Behavioral and Relationship Patterns in an Online Collaborative Reading Activity

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Abstract: Online collaborative reading has been widely implemented as an instructional activity in various context, with many studies demonstrating effective learning outcomes. Based on knowledge construction theory, we put forward an online collaborative reading approach to learning from an academic handbook in a graduate-level course. Through examination of the behavioral patterns and relationship patterns of different phases in the course, we found that student contributions to peers' micro-courses were not symmetric; some students would submit irrelevant comments in different collaborative phases, and almost all students kept in touch with each other directly. Our study also indicated that students' task load and consistency were two important factors to affect their collaborative performance. Our findings would help course teachers design and conduct collaborative reading activities at the postsecondary level in future.

Introduction

Knowledge construction has been widely used and discussed, which emphasizes that students construct new knowledge through social interactions (Huang, 2002; Kanuka & Anderson, 2007). Advancement in internet technology has led to an increase in instructional activities with computer support, such as English language reading instruction (Chen, Chen, & Sun, 2010). Based on knowledge construction theory, previous studies of online collaborative reading mainly focus on students' reading attitude, reading comprehension, reading strategy, motivation, and learning effectiveness, and reveal that students in collaborative learning environments demonstrate stronger cognitive development, more positive learning attitude, and higher learning motivation than control groups (Chen & Chen, 2014; Ding, 2009; Lin, Chen, Yang, Xie, & Lin, 2014).

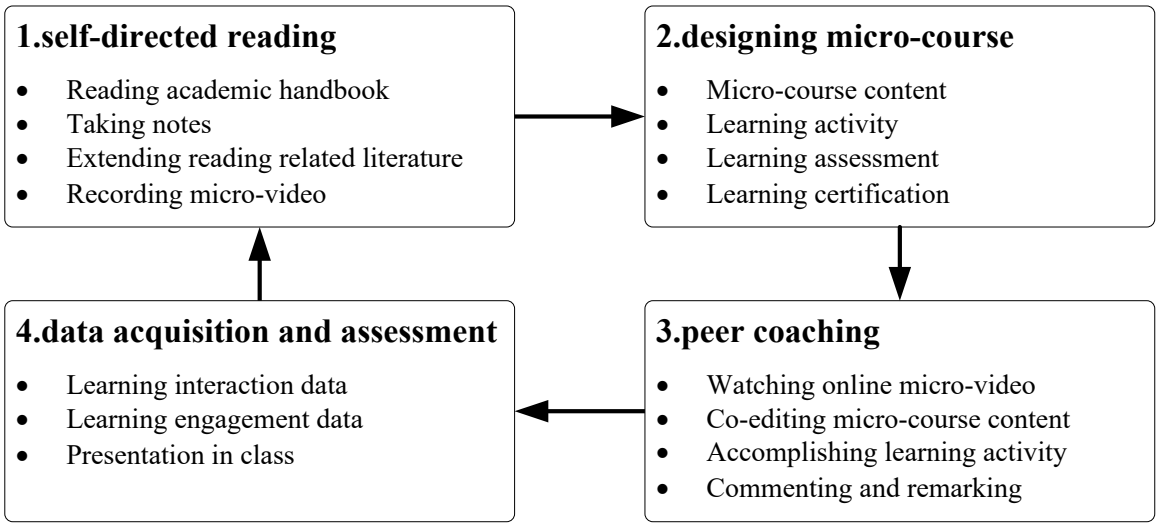

Figure 1. The online collaborative reading procedure. Adopted from Wan et al. (2015)

