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Scaffolding-Based Analysis of Group Online Collaborative Learning Engagement and Sequence Patterns

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Collaborative learning ability, as one of the core skills in the 21st century, is of great interest to national and internationally important organizations. The quality of collaborative learners' collaboration determines the effectiveness of collaborative learning, and the quality of collaboration is closely related to the engagement of collaborative learners. In this study, the online collaborative document was used as the technical scaffolding and the intervention of pedagogical scaffolding was administered. In addition, content analysis was used to code all the discourses of the whole process, and discourse analysis of the communication during the collaborative process was conducted with the help of GSEQ software using lagged sequence analysis. Then the collaborative learning behaviors of the three participants were explored in conjunction with interviews. The results found that the scaffolding strategy based on online collaborative documents led to a significant increase in collaborators' participation, engagement, and more complex transformation of individual behaviors. As a whole, there was also an increase in teamwork and a higher structure of collaborative behaviors. This study provides a useful reference for how to improve collaborative learning engagement and analyze online collaborative learning behavior sequences in higher education.

Additional Keywords and Phrases: online discourse analysis; pedagogical scaffolding; collaborative learning; learning behavior analysis; case study; lag sequence analysis

1 INTRODUCTION

With the advent of the Fourth Industrial Revolution, many international organizations, countries, regions, and scholars around the world are placing increasing emphasis on developing students' collaborative learning skills. In January 2020, the World Economic Forum (WEF) released a report titled 'Schools of the future: Defining new models of education for the fourth industrial revolution' [1], which proposes a global framework for Education 4.0 that includes 'problem-based and collaborative learning' as a key feature of the future of education. Similarly, the Organization for Economic Cooperation and Development (OECD), in 'Trustworthy Artificial Intelligence in Education: Promises and Challenges' [2], emphasizes that citizens should have social-emotional skills, such as persistence, communication or collaboration. As one of the core skills of the 21st century [3], collaboration has become a twenty-first-century trend [4]. Collaboration is considered an important learning competency for learners. Meanwhile, scholars believed that the importance attached to collaborative learning as a teaching method partly mirrors the importance attached to forms of cooperation in society at large [5].

Also, collaborative learning skills are a necessary prerequisite for the current development of AI technologies. Collaborative learning as a higher-order thinking skill can help learners address cognitive deficits and limited perspectives in the face of complex technologies and communities. Accordingly, if learners lack collaborative learning skills in social interactions, it will directly affect their engagement in learning and knowledge construction. It can be argued that students who lack collaborative learning skills also receive significant limitations to their personal development. Currently, many scholars have accumulated a wealth of experience in collaborative learning development. On the one hand, we can think about important ways to foster students' collaborative learning and explore tools that effectively serve learners' collaborative learning in order to promote effective collaborative learning. On the other hand, we can further explore how to achieve effective assessment of collaborative learning in the process of collaborative learning in order to help teachers in learning assessment and subsequent teaching organization.

This study uses online collaborative documents as a technical scaffold to administer interventions of scaffolded teaching strategies, and based on this, three research questions are posed:

(1) Do students' collaboration levels improve through scaffolding instruction?

(2) Is there a significant behavioral sequence in students' collaborative learning behaviors through the analysis of their online discourse?

(3) Do the sequence of students' collaborative behaviors change and become distinctive at different stages and with different learning tasks?

2 LITERATURE REVIEW

2.1 Collaborative learning

2.1.1Definition.

According to Laal et al., collaborative learning (CL) is an educational approach to teaching and learning that involves groups of learners working together to solve a problem, complete a task, or create a product [4]. Similarly, Slavin et al. proposed cooperative learning refers to teaching methods in which students work together in small groups to help each other learn academic content [6]. Some scholars believed that collaborative learning means a teaching method whereby learners get together to learn as a group and help each other to achieve a certain learning target [7]. In general, many scholars tend to have the same understanding of collaborative learning, and they all believe that collaborative learning is a

teaching method that can help learners complete common tasks and achieve common goals. In addition, studies show that through collaborative learning, learners can significantly improve in social, psychological, academic and assessment [8].

2.1.2Influence factors.

