Collective Cognitive Responsibility in Knowledge Building Community: Theoretical Model Construction and Application Research

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Abstract: Through observation of Knowledge Building (KB) teaching practice in the secondary vocational schools, the researchers found that the big challenge for the teacher was many students pay more attention to specific skills operation and lack the ability and motivation of collaborative inquiry learning in the classroom. The guiding theory and effective strategies will be the bridge to the practice. This research initially constructs a theoretical model for the teacher to enhance the students' collective cognitive responsibility (CCR) in KB community. Under the guidance of the theoretical model, the corresponding teaching strategies are designed and is carried out in the first experimental class for a semester. The research team systematically analyzed the teaching practice data and revised the CCR theoretical model, then conducted teaching practice in the second experimental class for another semester. The results of data analysis from two teaching practices show that the CCR theoretical model is effective to enhance students' CCR.

Introduction

Knowledge-Building (KB) is a theory of teaching and learning facing the knowledge societies in the 21st century which has been an important research branch of International Learning Science. The goal of KB is to reframe school as a knowledge-creating enterprise (Scardamalia & Bereiter, 2003) and engage every student as a participant in the creation of knowledge, not just a receiver, sharer, or disseminator. At the same time, nobody should be excluded from knowledge societies, where knowledge is a public good, available to each individual. Everyone in the knowledge creating organization has the responsibility and obligation to contribute to the collective production of new knowledge, which requires that they to assume Collective Cognitive Responsibility (CCR) in order to truly promote the development of collective cognition and generate new knowledge.

A number of scholars have done relevant research on this topic. In a systematic analysis of 875 studies the Johnson brothers found that positive interdependence among group members was the key to improving group creativity (Johnson & R. Johnson, 1989; Johnson & R. Johnson, 1994). More recent work found that students working on electronic portfolios guided by KB principles showed deeper inquiry and more conceptual understanding than their counterparts (Lee & Chan, 2006; van Aalst & Chan, 2007). The distributed social structures in real-world knowledge creating organizations and resulted in the highest level of collective cognitive responsibility, knowledge advancement, and dynamic diffusion of information (Zhang, 2009). Some scholars believed that the more balanced distribution of impactful builders in each inquiry group can influence and enhance the cognitive process of other learners and promote their CCR and create more community knowledge (Braojos, 2015, 2019). There are also other scholars believe that that collaborative innovation networks (COINS) mechanism should be adopted to promote learners to undertake collective cognitive responsibility more effectively (Ma, Matsuzawa, Chen, et al., 2016; Ma, Tan, Teo & Kamsan, 2017).

The above research results are suggestive but lack in-depth theoretical analysis of the internal mechanism of CCR and of the efficacy of the teaching strategies intended to develop it. Relevant unanswered questions include: How can the processes by which community members develop CCR be effectively analyzed? How can effective teaching strategies be designed to promote development of CCR by a Knowledge Building Community (KBC)? To address these questions, this study carried out two semesters of teaching practice in two experimental knowledge building classes in secondary vocational schools.

Method and Process

In order to address these two research questions, we carried out teaching practice for two semesters in two experimental classes according to the design research process shown in Figure 1.

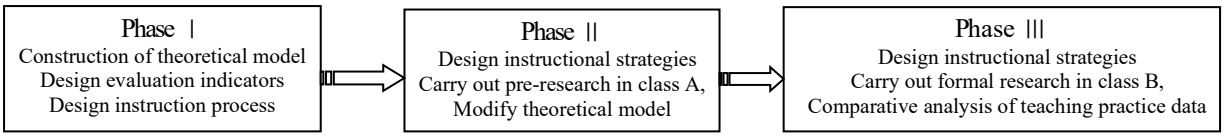

Figure 1. Research Process

Knowledge Building Environment

This study is a 2-year Design-based Research experiment (Collins, Joseph, & Bielaczyc, 2004) aimed at evaluating the possibility and means by which secondary vocational school students can assume collective responsibility for sustained knowledge advancement. Students reference, evaluate, build on, and work to continually improve ideas—their own and those of community members on the Knowledge Forum (KF) platform, which can provide statistics on the frequency of learners' participation and the number of posted notes and establish the social network structure among the Note-Linking.