Peer tutoring is vital to collaborative learning (Robinson & Hullinger, 2008). However, students in conventional collaborative learning environments tend to share and compare the available information rather than to construct new knowledge (Ma, 2009; Schellens, Van Keer, De Wever, & Valcke, 2008). They are usually only required to finish tasks according to reading materials rather than generate new knowledge for peer to study (Chen & Chen, 2014; Lin et. al, 2014). In this study, we put forward an innovative collaborative reading approach with four stages: self-directed reading, designing micro-course, peer coaching, and data acquisition and assessment (as shown in Figure 1; for detail referring to Wan, Yu, Cui & Chiang, 2015). Apart from sharing information, students not only need to generate new information through their own reading, but they also need to finish learning the

information generated by their peers in this innovative collaborative reading activity. Identification of students' collaboration pattern is of value to pedagogical and technical design (Lin et. al, 2014). For example, the sequential analysis technique could demonstrate the sequences of students' action and has been widely used to analyze online collaborative discussion (Hou & Wu, 2011; Shukor, Tasir, Van der Meijden, & Harun, 2014). Therefore, this study attempted to investigate the students' behavior and relationship patterns by lag sequential analysis and social network analysis to provide reference for course teachers to design and conduct collaborative reading activities in higher education.

Method

Participants

The participants were twelve graduate students and one visiting scholar in a graduate course, New Development of Educational Technology, at a university in China. The course contained lectures implemented by professors and the reading activity of an English academic handbook which made up the students' course assignment. Apart from simply reading the English academic handbook, the course required students to make a micro-course of each article they read according to their own understanding. Students were also required to learn and contribute to peers' micro-courses with the Learning Cell System (an online collaborative learning system described below). All the students received prior training and were capable of using this learning system with ease.

Procedures

At the beginning, the course teacher selected the Handbook of Research on Educational Communications and Technology (4th edition) published by Springer as reading materials. This handbook was written in English and included nine sections with seventy-four articles, covering foundations, methods, assessment and evaluation, general instructional strategies, domain-specific strategies and models, design, planning, and implementation, emerging technologies, technology integration, and look forward. The goal of reading the handbook was to support the students in developing a systematic understanding of educational technology research and its development.

Afterwards, each student randomly chose five or six articles. The course teacher divided the whole semester into three phases and each phase lasted six weeks. During each phase, the students completed four tasks, (i.e., reading two articles, making two micro-courses, learning twenty-four micro-courses of peers with learning system, and making one presentation in an offline class). Those micro-courses required students to create a complete teaching structure, including a micro digital resource (e.g., micro-video), a learning activity and a learning assessment.

Finally, all of the interaction data generated in the process of the collaborative reading activity were exported to one Excel file for further lag sequential analysis and social network analysis.

Instruments

Learning Cell System

An online collaborative learning system entitled Learning Cell System (LCS, http://lcell.bnu.edu.cn) (Yu, Yang, Cheng, & Wang, 2015) was used to observe the behavioral and social network patterns by supporting the whole process of the collaborative reading activity. The heart of LCS is an open, networked, communal knowledge community. Its main functions are learning cell, knowledge group, knowledge cloud, learning tool, personal space, and learning community. A learning cell serves as a micro-course, which usually includes learning content, learning activity and learning assessment. Students could share their ideas and information, and contribute to peers' ideas through authoring or coauthoring a learning cell.

Coding scheme

To understand the learners' process of social knowledge construction, the items in Gunawardena, Lowe and Anderson's (1997) coding scheme were adopted as the scheme has been widely used in many studies of online collaborative learning patterns (Choo, Kaur, Fook, & Yong, 2014; Hou & Wu, 2011; Yang, Li, Guo, & Li, 2015). Gunawardena et. al (1997) divided the knowledge construction process into five dimensions: 1) sharing and comparing information, 2) discovery and exploration of dissonance or inconsistency, 3) negotiation of meaning and co-construction of knowledge, 4) testing and modification of the proposed synthesis and co-construction, and 5) agreement statement(s) and applications of newly constructed meanings (see B1 to B5 in Table 1). In addition, we added a new dimension B6 to express irrelevant information to this collaborative reading task. Thus, the coding scheme for content analysis in online collaborative reading behaviors of English academic handbook is shown in

Table 1, which also provides behavior type and content example for each item to more clearly to clarify different behaviors.