The meta-analysis showed that students who learn collaboratively do achieve higher learning outcomes than those who complete the task alone and have a positive impact on knowledge and skill acquisition [9]. Overall, the factors affecting learning effectiveness during collaborative learning can be attributed to direct factors on the subjective side of the learners and potential factors on the external side of the learners. From the subjective side, learners' social interactions in the group, their engagement, and their prior knowledge and skills are the direct factors that influence learning effectiveness in collaborative learning. Firstly, the expression of learners' views and collaborative communication not only promote group cognition [10], but also facilitate learners' deep reflection on an issue, thus enhancing learning effectiveness [11]. What's more, the degree of commitment to collaborative learning tasks and processes has an important impact on the effectiveness of collaborative learning [12]. The engagement related to the collaborative learning task refers to the learners' continuous learning behavior in the learning task, including perseverance, effort, and contribution to the learning goal [13]; the engagement in the collaborative process refers to the social interaction among the group members [14, 15].In terms of external potential factors, activity scenario creation, learning task design, learning process support, and grouping strategy use are all potential factors that affect learning effectiveness in collaborative learning. For example, Salam et al. proposed that collaborative learning technology is a stimulus for the collaborative learning process [16]. It has also been proposed that social factors, i.e., interaction with peers and teachers, social presence, and use of social media, positively influence collaborative learning and student engagement, which in turn affects their learning performance [17].

2.1.3Related research.

Current research on collaborative learning design has focused more on the effectiveness of collaborative learning and the design of a particular session. One type of research direction is the use of technology to facilitate collaborative learning. For example, cloud services were used to enhance students collaboration [18] and improved the quality and performance of teamwork [19]. Augmented reality (AR) technology was applied to collaborative learning activities to improve students' levels of cognitive engagement [20]. Some scholars have also used mobile learning technologies to improve learners' attitudes towards collaborative learning and enhance mathematics learning performance [21]. Then there is the use of artificial intelligence to support collaborative learning, such as combining intelligent tutoring systems with collaborative learning and proposing a new conceptual framework underpinning 'Intelligent Tutoring Supported Collaborative Learning (ITSCL)' [22], and intelligent social robots as teaching assistants for collaborative learning [23]. Overall, technology-supported collaborative learning has shifted from an initial emphasis on the application and design of technology in teaching and learning to a mid-term focus on how to use technology to support group collaboration, and then to a focus on enhancing the effectiveness of computer-supported collaborative learning from a larger perspective [24].

The second is to facilitate collaborative learning by learning tools. Learning tools also play an integral role in the collaborative learning process. Meza et al. proved that the use of collaborative learning tools has contributed significantly to collaborative learning in Latin American higher education programs [25]. Studies have shown that social media tools, as a dynamic tool, can enhance the learning behavior and performance of participants in collaborative learning [26, 27]. In addition, the use of learning dashboards to visualize learning data and assist faculty and students in optimizing the collaborative learning process [28], as well as the use of collaborative concept mapping tools can facilitate group interaction [29].

Thirdly, it provides a scaffolding of teaching strategies for collaborative learning. In the process of collaborative learning, providing appropriate external pedagogical scaffolding helps learners develop and construct cognitive processes, which can enhance the learning effectiveness of collaborative learning to solve problems. For example, Huang et al. argued that procedural scaffolding can positively influence the level of group discourse and group learning effectiveness [30]. Lerchenfeldt et al. used peer feedback appropriately in the collaborative learning process, thus promoting professional behavior [31].

2.2 Teaching scaffolding

2.2.1Definition.

Cognitive psychologist Bruner introduced 'scaffolding theory' as a metaphor for support and guidance in learning, and this was the first time the concept of 'scaffolding' was introduced into the field of education [32]. Based on the constructivist and nearest developmental area theoretical perspectives, scaffolding is the support provided by teachers or parents to learners that promotes meaningful engagement in problem solving [33]. Scaffolding instruction is one of the three major models of constructivist teaching and learning. At its core, when teaching a new knowledge or skill, the teacher breaks down and simplifies the task to a level that a learner can achieve more easily by identifying the students' ability level. The learners are able to focus on the task within the ability and are assisted in acquiring new knowledge, crossing the Zone of Proximal Development and completing more difficult tasks. Wood et al. considered that scaffolding stimulates learners' interest in learning, maintains their motivation, and reduces dependency and frustration in the learning process [33].

2.2.2Classification of scaffolding.

The classification of scaffolding varies widely, with different criteria. There is no accepted method for the classification of scaffolding. Saye et al. classified scaffolding as soft and hard scaffolding [34]. Soft scaffolding refers to the support provided by the teacher during instruction, all depending on the needs of the students, while hard scaffolding refers to the instruction or help planned by the teacher according to the learner's learning situation. Holton and Clarke proposed three types of scaffolding based on the support learners need in learning, which are expert scaffolding, reciprocal scaffolding, and self-scaffolding [35]. Some scholars have also categorized scaffolding forms and scaffolding purposes in terms of teacher and students' classroom interaction discourse into six direct types, including questioning scaffold, feeding back scaffold, hints scaffold, instructing scaffold, explaining scaffold and modeling scaffold and two scaffolding purposes i.e., cognitive purpose and affective purpose [36]. Belland synthesized existing studies and classified three types of scaffolds: one-to-one scaffolding, peer scaffolding, and computer-based scaffolding [37]. One-to-one scaffolding refers to the assistance provided by teachers to learners in their nearest developmental area, which is often considered to be the ideal form of scaffolding. Peer scaffolding refers to the assistance provided by learning partners to each other [38]. Computer-based scaffolding refers to a variety of computer tools that act as teaching scaffolding. In conclusion, although many scholars have classified the types of scaffolding into schools from different perspectives, it is generally accepted that scaffolding are different depending on the instructional objectives.

