a clearer and deeper way. It mainly contains three primary classifications, eight secondary classifications, and 21 tertiary indicators, as shown in Table 1.

The data of one group were randomly selected from the online collaborative conversation logs of all groups as the test data to verify the consistency of coding. After was coded by two researchers independently, the consistency of their coding results was calculated. The kappa coefficient was obtained to be 0.79, which indicated that the coding results had a good consistency.

3.4. Data analysis methods

After completing data collection, for research questions 1 and 2, the method of ENA was used to compare and contrast the fixed-leader and rotating-leader groups. For research question 3, the method of trajectory analysis was used to explore the developmental patterns of cognitive processing over time.

Table 1
The coding scheme of cognitive processing in online collaborative conversation

Level 1 indicators	Level 2 indicators	Level 3 indicators	Code
Process phases of cognitive processing	Sharing and comparing information	Statement of personal views and opinions	Statement
		Providing external ideas and sharing information	Sharing
		Asking and answering questions to clarify presentation details	Details
		Agreeing with others	Agreement
	Discovering and analyzing discrepancies and contradictions	Statement of individual dissenting views	Dissenting
		Analyzing differences in viewpoints with peers	Differences
	Consultative discussions and knowledge construction	Re-analysis and discussion of relevant terms	Terms analyzing
		Asking and answering questions to explain conflicting views	Conflicts explaining
		Identifying commonalities between conflicting viewpoints	Commonalities identifying
		Proposing supplementary or revised information	Supplementary
		Proposing new ideas	New ideas
	Summary	Synthesizing ideas, distilling and summarizing them	Summary
	Reflection	Reflecting on the gains and losses in the learning process	Reflection
Management	Management	Clarification of members' responsibilities, members' online presence	Management
		Organizing and adjusting the topics, pace of discussion	Adjusting
		Asking questions to guide others in the discussion	Guiding
		Notification arrangements, information dissemination	Notification
Non-task content	Social (Emotion)	General social information	General Socialization
		Positive emotional communication	Positive
		Negative emotional communication	Negative
	Others	Other messages that do not fit into the above categories	Others

4. Results

Based on the processed data, the results of ENA were shown as follows, respectively. In total, there were some differences in cognitive structure and behaviors between rotated-role groups and fixed-role groups.

4.1. What was the cognitive processing of groups in online collaborative sessions between rotated-role groups and fixed-role groups?
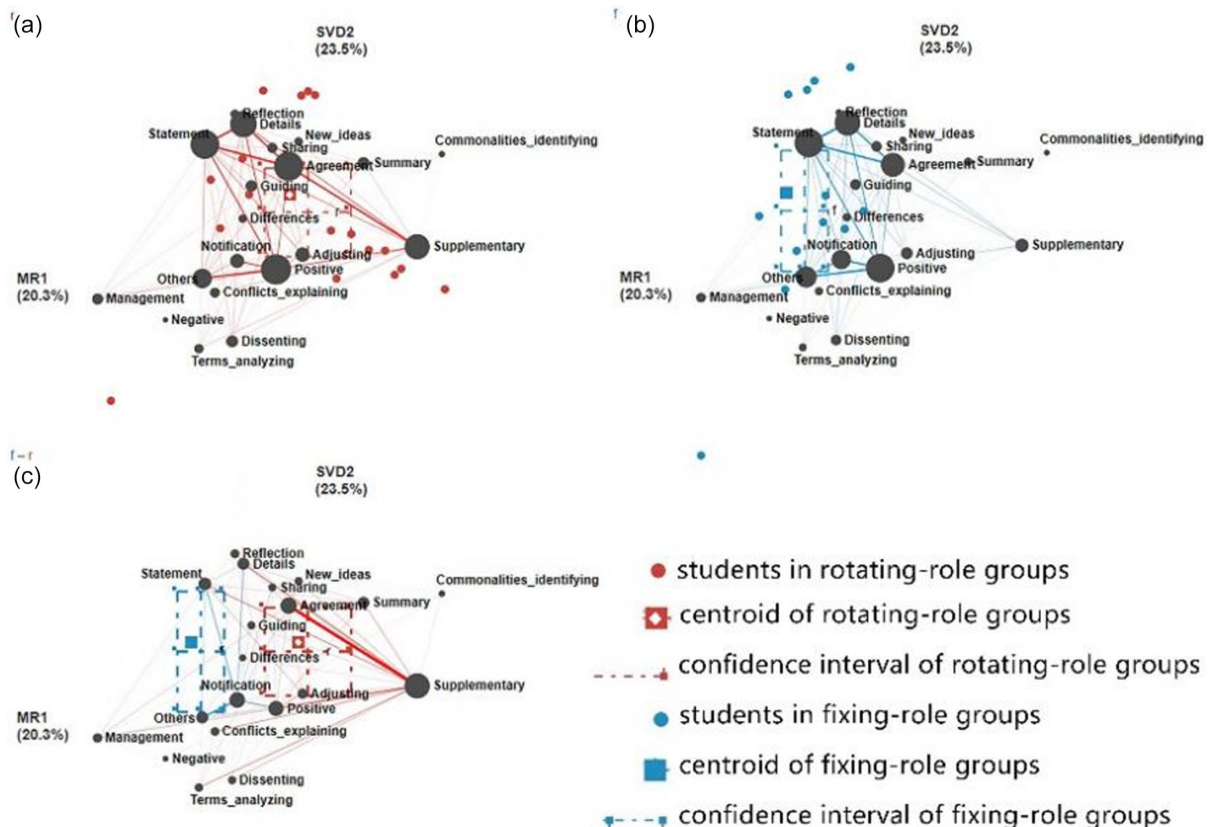
For exploring the differences in cognitive processing between the rotated-role group and fixed-role group in online collaborative conversations, this study used the group type and the students in different types of groups as the unit of analysis, using the content of each group's daily communication as the unit of conversation. With the window size set to 5 for comparative analysis, the epistemic networks and the subtracted network obtained are shown in Figure 3.