Construction of CCR Model

Responsibility is a core concept in ethics, political science and law, and has multiple meanings. As used in these studies, the responsibility connects the ***subject, behavior, consequence and evaluation*** (Jonas, 1985; Wang, 2015). CCR is a kind of responsibility and it also involves three elements: subject, behavior and consequence. There are some differences in educational research, the consequence often refers to the result and effect of learning, and its essence is reflected in the development and change of learners' cognition, the evaluation reflects the result of CCR undertaken by learners, which is carried out separately in this study. According to the literature review and previous teaching practices, the paper analyzed the development and transformation process of the CCR assumed by the members in the KBC from the perspectives of the subject, cognition and process, and designed a three-dimensional theoretical model (Figure 1) for analyzing the KBC members' CCR for the pre-research providing a theoretical framework. In the subjective dimension, the role of the student who takes CCR is a dynamic process from individual to Knowledge Construction Group to class community, and the key influencing factor is the socialization structure of students. In the cognitive dimension, students' CCR is embodied in the gradual process from surface cognition to deep cognition, and the key influencing factor is the quality of KB Discourse. In the process of dimension, learners undertake CCR through the development process from no-discipline to heteronomy to self-discipline, and the key influencing factor is the establishment of KB rules.

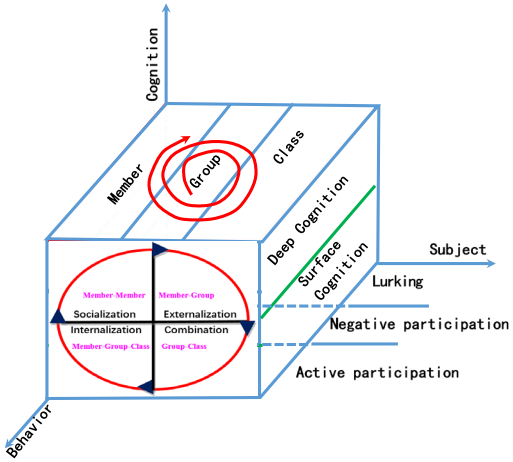

Figure 2. Initial CCR Model

Design Evaluation Indicators

The performance of learners' CCR is reflected mainly in three dimensions: behavior, cognition and subject, the research team constructed the evaluation indicators based on these dimensions.

Behavioral Dimension

There are many indicators to evaluate learners' participation. In addition to the indicators such as Frequency of Participation and Interaction Frequency on the KF platform, the research team has also constructed the member activity index (MAI) for assessing community members' CCR referring to Activity Index formula (1) which is a widely used index to evaluate the relative competitive advantage in the field of economics (J.D. Frame, 1977). The Activity Index formula is used to measure the competitiveness of a country, which is carried out by measuring the number of scientific papers published by various industries in a country, and it is very similar to the number of notes posted by learners in KF platform.

$$MAI = \frac{NMF/NMC}{NAMF/NAMC} \quad (1)$$

In MAI *NMF* denotes the number of notes posted by member A in Field K (The teacher and students divide the questions and notes posted by all the community members on KF platform into different research directions, Field K is one of them), *NMC* denotes the number of notes posted by member A in Community, *NAMF* denotes the number of notes posted by all members in Field K, *NAMC* denotes the number of notes posted by all members in KBC.

Cognitive Dimension

The common methods of evaluating members' CCR by researchers is online discourse analysis which identifies the epistemic levels of students' inquiry and explanation. (Eddy Y.C. Lee, Carol K.K. Chan & Jan van Aalst, 2006). However, there are also some ideas are declarative descriptions shown in Figure 3, not questions or answering questions. Following Piaget's theory of Genetic Epistemology, the author constructed a cognitive depth model (see Figure 4) referring to Biggs' SOLO (Structure of Observed Learning Outcomes, 1982) model and Webb's (2002) Depth of Knowledge (DOK) model for assessing these declarative descriptions. The author developed a rating scale for students' views which include questions, explanations and descriptive descriptions (see Table 1).