Each log or comment message was treated as a unit and coded, and the codes were then arranged in chronological order. 9343 log messages and 851 comment messages were yielded during the 120-day observation. These log messages were coded according to their categories (e.g., creating learning cell, browsing, cooperative editing learning cell, remark, reflection) defined in LCS. These comment messages were coded by two coders with the same expertise according to the scheme and the kappa value was 0.73.

Table 1: Coding scheme for knowledge collaborative construction behaviors

Code	Dimension	Behavior types and examples
B1	Sharing/comparing of information	Creating learning cell, adding learning activities, uploading learning material, and releasing reading work and concept map.
B2	Discovery and exploration of dissonance or inconsistency among participants	Browsing, collecting, and giving feedback on learning cell created by peer; coming up with confusion during learning. Can "qualitative research" be translated into "质性研究" or "定性研究"?
B3	Negotiation of meaning/co-construction of knowledge	Cooperative editing learning cell, modifying video and content, adjusting content structure, comment. Discussion with peer on topics and give suggestion on problems.
B4	Testing and modification of proposed synthesis or co-construction	Remark, comment, annotation, pointing out problem. I cannot hear clearly of the back of video. I think "educational design research" translated into "教学设计研究" will lead to misunderstanding. The micro-course does not include learning activity.
B5	Agreement statement(s)/application of newly constructed meaning	Reflection, comment, annotation. Writing reflective journal entries. I think teacher cannot be replaced by pedagogical agent. I agree that both the internal validity and external validity are important for a study.
B6	Other interactions with no relations with the reading task	Irrelevant information. Very good. You have done a good job. You are an idol for me. I have got a lot from it.

Results and discussion

At the end of semester, we found that the students did not strictly follow the pre-class requirement made by course teacher, (i.e., reading two articles and making two micro-courses in each phase). Four micro-courses were submitted after the end of course and one micro-course was incomplete. Hence, the coded 10194 messages were about those sixty-nine micro-courses. The sum frequency of B1 was 312, of B2 was 7490, of B3 was 963, of B4 was 729, of B5 was 401 and of B6 was 299. The distribution of those coded messages in each phase is shown in Figure 2. As shown in Figure 2, the behavior frequency in phase 3 is more than phase 1 and phase 2. And the behavior frequency difference was very big because students only made 18 micro-courses during the first phase, 12 micro-courses during the second phase and 41 micro-courses during the last phase. In each phase, the behavior frequency of B2 was always larger than other behaviors, even the sum of other behaviors.

GSEQ 5.1 (Bakeman & Quera, 2011) was used to conduct lag sequential analysis by analyzing the behavioral patterns of knowledge construction in collaborative reading process. Table 2 shows the frequency of each behavioral category immediately following another behavioral category in different phases (Phase 1, Phase 2, and Phase 3). The columns represent the starting behaviors, whereas the rows represent the behaviors that occurred after the starting behaviors finished. The numbers represent the total number of times a column behavior occurred immediately after a row behavior ended (e.g., in row 2 column 3, the number 216 meant that "B3 occurred immediately after B1," which happened 216 times in Phase 1).