Figure 3(a) displays the epistemic network structure, centroids, and confidence intervals of the students in the rotated-role groups. Figure 3(b) displays the epistemic network structure, centroids, and confidence intervals of the students in the fixed-role groups. Figure 3(c) shows a subscription plot of the two types of groups, in which the color of the lines was consistent with the color used by the stronger connected group. It can be seen from the set of plots that the centroid of the rotated-role group was located on the right-hand side of the coordinate, which meant that there were a great number of

proposed supplementary or revised information occurred during students' cognitive processes. And rotated-role groups' students had more connections on agreement-supplementary, positive-supplementary, terms_analyzing-supplementary, and etc. In addition to the significant differences between the rotated-role group and the fixed-role group in terms of the location of the centroids, there were also significant differences in the connections between the elements of their cognitive processes. From Figure 3(c), it can be seen that the rotated-role group had more connection transitions than the fixed-role group, which indicated that the rotated-role group had more varied cognitive patterns and more active cognitive processes. In addition, the fixed-role group had a significantly stronger connection strength on other-notification than the rotated-role group, while the rotated-role group had a significantly stronger connection strength on supplementary-agreement than the rotated-role group. Furthermore, due to the links to the general socialization being too weak, this code is not shown in Figure 3.

These results reflected the differences in cognitive processing between the rotated-role group and the fixed-role group. The cognitive processing of the rotated-role group showed more proposed supplementary or revised information, which belonged to the stage of negotiation and knowledge construction, while the fixed-role group showed more member management and sharing information, of which member management belonged to the category of management and sharing information. The fixed-role group had more member management and sharing information, with member management belonging to the management category, and sharing belonging to the sharing and comparing information

Figure 3
Diagram of the difference in cognitive network structure between the rotated-role group and the fixed-role group

stage. This difference in cognitive processing suggests that the rotated-role group had a greater number of higher-order cognitive activities during cognitive processing, while the fixed-role group invested more in membership management.

4.2. What were the functions of the group leaders in the cognitive processing of the groups in different ways of organizing social roles?

In online collaborative conversation activities organized in small groups, the group leader had a crucial role in the organization of the learning process, progress monitoring, and topic guidance. Therefore, exploring whether there were differences in the cognitive activities of group leaders in two different types of social role organization helped to better understand the cognitive processing of two types of groups. Taking the group type and students as the unit of analysis and excluding all group members who were not group leaders, keeping only the group leaders as the object of analysis, and using the daily communication content of each group as the conversation unit, with the window size set to 5 for comparative analysis, the obtained epistemic networks and the subtracted network among group leaders are shown in Figure 4.