2.2.3Related research.

Through the literature review, we found that there are two main types of research on scaffolded teaching: one is scaffold-based teaching practices, and the other is the theoretical exploration of scaffolding teaching, and there are more studies on the former.

Scaffolding teaching can help teachers achieve better teaching results and students acquire better knowledge and skills. Several studies have shown that scaffolding instruction is somewhat universal in that it can improve learner achievement across school levels and subjects. Bakker et al. provided scaffolding in mathematics to better facilitate the implementation of the process [39]. van Rooij found that providing learners with project management tools and templates (e.g., task breakdown structure templates, activity list templates, and project status report templates) do facilitated intra-team communication and positive cooperative behavior [40]. Raes et al. experimentally found that multiple scaffolding (i.e., teacher scaffolding and technology scaffolding) improved learners' knowledge acquisition and metacognitive awareness [41]. Kim's meta-analysis of 145 empirical studies using computer-based scaffolding in problem-centered STEAM instruction showed that Computer-Based Scaffolding leads to statistically significant cognitive learning effects when students solve problems individually, as well as working in pairs, triads, and small groups [42]. Theoretical explorations, such as Reynolds' theoretical framework for scaffolding and reading comprehension, suggested that the question of how context and mediating resources shape scaffolding can be addressed in terms of classroom culture, material tools, and disciplinary goals [43].

2.3 Lag Sequential Analysis

This study analyzed collaborative language behavior using Lag Sequential Analysis (LSA) proposed by Sackett (1978) [44], which has become an important tool for researchers of inter-personal. LSA is used to calculate the probability that one behavior follows another behavior (i.e., the probability of the path of the behavior). This method enables one to explore and summarize cross-dependencies occurring in complex interactive sequences of behavior [45], which is a common research method in the field of learning analysis. For example, Tan et al. explored the development trajectory of shared epistemic agency in online collaborative learning through epistemic network analysis and lag sequential analysis [46]. Sun et al. used LSA to analyze student group knowledge-construction behaviors in a mobile learning environment [47]. Wang et al. explored the effect of gender on online learning behavior patterns with the help of LSA. In conclusion, LSA has been widely used to analyze group interaction behaviors, individual knowledge-construction behavioral patterns in online discussions [48].

3 RESEARCH METHOD

3.1 Methods and Objects

3.1.1Case Study Method.

This experiment has high requirements on the individual ability of the subjects, who should have certain cooperation ability and consciousness, and have the basic experience of using online learning. In addition, due to the epidemic, the experiment could not be carried out on a large scale. Therefore, this study randomly selected three postgraduate students from a university in Shanghai, and selected two reading comprehension articles with the same difficulty coefficient in the original IELTS test as experimental materials, and carried out a one-week teaching intervention. Because all the participants had the experience of online learning and using online collaborative documents and collaborative learning. What's more, all participants have good reading skills in English, so the selection of participants can meet the requirements of this experiment well.

This study adopts the comparative study of pre and post-test. Firstly, the pre and post-test can truly reflect whether the cooperation level of cooperative learners can be improved after the intervention of teaching scaffold. In addition, the pre

and post-test can visually compare the changes of cooperative learning behavior sequence before and after the intervention. Besides, it can compensate for the error caused by different participants in the control experiment.

3.1.2Lag Sequence Analysis.

This study focuses on the research and analysis of group interaction behavior in online discussion, so it adopts Sackett's lag sequence analysis method. Meanwhile, GSEQ software was used to analyze the language sequences of the subjects.

The specific operation is to encode a series of linguistic behavior data and input the code according to the sequence of time occurrence. The significance of behavior state can be obtained by selecting corresponding operation items. Salience is related to the order in which all actions are taken in the sequence. In the behavior sequence with the same total number of behaviors, the longer the sequence, the more single sequences, and the easier the result is to reach the significance level. According to the coding results compiled and imported into GSEQ software for analysis, this study obtained the conversion frequency and residual value of language behavior in each stage, and drew the behavior conversion diagram for visual presentation.

3.2 Data Processing and Collection

3.2.1Post-experiment Investigation and Interview.

According to the relevant scenes of the experiment, the researchers were interviewed to understand the habits and attitudes of learners in digital reading, online collaborative reading and reading annotation before and after the experiment. After the experiment, the recognition of collaborative learners of the teaching scaffold designed in this study and the expectations of the subsequent improvement of collaborative learning ability through this scaffolding teaching were understood.