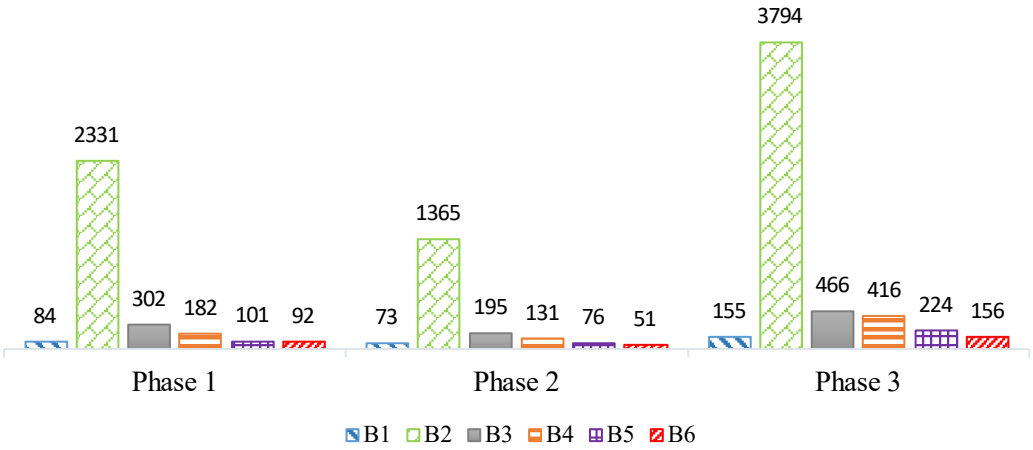

Figure 2. Frequencies of knowledge collaborative construction behavior (Phase 1 to Phase 3).

Table 2: Frequency transition table (Phase 1 to Phase 3)

	Frequency	B1	B2	B3	B4	B5	B6	Total
Phase 1	**B1**	42	26	12	1	0	2	83
	B2	16	1889	216	136	26	32	2315
	B3	7	217	42	26	6	4	302
	B4	0	43	13	8	68	50	182
	B5	0	84	10	6	1	0	101
	B6	1	72	9	5	0	4	91
	Total	66	2331	302	182	101	92	3074
Phase 2	**B1**	24	34	12	1	2	0	73
	B2	24	1077	118	95	26	15	1355
	B3	10	115	46	19	3	2	195
	B4	1	35	10	10	42	32	130
	B5	1	62	5	5	2	0	75
	B6	2	41	4	1	1	2	51
	Total	62	1364	195	131	76	51	1879
Phase 3	**B1**	68	57	26	1	1	2	155
	B2	37	2944	71	289	71	44	3756
	B3	7	356	33	57	5	6	464
	B4	0	97	24	139	139	101	416
	B5	0	199	6	7	7	1	223
	B6	2	141	6	1	1	2	156
	Total	114	3794	466	416	224	156	5170

Table 3 shows the results of adjusted residuals. The Z-score of a sequence greater than 1.96 means that the connectivity of this sequence reached statistical significance ($p < 0.05$) (Bakeman & Gottman, 1997). According to those 22 statistically significant sequences with Z-score greater than 1.96 in Table 3, we formed the behavioral transition diagrams (see Figure 3.) The node represents one of the six behavioral categories, the numerical value represents the Z-value for the sequence, the arrowheads represent the transitional direction, and the connecting line thickness represents the level of significance.

Table 3: Adjusted residuals table (Z-scores) (Phase 1 to Phase 3)

	Z-score	B1	B2	B3	B4	B5	B6
Phase 1	**B1**	**30.88***	−9.60	1.44	−1.85	−1.70	−0.32
	B2	−9.73	**13.05***	−1.61	−0.19	−11.75	−9.15
	B3	0.22	−1.70	**2.51***	**2.08***	−1.33	−1.79

	B4	−2.06	−16.96	−1.25	-0.90	**26.59***	**19.98***
	B5	−1.51	1.75	0.03	0.01	−1.32	−1.79
	B6	−0.70	0.74	0.02	−0.17	−1.78	0.80
Phase 2	**B1**	**14.43***	−5.08	1.73	−1.92	−0.58	−1.46
	B2	−5.96	**10.77***	−3.82	0.11	−7.52	−6.89
	B3	1.51	−4.50	**6.39***	1.61	−1.88	−1.53
	B4	−1.67	−12.10	−1.04	0.33	**16.95***	**15.93***
	B5	−0.97	**2.00***	−1.08	−0.11	−0.62	−1.48
	B6	0.25	1.27	−0.60	−1.42	−0.77	0.54
Phase 3	**B1**	**35.87***	−10.47	**3.43***	−3.44	−2.29	−1.28
	B2	−9.74	**13.25***	**3.54***	−1.52	−14.06	−12.65
	B3	−1.07	1.71	−1.50	**3.52***	−3.61	−2.28
	B4	−3.19	-24.10	−2.41	**4.05***	**30.38***	**26.44***
	B5	−2.29	**5.48***	−3.37	−2.00	−0.90	−2.29
	B6	−0.80	**4.88***	−2.29	−2.56	−2.30	−1.29