Figure 4(a) displays the epistemic network structure, centroids, and confidence intervals of the leaders in the rotated-role groups. Figure 4(b) displays the epistemic network structure, centroids, and confidence intervals of the leaders in the fixed-role groups. Figure 4(c) shows a subscription plot of the two types of groups. It can be seen that the centroid of the rotated-role groups' leaders is located on the right-hand side of the coordinate, which means that there are a great number of proposing new idea, stating different idea, and analyzing the different ideas between peers. The centroid of the leaders in fixed-role groups is located on the left-hand side of the coordinate, meaning that they had more percent of notification and positive emotional communication. Furthermore, there was also a significant difference in the strength

of connection of cognitive elements between group leaders in the rotated-role groups and fixed-role groups. The leaders of rotated-role groups had stronger connection on supplementary-agreement, supplementary-positive, while the leaders of fixed-role groups had stronger connections on notification-statement, notification-others, and notification-positive.

From these differences, it can be seen that compared with the group leaders of the fixed-role groups, the group leaders of the rotated-role groups took more responsibility for guiding and facilitating the cognitive processing process in the online collaborative sessions and contributed to the creation of the group atmosphere through agreement and positive emotion exchange, etc., whereas the group leaders of the fixed-role groups focused more on posting notices and took on more management work, and contributed less to the facilitation of cognition and cognitive deepening.

4.3. What were the developmental patterns of cognitive processing over time in rotated-role groups versus fixed-role groups?

In order to explore the pattern of cognitive processing over time in each group, this study divided the 16-week learning process into 4 months, with every 4 weeks as a month, labeled as month1 to month4. ENA was conducted on the learners of the fixed-role groups and the learners of the rotated-role groups on the basis of each month to track the trajectory of their cognitive processes, and the results obtained are shown in Figure 5.

As can be seen in Figure 5, the learning trajectories of the learners in the fixed-role groups were mainly concentrated on the right-hand side of the coordinate, while those of the learners in the rotated-role groups were mainly concentrated on the left-hand side of the coordinate system. In addition, there were significant differences in the developmental trajectories of their cognitive processes. The centroid of the epistemic network of the rotated-role group's learners showed wavy changes during the four months of learning, but the overall trend was getting closer to the

Figure 4
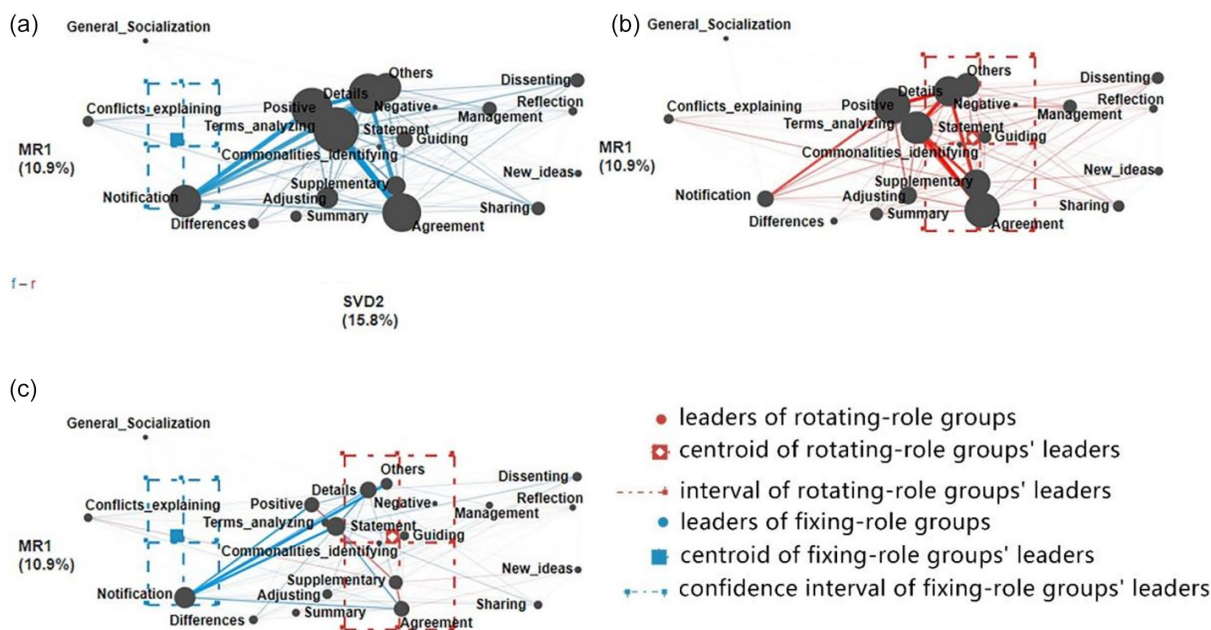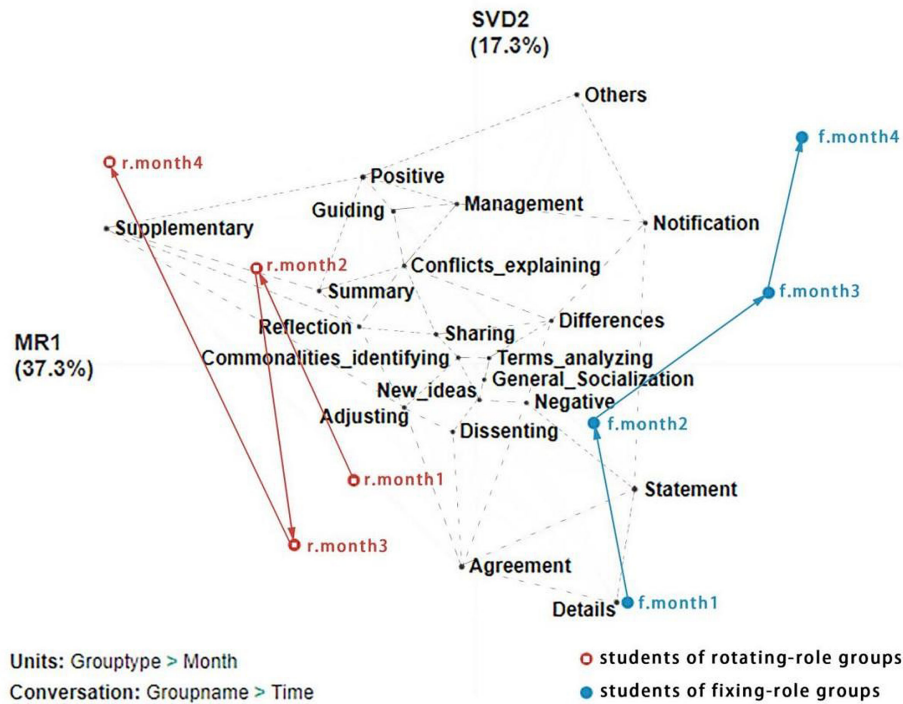**Epistemic network of leaders in rotated-role group and fixed-role group**