3.2.2Collaborative Learning of Discourse Data.

Collaborative learning is one of the keys to language communication in the process of collaboration, so learners' collaborative discourse is one of the important indicators of online collaboration of reading. And then, good language communication will largely promote the goal and task collaboration learners. This study focuses on collection and coding the collaborators discourse data in the learning process. With the help of discourse data analysis, we can judge the changes and characteristics of learners' collaborative learning and behavioral sequence transformation.

3.3 Coding Scheme

According to the process of the experiment, the whole process can be roughly divided into two stages, namely, the pre-test stage and the post-test stage. Each stage can be roughly divided into two small scenes, namely, the division of labor scene and the discussion scene, according to the characteristics of the participants' activities, a total of four scenes. In this study, the research was decomposed and coded. The coding is divided into three dimensional vectors. The first dimension is the subject coding, whose values are A, B and C, corresponding to subject 1, subject 2 and subject 3 respectively. The second dimension is language behavior coding, which is based on all the activities of the subjects, and on this basis, the similar language behavior activities are merged and integrated into ten categories (their corresponding codes and specific meanings are shown in Table 1). The third dimension is the session duration of the subjects in seconds.

In this study, the content analysis method is used to encode the second dimension language behavior. The two coders who participated in the coding completed the coding independently after deeply understanding the coding system. The coders coded all the utterances of the six scenes. Secondly, the consistency test was carried out on the coding results of the

coders, and the similarity was 95%. The test found that the consistency was good and the reliability was high. The inconsistent parts are then negotiated and discussed to determine the coding sequence.

Table 1: Coding Table of Language Behavior

Classification	Coding	Meaning
Information Provision	0	A member's paraphrase of the information provided.
Opinion Sharing	1	The expression of a member's own thoughts and views on an issue.
Emotion Expression	2	Members' attitudes and emotions towards the collaborative process include the process of collaboration and the behavior of group members.
Conflict Coordination	3	Coordinate conflict of opinion and division of roles within the group.
Putting forward the Proposals	4	Make suggestions about a problem or point of view.
Implementation	5	To implement the task of the group and the cooperation task.
Task Division	6	Internal division and coordination of cooperation issues.
For Advice	7	Group members ask questions about their own problems or about others' problems.
Communication	8	The communication of group members on a common issue or topic.
Detection of Feedback	9	Summary feedback on your own and group tasks.

4 COLLABORATIVE DISCOURSE DATA ANALYSIS AND RESULTS

This study used both pedagogical and technological scaffolding to develop learners' collaborative learning skills. The technological scaffolding was reflected in the use of an online collaboration tool for graphite online collaborative documents. The pedagogical scaffolding is reflected in the experimental interventionist providing support to learners in reading annotation strategies to help learners better use technology to solve problems and avoid the cognitive load generated by free collaboration. The researchers provided learners with three devices, each containing an identical graphite online collaborative document (the document content was an English reading comprehension). Three learners worked in groups for a specified period of time (25 minutes) and could collaborate in any format to complete the reading comprehension, with no restrictions on the way they collaborated. The experiment was repeated after receiving instructional scaffolding assistance. After the experiment, participants were interviewed. The process is shown in Figure 1.

The analysis of collaborative language is mainly carried out in two stages of pre and post-test for feature extraction and collaborative behavior analysis of the following data:

1. Language frequency analysis: the order and number of conversations of group members are compared horizontally;

2. Language behavior analysis: the learning process is divided into two scenarios of group division of labor and group discussion for the changes of activities, and then the language behavior conversion of different scenarios is analyzed.

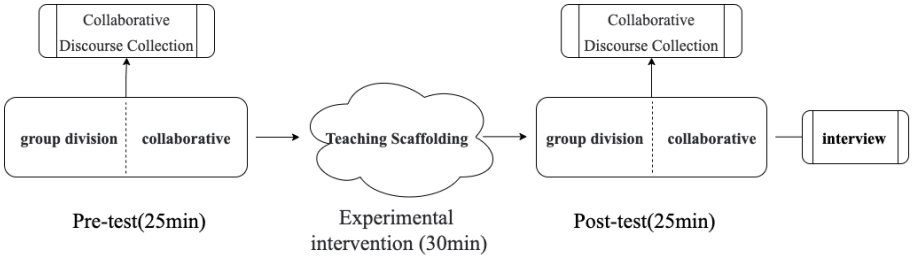

Figure 1: The experimental process

4.1 Language Frequency Analysis

In this study, the frequency, duration and order of the conversations of the three group members were analyzed by coding statistics with the completion of a sentence as one time, as shown in Table 2. According to the descriptive statistics, from the perspective of the total number of team times, the number of conversations among the three people in the pre-test was 51 times, and the number of conversations in the post-test was doubled, and the length of conversations increased significantly from 236 seconds to 842 seconds, indicating that the frequency of cooperative conversations and exchanges between the teams increased, and cooperation became more frequent. From the perspective of personal engagement, the number and duration of conversations among the three members also changed significantly. Among them, the number of conversations of member A increased from 21 to 45, and the duration increased from 121 to 520 seconds, reflecting that the individual participation of the members increased significantly after the intervention.