Figure 3 shows that there were remarkably different behavior sequences in different phases. In phase 1, the significant behavioral sequences included: B1→B1, B2→B2, B3→B3, B3→B4, B4→B5, and B4→B6. Meanwhile, phase 2 also had six significant behavioral sequences, just B5→B2 substituting B3→B4. In phase 3, the significant behavioral sequences included: B1→B1, B1→B3, B2→B2, B2→B3, B3→B4, B4→B4, B4→B5, B4→B6, B5→B2 and B6→B2. In addition, B1→B3, B2→B3, B6→B2 were three new emerging behavioral paths. These sequences demonstrated the whole behavioral patterns in online collaborative reading activity.

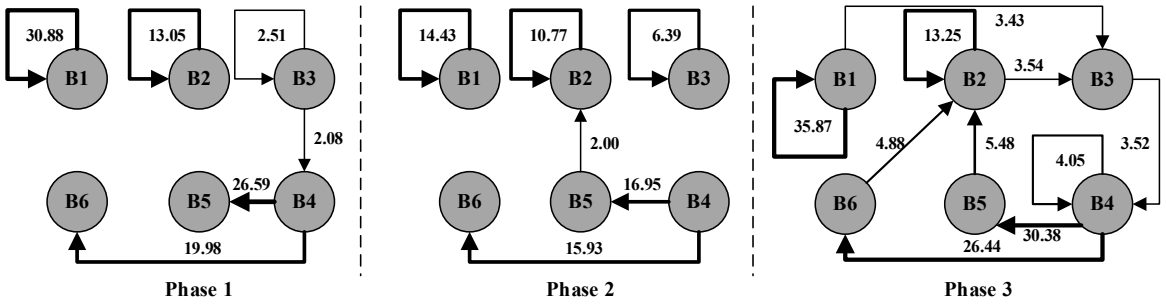

Figure 3. Behavioral transition diagrams in different phases.

First, let us turn to those uniform behavioral sequences in the three phases. The behavioral path B1→B1 in the three phase indicates that students tended to preserve their behavioral transition when they shared or compared information. This is because students usually added learning activities or uploaded resources after creating learning cells. And the Z-score of behavioral path B1→B1 in three phase seems to be positively correlated to the number of micro-courses created by students in each phase. The behavioral path B2→B2 in the three phases indicates that students tended to maintain their behavioral transition when they discovered and explored the dissonance or inconsistency. In order to understand peers' micro-course, students needed to watch the micro-videos again and again, and participated in learning activities. The Z-score of behavioral path B4→B5 in each phase is relatively large, which demonstrates B4 and B5 have significant correlations with each other in the collaborative reading process. But this result is inconsistent with the previous research findings (Hou, Chang, & Sung, 2007; Hou & Wu, 2011; Yang et. al, 2015), which held the view that B4 and B5 rarely occurred in the overall cooperation process. During this online collaborative reading activity, however, students were prompted to revise their micro-courses according to peers' comments before reaching an agreed upon understanding of the core idea of the article related to the micro-course. The behavioral path B4→B6 in each phase reveals that students discussed some irrelevant topics with the current collaborative reading task after pointing out the problem or rating. In addition, the Z-score of this behavioral path is very high in each phase, which indicates that the teacher needed to give some guides to help students solve the problem rather than just let the students explore freely.