Figure 3. Declarative Description in KF Platform

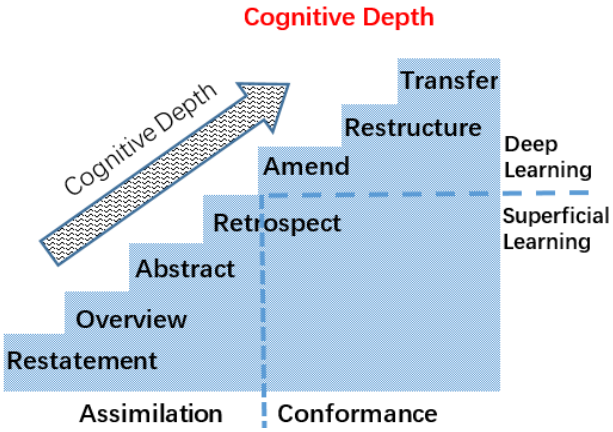

Figure 4. Cognitive Depth Model

Table 1: Rating scheme for cognitive depth

Rating	Description	Content Explanation
1	Restatement	Give opinion without evidence or elaboration; repeat or simply restate a fact or a statement that has been made, cutting and pasting are used rather than making their own interpretation.
2	Overview	Give factual information and general description; give a brief summary; responses are usually centered on facts and topics.
3	Abstract	Make a summary of the problem and different ideas, make a reasoning based on relevant information.
4	Retrospect	Make assertions supported with explanation, evidence and relevant examples.
5	Amend	Adjust and correct one's ideas and concept according to others ideas.
6	Restructure	Synthesize different points of views and make a 'rise-above' summary.
7	Transfer	Analyze problems in depth, explain problems from a theoretical level, and propose the solutions to the other related problems.

Community knowledge is public knowledge—ideas made accessible to all community members through contributions to collective knowledge spaces. Key terms (or words) represent a fairly objective unit of analysis and it is possible to easily extract key terms from a KF database as all the network behavioral data of KF students are recorded and stored. Some researchers used the Key terms to assess the Community knowledge in a knowledge building environment (Hong, 2014). Other scholars constructed the indicators of Key-term-based to measure knowledge elaboration (Zheng, 2016). However, because these indicators can't comprehensively reflect the quality of community knowledge, the author constructed a set of triangular evaluation methods based on key terms shown in Figure 5.

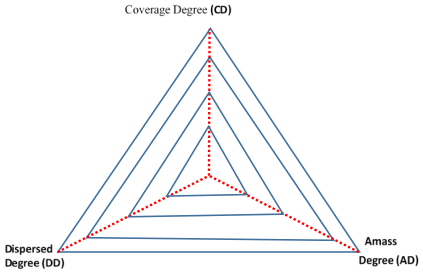

Figure 5. Triangular Evaluation

Coverage Degree indicator represents the scope of community knowledge covering teaching content and it can be calculated by formula (2). The larger the value, the wider the coverage of community knowledge.

$$CD = \frac{GKn}{EKn} \quad (2)$$

Where *GKn* denotes the total number of key terms proposed by all community members, *EKn* denotes the number of discipline keywords set by subject experts and professional teachers.

Amass Degree indicator represents the aggregation degree of community knowledge and it can be calculated by formula (3). The smaller the value is, the more diverse the notes are.

$$AD = \frac{Gkn}{\sum_{i-1}^{N} GiKn} \quad (3)$$

Where *GiKn* denotes the number of key terms contained in a member's notes and N is the number of community members. The same key terms may be contained in the notes posted by different members, the more key terms repeated, the more relevant the ideas discussed by students.

Dispersed Degree indicator (coefficient of variation which is the ratio of standard deviation to average) denotes the dispersion degree of community knowledge and it can be calculated by formula (4). The smaller the value, the more obvious the concentration trend of the views expressed by members, that is, the more balanced the community members' CCR.

$$DD = \frac{\sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(GiKn - \frac{GKn}{N}\right)^2}}{GKn/_N} \quad (4)$$

Instructional Design

The public discussion "Is one of the central ways that a learning community expands its knowledge" (Bielaczyc, 1999). In this study, the researcher designed and adjusted the content of the course according to the teaching plan; the instructional design is shown in Figure 6.