Table 2: Description Statistics of Dialog Information

Pre-test	The dialogue time (s)	Number of dialogue	Member	Number of dialogue	The dialogue time (s)	Post-test
	121	21	A	45	520	
	42	10	B	18	74	
	73	20	C	32	248	
	236	51	--	95	842	

4.2 Language Behavior Analysis

4.2.1Pre-test division of labor process behavioral discourse analysis results.

A total of 41 effective single sequences were generated during the division of labor in the pretest stage. In this process, there are many single sequences, including communication → communication (8→8), communication → task division (8 →6), information provision → information provision (0→0), information provision → communication (0→8), task division → conflict coordination (6→3), and the sequence are four, four, three, three, three respectively. Moreover, Table 3 shows the adjusted residual values. According to lag sequence analysis theory, if Z-score>1.96 indicates that the behavior path has great significance [49]. It can be seen from Table 4 that there are four significant sequences, namely, information provision → information provision (0→0), opinion sharing → emotion expression (1→2), emotion expression → task division (2→6), conflict coordination → implementation (3→5).

Table 3: The Pre-test of the Division of Labor Process Adjustment Residuals

	0	1	2	3	4	5	6	7	8	9
0	2.32*	-0.82	-0.66	-1.08	0.78	-0.66	-1.76	0	1.47	0
1	-0.74	-0.51	2.38*	-0.67	1.8	-0.41	0.26	0	-0.95	0
2	-0.6	-0.41	-0.33	-0.54	-0.41	-0.33	2.39*	0	-0.77	0
3	0.62	1.43	-0.48	-0.78	-0.59	1.97*	-0.09	0	-1.12	0
4	0.95	-0.51	-0.41	1.16	-0.51	-0.41	0.26	0	-0.95	0
5	0	0	0	0	0	0	0	0	0	0
6	-0.61	1.62	-0.88	1.79	-1.09	0.76	-0.76	0	-0.35	0
7	0	0	0	0	0	0	0	0	0	0
8	-1.61	-1.09	0.76	-0.37	0.26	-0.88	0.83	0	1.35	0
9	0	0	0	0	0	0	0	0	0	0

* indicates that the Z-score value is significant.

In order to more visually present the user behaviour sequence, the behaviour transformation diagram is drawn based on the significant behaviour data. The nodes in the figure represent various user behaviours, the lines represent the significant connection between behaviors, the arrows represent the direction of behavior transformation, the thickness of the lines represent the significance level of behavior connection, and the data on the lines are the adjusted residual value (Z-score). As can be seen from Figure 2, in the pre-test division of labor, collaborators will continuously provide information in a certain period of time (0→0, Z-score =2.32) to clarify the current task, and then express their own views, ideas and emotions on the specific division of labor (1→2, Z-score =2.38), and then confirm the division of labor (2→6, Z - score = 2.39). In this process, there will be conflicts of opinions or role division. After reaching an agreement in coordination, collaborators will start to implement the plan (3→5, Z-score =1.97). In general, as for the process of this division of labor, there are not many significant sequences, the behavior transition map does not form long behavior connections, and there are free single behavior and multiple independent behavior connections, the overall structure is not high.

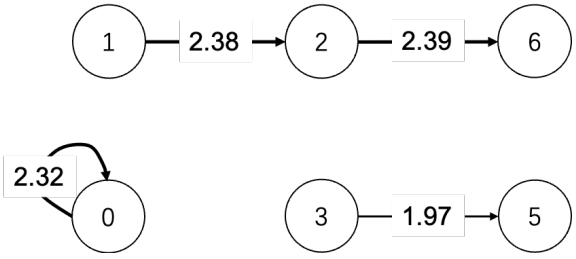

Figure 2: The Pre-test of the Division of Labor Process Behavior Transformation

4.2.2Pre-test discussion process behavioral discourse analysis results.

A total of 6 effective single sequences were generated in the discussion process of the pre-test stage, and few effective single sequences were generated in this process. Table 4 shows the adjustment residuals value. There are two significant sequences: for advice → conflict coordination (7→3) and conflict coordination → implementation (3→5). It can be seen from Figure 3 that in the pre-test discussion process, collaborators will express their own opinions and coordinate the problems with different opinions (7→3, Z-score =2.45). After coordination, the answer of the question will be unified and the plan will be implemented (3→5, Z-score =2.45). In short, as for the process of this discussion, the significance sequence is less, the behavior connection in the behavior transition diagram is single and short, and the overall structure is not high.