Next, we explain the disparate behavioral sequences in each phase as shown in Figure 2. In phase 1, students always maintained their behavioral transition when they collaboratively edited the learning cell, adjusted content or learning activity, and discussed with peer about article idea (B3→B3, Z-score=2.53). Meanwhile, the behavioral path B3→B4(Z-score=2.08) suggests that students would often give a rating after they had completed

micro-course learning or proposed questions. In phase 2, the behavioral path B3→B3 shows that students maintained their collaborative editing of the learning cell, adjusting content or learning activity and discussing ideas in the article with peers. Those behaviors could facilitate the advancement of the micro-course, and that may explain why the quality of the micro-course in the first two phases was better than the last phase. In addition, students did not make reflections or state their point of view all the time, rather, they put forward new questions or expressed confusion during their agreement statements (B5→B2, Z-score=2.00). Being a coauthor of peers' micro-course means that the student would have the same authority as the micro-course creator, such as editing learning content without checking, and cooperatively designing the learning activity and learning assessment. In phase 3, students coauthored peers' micro-courses and added learning activity and uploaded the resources by themselves (B1→B3, Z-score=3.43). Moreover, students coauthored their peer's micro-courses and provided some solutions for problems when they learned in the micro-courses (B2→B3, Z-score=3.54). In addition, a helpful behavioral path B6→B2 indicates that students did not do irrelevant things repeatedly, but returned to learn in the micro-courses or declare their confusion. Moreover, students sustained their behavioral path B3→B4 appearing in phase1, and B5→B2 appearing in phase 2.

Next, Ucinet 6 (Borgatti, Everett, & Freeman, 2002) was used to conduct social network analysis by analyzing the patterns of relationship among members in collaborative reading process. Figure 4 illustrates that the social network of collaborative reading activity is a connected graph. The node represents the student, the line represents the relationship between students, and the arrow direction represents the information flow. Cohesion means that a network of individuals contains many ties and yields a tighter structure, which is usually identified by density, reciprocity, and actor distance (Hu & Racherla, 2008). The density of this network is 0.92, which implies that it is high-density network. Students almost kept in touch with every other student. The hybrid reciprocity of the network is 0.83, which implies lots of reciprocal interactions generated among students. The average distance of the network is 1.01, which implies that each student could almost directly contact with other students. In short, the whole social relationship network was symmetric, and all the students maintained a relatively frequent contact with each other, except the visiting scholar who only designed her own micro-courses without learning from other students' micro-courses. The reason for it may be she did not hold any pressure to obtain the course credit. Hence, it required course teachers to take the consistency of participants into consideration before implementation.