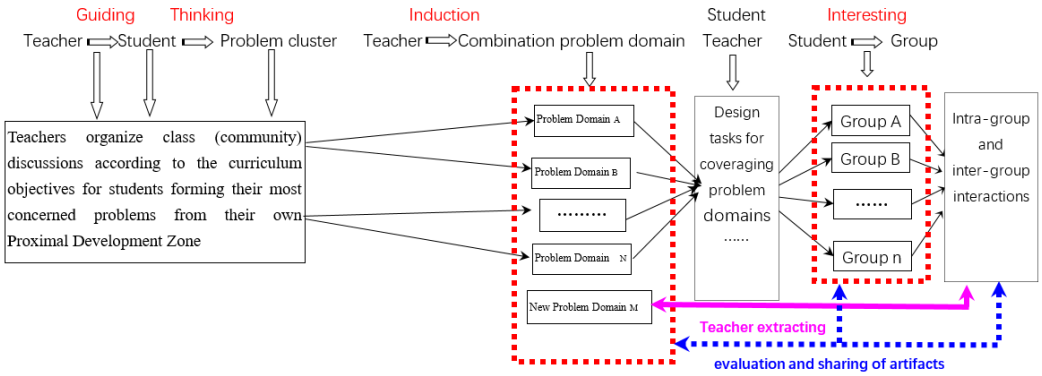

Figure 6. Instructional Design

The Process of Pre-research

The research team carried out the teaching practice in class A (9 Boys, 22 Girls) for 20 weeks in the fall semester of 2018 for a total number of 110 lessons. At the end of the semester, the students had posted 938 notes on the KF platform and formed seven television crews (see Figure 16). The teacher used four main instructional strategies including "jigsaw" method, KB Wall, Paper Task (Scaffold) and Class Report shown in Table 2.

Table 2: The instructional strategies in class A

Week	Course Content	Instructional Design
1-6 weeks Knowledge inquiry	Basic knowledge of video editing and clipping	**Jigsaw**—— Learners choose what to inquiry according to their interests
7-13 weeks Knowledge Building Intra-group Theoretical construction	Theory construction of video clipping Script, storyboard, shooting schedule	**Jigsaw**—— Learners with different knowledge backgrounds form inquiry groups **KB Wall**——Inter group interaction for only a week; **Paper task list**——Improve discourse quality
14-20 weeks Knowledge Building Inter-group Carry out practice	Video shooting Video clipping	**Practical training**——Video shooting and clipping **Class Report**——Each group will report the final video

The Process of Formal Research

After the pre-research finished, the research team systematically analyzed the experimental data, and interviews with students about the KB teaching, then modified the CCR model shown in Figure 7.

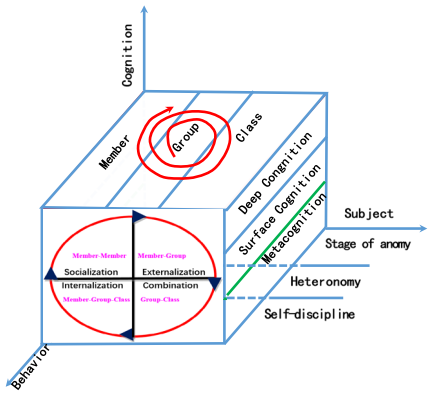

Figure 7. Modified CCR Model

The formal research was carried out in class B (13 Boys, 18 Girls) according to the modified CCR Model. The new instructional strategies such as KB circle, rotating group leader and participatory evaluation were used. At the same time, the instructional strategies such as KB Wall and electronic scaffold were adjusted. Those instructional strategies been used in Class B were shown in Table 3.

Table 3: Instructional strategies in class B

Week	Course Content	Instructional Design
1-4 weeks Knowledge inquiry	Basic knowledge of video editing and clipping	**Jigsaw**—— Learners choose what to inquiry according to their interests **KB Circle**—— Develop and enhance KB metacognition，foster knowledge construction culture ***Electric Scaffold***—— Structured KB discourse
5-9 weeks Knowledge Building Intra-group Theoretical construction	Theory construction of video clipping Script, storyboard，shooting schedule	**Jigsaw**—— Learners with different knowledge backgrounds form inquiry groups **KB Wall**——Inter-group interaction for 3 weeks ***Participatory peer evaluation*** ——Improve discourse quality and enhance interaction engagement
10-14 weeks， Knowledge Building Inter group Carry out practice	Video shooting Video clipping	***Rotating Group leader***——Rotating leader of the group should not only be responsible for the communication within the group, but also organize other groups to communicate in the classroom **Practical training**——Video shooting and clipping

The research team carried out the KB teaching in class B for 14 weeks in the fall semester of 2019 for a total number of 112 lessons. At the end of the semester, the students put forward 1465 notes on the platform of KF and formed six television crews (see Figure 17).

Data Analysis

The Data Analysis of Pre-research

The research team who carried out the instruction had taught with KB in school education for several years, and the teachers and administrators of the experimental school are very supportive of this educational reform. At the beginning of KB, the classroom atmosphere and the students' activities of mutual inquiry were very positive, but as the course drew on, the active classroom and mutual inquiry of the first few weeks corresponded with less activity in the KF database (Figure 8).