Table 4: The Pre-test of Discussion Process Adjustment Residuals

	0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	-0.49	-0.49	2.45*	0	-0.49	-0.49	-0.49
4	0	0	0	-0.77	1.55	-0.77	0	-0.77	1.55	-0.77
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	2.45*	-0.49	-0.49	0	-0.49	-0.49	-0.49
8	0	0	0	-0.77	-0.77	-0.77	0	1.55	-0.77	1.55
9	0	0	0	0	0	0	0	0	0	0

* indicates that the Z-score value is significant.

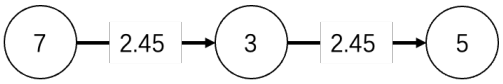

Figure 3: The Pre-test of Discusses Process Behavior Transformation

4.2.3Post-test division of labor process behavioral discourse analysis results.

A total of 42 effective single sequences were generated during the division of labor in the post-test stage. In this process, there are many single sequences, including opinion sharing → communication (1→8), communication → task division (8 →6), information provision →opinion sharing (0→1), for advice → communication (7→8), communication → information provision (8→0), and the sequence is four, four, three, three, three respectively. It can be seen in the Table 5, there are 8 significant sequences. Namely implementation → information provision (5→0), information provision → opinion sharing (0→1), information provision → conflict coordination (0→3), putting forward the proposals → putting forward the proposals (4→4), putting forward the proposal → implementation (4→5), conflict coordination → task division (3→6), communication → task division (8→6) and opinion sharing → communication (1→8).

Table 5: The Post-test of the Division of Labor Process Adjustment Residuals

	0	1	2	3	4	5	6	7	8	9
0	-1.52	2.09*	0	2.09*	-0.7	-0.7	-1.16	0.7	-0.09	0
1	0.96	-1.08	0	-0.41	-0.59	-0.59	-0.97	-1.18	2.44*	0
2	0	0	0	0	0	0	0	0	0	0
3	-0.49	-0.41	0	-0.16	-0.23	-0.23	2.75*	-0.45	-0.6	0
4	-0.87	-0.73	0	-0.28	2.41*	2.41*	-0.66	0.8	-1.07	0
5	2.18*	-0.73	0	-0.28	-0.4	-0.4	-0.66	0.8	-1.07	0
6	-0.7	-0.59	0	-0.23	-0.32	-0.32	-0.53	1.3	0.78	0
7	-0.52	0.96	0	-0.49	-0.7	-0.7	-1.16	0.7	0.81	0
8	0.81	-0.57	0	-0.6	0.78	0.78	2.92*	-1.73	-1.5	0
9	0	0	0	0	0	0	0	0	0	0

* indicates that the Z-score value is significant.

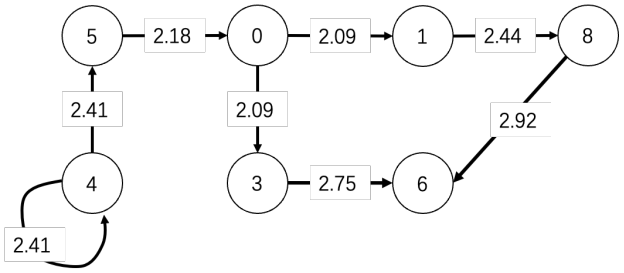

Figure 4: The Post-test of the Division of Labor Process Behavior Transformation

It can be seen from Figure 4 that, after the pre-test and teaching intervention, collaborators will provide information and then express their own ideas and opinions in the post-test division of labor (0→1, Z-score =2.09). At this time, there will be different opinions (0→3, Z-score =2.09), but the division of labor of tasks will be confirmed through communication and exchange (8→6, Z-score=2.92), or confirm the division of labor through coordination conflict (3→6, Z-score =2.75). And collaborators in the process of discussion in a period of time will continue to put forward suggestions (4→4, Z-score =2.41), and then implement the scheme (4→5, Z-score =2.41). It will also give new information (5→0, Z-score =2.18) after the implementation of the scheme.

Compared with the division of labor in the pretest stage, the significance sequence in the division of labor increased significantly, and the behavior transition map formed a long behavior connection, and there was no free single behavior and independent behavior connection, and the overall structure was higher than that in the pretest stage.

4.2.4Post-test discussion process behavioral discourse analysis results.