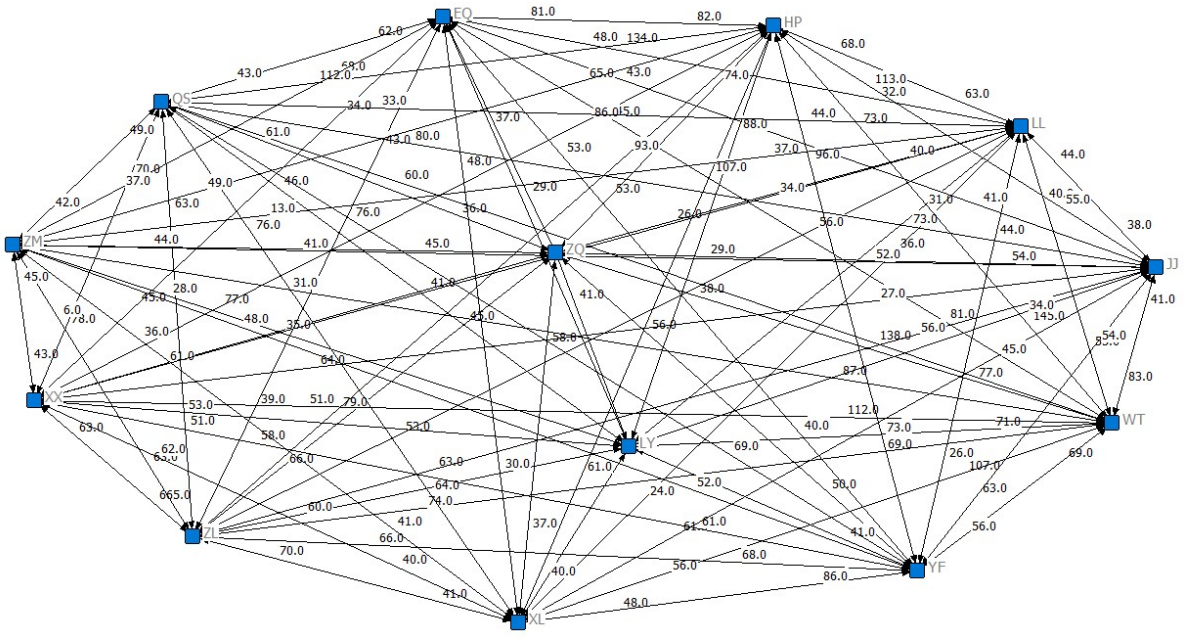

Figure 4. Social relationships network in online collaborative reading activity.

Conclusions and suggestions

In this study, we coded the logs and comment message contents, and conducted a sequential analysis of behaviors and a social network analysis in an online collaborative reading activity. We found that 1) the behavioral sequences of students' knowledge construction presented different characteristics in three phases, though some

behavioral paths, such as B1→B1, B2→B2, B4→B5, and B4→B6, appeared all the time; 2) the behavioral path became more and more abundant with further deepened collaboration, such as the path B6→B2 emerging in the third phase, which might be caused by students' increasing interest and adeptness in this innovative collaborative reading approach; 3) students maintained relatively frequent contact with each other, which might be due to peer coaching instruction strategy. In addition, we also discovered that 1) contributions that students made to peers' micro-courses were not symmetric, such as someone contributing a lot to peers' micro-courses but receiving little contribution from peers on his or her own micro-courses; 2) students would submit some irrelevant comments in order to increase their course score. One reason for the irrelevant information may be that LCS could not make semantic analysis of students' comment content automatically at this moment which resulted in assessment according to the quantity rather quality. A possible solution to these problems is that the course teacher designs a better assessment scheme including artificial assessment and word segmentation. Moreover, contributions to peers' micro-courses and the quality of comments should be covered in artificial assessment.

In summary, this study explored interactive behavioral patterns and relationship patterns in an online collaborative reading activity through an innovative approach. This innovative approach is very different from previous studies: we used adult participants while previous studies used primary and secondary school students (Chen & Chen, 2014; Goh, Chai, & Tsai, 2013; Lin et. al, 2014); each of our participants used different reading material, rather than having participants use the same material (Chen et. al, 2010; Looi, Lin, & Liu, 2008); and we employed a new learning platform(LCS) for knowledge building, rather than using wiki (Chang, 2009; Kimmerle, Moskaliuk, & Cress, 2011) or knowledge forum (Hong, 2014; Hong, Chang, & Chai, 2014). Furthermore, our findings are helpful to further study collaborative reading among EFL students in higher education. For course teachers, they need to provide an effective incentive mechanism and assessment scheme, take the students' load of reading task and participants' consistency into considerations, and allocate the materials of the same theme to one person. Nevertheless, there exist some limitations to this study. Firstly, only thirteen students participated in this study which led to some analysis outcomes that are not statistically significant. Second, the study lasted a long time and generated many behaviors, with the result that some behaviors were inappropriately coded according to the categories defined in LCS. In the future, we will increase the number of participants and set up a control group to investigate the actual effect of this innovative collaborative reading approach on learning performance.

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