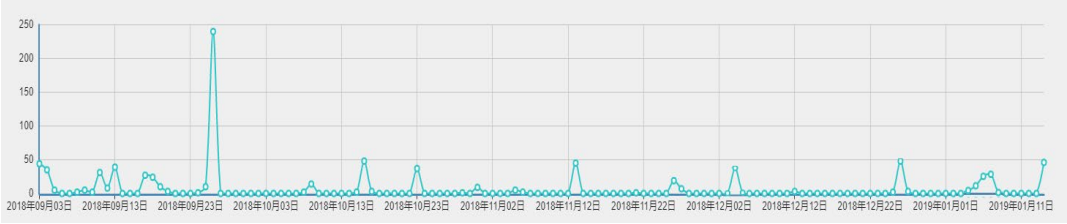

Figure 8. Frequency of Participation

In order to further investigate the above phenomenon, the researchers analyzed the change of learners' cognitive depth in the three stages and coded students' notes (Table 4).

Table 4: Coding of cognitive depth

Student ID	Date	Title	Ideas	Cognitive Depth
12	September 26	Script evaluation	I see a lot of psychological state in the script of *Come On Mengxi*. The script is different from the novel. The script language needs to be expressed by dialogues, voiceover, and body languages. The psychological state appears in the script. There is also a little use of punctuation in the script, the script is for actors, directors to see, improper use of punctuation will make people unable to understand, or do not understand, but read more laboriously. The above is for reference only.	4
18	September 3	Screenwriter	Screenwriters are mainly responsible for the plot of a movie and the actor's lines. In addition to these, they can also recommend actors to directors or give advice to actors according to the needs of their own plots. Writers are the creators of scripts and literary writings. They mainly complete the overall design of programs in the form of written expressions. They can either create original stories or adapt existing stories. Generally, after a good script is created, the script will be submitted to the director for examination. If it fails to pass the examination, the script will be re-created together with the director.	2
14	September 26	Storyboard	A storyboard is the concrete implementation of the director's ideas, which can be well represented by drawing or writing.	3
29	September 26	Script language	The language of the script includes two aspects: dialogues and stage directions. The dialogues are what the actor says in the play, including dialogues, monologues and narration. The dialogue in this play are few and incomplete, monologues and narration are not very specific.	3
10	September 26	The soul of clipping	Digital media is the use of visual information, the so-called soul is the author's ideas and creativity. Montage is just a technique. This technique is the experience of generations of editors. Only by expressing your creativity skillfully can you create soul-like editing.	2

All students' notes were scored by the author according to the rating scheme for cognitive depth; a second rater independently scored 30% of the sample. The Pearson Correlation for inter-rater reliability of cognitive depth was .86. The cognitive depth of students' ideas in the three teaching stages tested by independent sample test were shown in Table 5 and the cognitive depth of each student's idea been added up was shown in Figure 9.

Table 5: Independent samples test

Congnition Depth		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
1-6 Weeks 7-13 Weeks	Equal variances assumed	3.361	.072	-3.490	60	.001	-27.19355	7.79286	-42.78158	-11.60551
	Equal variances not assumed			-3.490	54.473	.001	-27.19355	7.79286	-42.81418	-11.57292
7-13 Weeks 14-20 Weeks	Equal variances assumed	12.648	.001	-5.581	60	.000	-39.03226	6.99395	-53.02224	-25.04228
	Equal variances not assumed			-5.581	42.683	.000	-39.03226	6.99395	-53.13993	-24.92459

The Sig. value in Table 5 were 0.001 and 0.000, both less than 0.05, indicating that the cognitive depth of learners was significantly improved in the second stage, and significantly decreased in the third stage. The results of the above data analysis show that the instructional strategies designed according to the CCR model only played a good role in the first stage, the phenomenon of KB inhibition and KB loafing appeared after the second stage.