A total of 47 valid single sequences were generated during the discussion in the post-test stage. In this process, there are many single sequences, including opinion sharing → opinion sharing (1→1), opinion sharing → communication (1→8), communication → opinion sharing (8→1), which are seven, three and three respectively. Table 6 shows the adjustment residuals value, in which there are ten significant sequences. The emotion expression → detection of feedback (2→9), putting forward the proposals → conflict coordination (4→3), conflict coordination → putting forward the proposals (3→4), implementation → detection of feedback (5→9), detection of feedback → information provision (9→0), communication → implementation (8→5), for advice → putting forward the proposals (7→4), task division → for advice (6→7), information provision → emotion expression (0→2), information provision → task division (0→6).

Table 6: The Post-test of Discussion Process Adjustment Residuals

	0	1	2	3	4	5	6	7	8	9
0	-0.64	-1.43	2.15*	0.97	-0.72	-0.31	3.31*	-0.72	-0.8	1.59
1	-0.31	1.49	-0.99	0.41	-1.62	-0.69	-0.69	0.41	1.02	-1.23
2	-0.55	0.05	-0.38	-0.62	1.32	-0.26	-0.26	-0.62	-0.68	1.97*
3	-0.72	0.41	-0.5	-0.82	2.25*	-0.35	-0.35	0.72	-0.9	-0.62
4	-0.72	-0.6	1.85	2.25*	-0.82	-0.35	-0.35	-0.82	0.51	-0.62
5	-0.31	-0.69	-0.21	-0.35	-0.35	-0.15	-0.15	-0.35	-0.39	3.87*
6	-0.31	-0.69	-0.21	-0.35	-0.35	-0.15	-0.15	2.93*	-0.39	-0.26
7	-0.64	-0.31	-0.44	-0.72	2.67*	-0.31	-0.31	-0.72	0.77	-0.55
8	1.83	0.37	-0.65	-1.07	-1.07	2.23*	-0.46	0.19	-0.02	-0.81
9	3.31*	-0.69	-0.21	-0.35	-0.35	-0.15	-0.15	-0.35	-0.39	-0.26

* indicates that the Z-score value is significant.

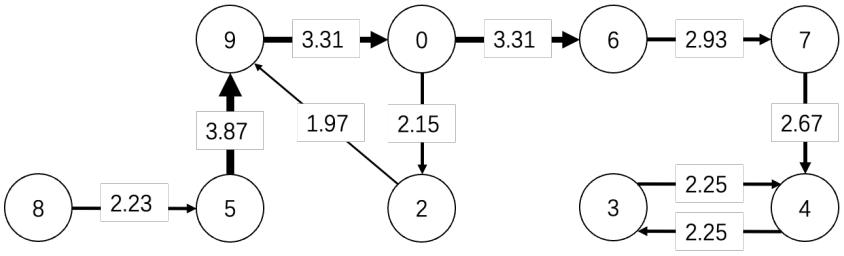

Figure 5: The Post-test of Discusses Process Behavior Transformation

As can be seen from Figure 5, in the post-test discussion process, collaborators divided tasks twice. Collaborators who had completed their own tasks sought the opinions of those who had not completed their own tasks to supplement and improve the group tasks (6→7, Z-score =2.93). After improvement, collaborators entered the discussion stage and put forward their own suggestions combined with opinions from various parties (7→4, Z-score=2.67) to promote the progress of the group. When their suggestions and information conflict, while expressing their own attitudes (0→2, Z-score =2.15), the members of the group constantly try to establish a balance point of negotiation and coordinate the intra-group conflict (4→3, Z-score =2.25; 3→4, Z-score =2.25), and then determined the division of labor (0→6, Z-score =3.31). Through continuous communication, team members worked out feasible plans and implemented them (8→5, Z-score =2.23). Finally, combined with the attitude of the group members, the progress of program improvement and the relevant information provided by the group members, the evaluation of the current collaborative reading results was evaluated (2→9, Z-score =1.97; 5→9, Z-score =3.87), and then according to the prompts of the experimental intervener (time, answer filling, etc.), the members presented the final result feedback (9→0, Z-score =3.31).

Compared with the sequence of the same process in the pretest stage, the significance sequence in the discussion process is significantly increased, and the behavior transition graph forms longer and more complex behavior connections. The number of behavior transition paths is more significant, and the overall structure is relatively high.

In general, after building a learning scaffold for learners, both language frequency and language behavior have significant changes from the perspective of collaborative language behavior, which reflects the obvious improvement of individual participation and team cooperation ability to a certain extent.

5 DISCUSSION

5.1 Discussion of Collaborative Discourse Data

In the process of group collaborative reading, we divided the dialogue data into two parts: language frequency analysis and language behavior analysis. Descriptive statistics were used for the former, lag sequence analysis was used for the latter, and GSEQ software was used to study the behavior transformation of collaborative language.