Figure 5
The trajectory of learners' cognitive processes

From this difference, it can be seen that in the cognitive processing of online collaborative conversations, the number of supplement of rotated-role groups was more and more, meaning the source of knowledge was becoming more and more comprehensive, while the fixed-role group of learners in the cognitive processing of the cognitive level gradually declined over time, and the proportion of management and others and other, which belonged to the non-cognitive information, was gradually increased. This meant that when the leader was fixed, the groups' cognitive efficiency of the online collaborative conversations significantly declined in the cognitive processing.

5. Discussion and Implications

This study had investigated the differences in cognitive processing between fixed-role groups and rotated-role groups in online collaborative conversations and the patterns of change over time through empirical research.

The first implication was that the organization of online collaborative conversation activities using rotated-role better promotes higher-order cognitive development in learners and was more efficiently managed when using fixed role. Specifically, the results of the ENA showed that when social roles were fixed, management-related activities occurred more often during the conversation and the group's activities were organized more efficiently. This was consistent with previous research findings, which had shown that when a team remains static, there would be more cohesive strategies [30]. When social roles were rotated, learners showed more higher-order cognitive

activities and richer cognitive patterns. Previous research findings proposed that the role-rotating groups had higher knowledge construction level, but may not guarantee long-term positive effects [31]. There were also studies pointed out that if too many roles had been involved, it may lead to some role bearers being unable to achieve better knowledge construction [4, 32, 33]. To avoid these disadvantages, this study rotated the team leaders and it worked. Totally, before organizing collaborative learning activities, the way of rotated role can be chosen by teachers to conduct group activities if they want to cultivate more higher-order cognition and inspire learners' cognitive activities from multiple perspectives. Compared with the fixed-role group, learners in the rotated-role group had richer cognitive patterns and a greater number of higher-order cognitive processes, which was more conducive to their cognitive development. If the collaborative learning task was relatively less difficult and more emphasis was placed on the efficiency of managing learning activities, it can be organized in a fixed-role way. In this way, learning activities were organized more efficiently, but learners' higher-order cognitive development was relatively lacking.