From the analysis results, there were significant differences in the changes of group members before and after the test, and the frequency and duration of individual and group speech were significantly improved. It can be seen that after the intervention of the teaching support, the collaborative attitude of the collaborators became more positive and the degree of collaboration became more intensive. At the same time, the group members' behavior changes more frequently, from the original single language behavior to diversified language behavior. In general, the collaborative discourse data, to some extent, reflects the obvious improvement of individual participation and team cooperation ability.

5.2 Discussion of Interview Results

At the end of the experiment, three subjects were interviewed about their feelings in the process of collaborative reading. See Appendix 1 for specific questions in the interview. The interview found that after collaborative reading and learning, the participants could basically express their own ideas and understanding. Especially when the collaborators had different opinions with other members in the process of collaboration, two collaborators would mainly participate in the discussion and negotiation, and the results were discussed with others, and the problem could be solved easily.

At the same time, in terms of the attitude towards collaborative reading, one collaborator thought that he was more active than in the previous learning activities, another collaborator thought that there was no much difference compared with the past collaborative learning activities, and another collaborator thought that his performance was not as positive as before, because of personal personality and experimental reasons. As a result, the first time they cooperated with other collaborators, they could not really express their ideas, but the three subjects all thought that their own investment in the collaborative reading process was higher than before, and the cooperation was interesting to a certain extent.

From the perspective of teaching support, first of all, collaborators agree with the tool support of collaborative learning tool. They all think that the operation of collaborative learning tool is more skilled than the previous collaborative learning tool, and the use of collaborative documents makes the collaboration between collaborators more convenient and convenient. Secondly, support for teaching intervention, the two collaborators that guides provided by the cooperative reading skills and methods for their strong help reading comprehension, and a collaboration is thought to help sex is extremely strong, collaborative test after reading process is relatively easy, but as a result of experiment is difficult to read text, fewer intervention and lack of continuity, Therefore, it is difficult to improve the reading comprehension ability of collaborators in a short period of time.

From the perspective of future learning tendency, the collaborators held a positive attitude towards collaborative learning. The three collaborators expressed that they hoped to have more opportunities to participate in collaborative learning to improve their English reading comprehension ability in the future, and they also paid more attention to the improvement of their future collaborative ability.

6 CONCLUSION

In this study, the online collaborative document was used as a technical scaffolding and the intervention of scaffolding instructional strategies was applied to analyse the two collaborative learning discourses of the three participants before and after the intervention. The analysis of the two collaborative discourses before and after the intervention revealed that the frequency and extent of collaborative editing and language behaviour change were significantly higher in the post-test than in the pre-test, i.e., the intervention of the scaffolding strategy had a positive effect on the learners' collaborative reading level. In the post-experimental interviews, all three participants expressed their positive perceptions of collaborative reading and collaborative learning in terms of their own psychological, attitudinal, and learning tendencies, as well as the change in their own thoughts in the pre and post-tests. The multi-faceted analysis confirmed the effectiveness of the scaffolding instructional strategy designed for this study and the operability of the online collaborative document-based tool.

The limitations of this study are attributed to two points. Firstly, this study adopted case study approach, and due to various factors and limitations, only three graduate students were selected for the study, which was not fully representative. The data from the three participants may not be sufficient to support the research questions of this study. Secondly, this study selected IELTS reading questions as the material for collaborative reading in English. Because of the difficulty of

the experimental reading text, the small number of interventions and lack of continuity, it was difficult to improve the overall reading comprehension ability of the collaborators in a short period of time.

Future research on collaborative learning can select texts with more complete content systems, pay attention to the difficulty design of learning tasks, take into account different contexts and scenarios, control the cognitive load of collaborators within a reasonable range. Besides, we need to make full use of the support of technological tools such as online collaborative documents, and design more scientific and effective scaffolding teaching strategies to promote learners' collaborative reading ability.

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A APPENDICES

A.1 The Interview Outline

1. Through this collaborative learning, do you feel that you could not solve the problems comfortably and can not express your ideas completely?
2. During this collaborative learning process, when you disagreed with other members during the collaborative process, how did you handle it?
3. During this collaborative learning process, do you feel that you performed more actively than in previous collaborative learning activities?
4. Do you feel that you are more proficient in the operation of the collaborative learning tools than you were in the past?
5. Do you find the collaborative process more interesting and engaging through this collaborative learning?
6. During this collaborative process, do you think the instructor brought help to the collaborative learning?
7. Do you feel that collaborative learning became easier than before through this collaborative learning?
8. Do you think your collaborative learning skills have improved very much as a result of this collaborative learning?
9. Do you want more opportunities to improve your collaborative learning skills through collaborative learning as a result of this collaborative learning?
10. Have you paid more attention to the improvement of collaborative ability through this collaborative learning?