The second implication was that group leaders played an important role for the cognitive development and good atmosphere creation. In the fixed-role groups and the rotated-role groups, the group leaders assumed a very different function. In the rotated-role group, the group leaders focused on organizing and coordinating the cognitive process, mobilizing the group atmosphere, and assuming the organization and facilitation of the cognitive process. On the other hand, the group leaders in the fixed-role group focused on notification and concept definition, which suggested that the group leaders in the fixed-role group positioned himself/herself as a manager rather than a coordinator and facilitator of the cognitive process. The differences in the roles of group leaders also affected the cognitive processing and cognitive development of the whole group to a certain extent. Previous studies had argued that multiple different role functions

need to be undertaken in a collaborative group, such as project planner, communicator, data collector, and editor [3, 5, 6, 34]. When only the group leader role was assigned, it meant that the group leader was expected to undertake multiple functions. Therefore, teachers should emphasize the important functions and roles of group leaders in group learning and guide them to play a greater role in collaborative group learning, including facilitating and coordinating the cognitive development process of the group, rather than only assuming managerial responsibilities.

The third implication was that the fixed-role groups experienced a rapid decline in cognitive levels in the later stages of the collaborative conversation, requiring more teacher intervention and guidance. The results of the trajectory analysis showed that over time, the fixed-role group in the online collaborative conversation activity would need more teacher intervention and guidance to complete the collaborative task with high quality; otherwise, their learning process would become more and more formal. Research has shown that fixed social roles have limitations, and learners who hold the same role for a long time may experience fatigue and decreased learning motivation, leading to a single and ordinary discussion content [6]. Echoing this finding, our research showed that the fixed-role group showed a significant downward trend in cognitive processing, while the rotated-role group was relatively stable and showed wave-like fluctuations. If there was a lack of teacher intervention and guidance, the later the learning period, the lower the cognitive efficiency of the fixed-role group was, and ultimately gradually towards management and other topics unrelated to the cognitive goal. Therefore, for online collaborative conversation activities with fixed role, teachers need to give more intervention and attention in the process of organizing and rotate the leader so as to stimulate the vitality of group collaboration and achieve better learning results.

6. Limitations

There were some shortcomings in this study. First, the sample size of learners was relatively small, resulting in a slight lack of generalizability of the conclusions. Second, the window size normal of ENA in this research was an estimated value. It's important and difficult to find the most accurate window size. Third, the data source was relatively single, using only the textual data in the course of learners' online collaborative conversation activities. If questionnaire and interview data can be introduced to further support the experimental results, the comprehensiveness and reliability of the conclusions will be higher.

7. Conclusion and Future Study

Group leaders, as an important role in collaborative learning, are usually considered different from other group members in behaviors and contribution. However, it is a question that compared with only one leader, whether every peer can be the leader would make the group achieve better performance in cognitive construction. Exploring different ways of organizing social roles is important for understanding the cognitive process of online collaborative conversations and optimizing the organization of online collaborative conversations. This study investigated the differences in cognitive processing between fixed-role groups and rotated-role groups in online collaborative conversations and the patterns of change over time through empirical research. The results found that the way of rotating social role can enhance the cognitive level and enrich the cognitive structure of learners. Compared with the fixed-role groups, the leader of the rotated-role groups can better regulate the collaborative atmosphere of the group and better organize and

coordinate the cognitive process. Over time, the cognitive efficiency of the fixed-role groups decreased significantly and required more guidance and teacher intervention. These differences provide some references for the organization and management of online collaborative conversation activities. In the future, the number of samples and the scope of courses could be further expanded. More type of data, such as physiological data including skin conductance and electroencephalography, can be concerned together to get further understanding of students' cognitive process and learning engagement under different ways of group organization.

Recommendations

The finding revealed that the lack of training for both teachers and students was the main factor that prevented them from using educational technology tools in teaching and learning Ecology. Therefore, training on educational technology for both teachers and students is recommended. Since educational technology tools have aroused excitement and curiosity among students, they recommended other module tutors to use educational technology tools as well. Educational technology tools integrated in the module will be further replicated by student's teacher during teaching practice or as a full-fledged teacher. Therefore, tutors were recommended to use variety of educational technology tools in learning, teaching, and an assessment.

Acknowledgements

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Linjing Wu: Conceptualization, Writing – original draft, Writing – review & editing, Supervision, Project administration. **Yu Gao:** Writing – original draft, Writing – review & editing, Visualization. **Yujia Zang:** Investigation, Formal analysis, Writing – original draft. **Puliang He:** Data Curation, Resources.

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