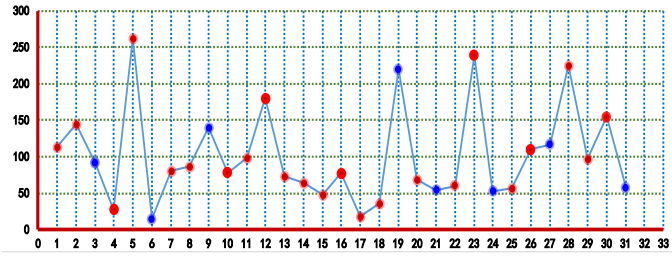

Figure 9. Distribution Curve of Cognitive Depth

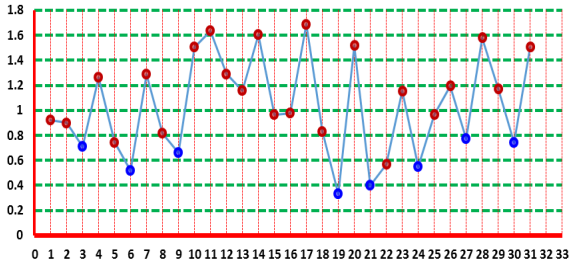

Figure 10. Distribution Curve of Average Active Index

When the individual performance of learners in a group are not accurately evaluated, they may become negative participants, which will lead to the case of KB loafing. Unclear tasks of individual members in the process of learning inquiry with no corresponding reward or evaluation can lead to a perceived gap between their abilities and expectations. As a result, they may not want to assume CCR, leading to the case of KB inhibition. The Distribution Curve of Average Active Index (see Figure 10) and Distribution Curve of Cognitive Depth (see Figure 9) fully explain the above two situations.

KB is still a relatively new educational theory in school education environment in China. Most students are unfamiliar with KB; they have some deficiencies in how to learn with KB principles and how to assume CCR. On the other hand, it is difficult to form the KB culture without the KB principles. Rules are the core of forming norms and group norm is an effective way to avoid inhibition and loafing (Daniel, 2017).As we know that the principle is a rule or belief that influences one's behavior and which is based on what he thinks is right (see the semantic meaning of principle in Oxford Dictionary), and principles are more guidelines than rules. In view of the above reasons, the author modified the three behavior types in the behavior dimension and added the meta-cognition on cognition dimension by adjusting the CCR model structure as shown in Figure 7.

The Data Analysis of Formal Research

The instructional strategies of Rotation Group Leader and Participator Peer Evaluation are very effective for cultivating the KB culture. The participation frequency of students has been effectively maintained (see Figure 11) and the average activity index of students is more balanced (see Figure 12) in the dimension of behavior.

Figure 11. Frequency of Participation

Although there are also some gaps in the different students' cognition depth (see Figure 13), the trend of these differences has slowed down compared with the pre-research (see Figure 9).

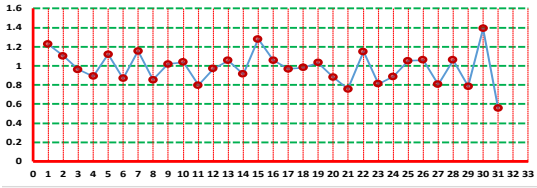

Figure 12. Distribution Curve of Average Active Index

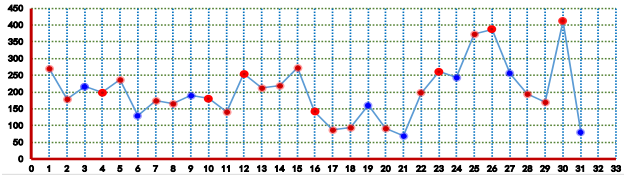

Figure 13. Distribution Curve of Cognitive Depth

Results and Discussion

Under the mechanism of Rotation Group Leader, each student has the obligation to organize the interaction within the group, and also has the responsibility to organize the interaction between groups. The mechanism in formal research is more conducive to produce group pressure, which makes most students actively participate in knowledge inquiry in the KB teaching.

The Cognitive Depth of Individuals Has Changed Significantly

The author coded all the students' notes according to the coding rules in the pre-research (see Table 4), and inputted the encoded data into SPSS, then made a comprehensive multiple comparative analysis of three stages about cognition depth of all the students' ideas as shown in Table 6.

Table 6: Multiple comparisons

Dependent Variable: Congnition Depth

	(I) Research Type	(J) Weeks	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Tamhane's	Formal (1-4weeks)	Formal (5-9weeks)	-40.83871*	7.91415	.000	-56.4551	-25.2223
		Formal (10-14weeks)	-26.09677*	7.91415	.001	-41.7132	-10.4803
		Pre-research(1-6weeks)	16.74194*	7.91415	.036	1.1255	32.3584
		Pre-research(7-13weeks)	-10.45161	7.91415	.188	-26.0681	5.1648
		Pre-research(14-20weeks)	28.58065*	7.91415	.000	12.9642	44.1971
	Formal (5-9weeks)	Formal (1-4weeks)	40.83871*	7.91415	.000	25.2223	56.4551
		Formal (10-14weeks)	14.74194	7.91415	.064	-.8745	30.3584
		Pre-research(1-6weeks)	57.58065*	7.91415	.000	41.9642	73.1971
		Pre-research(7-13weeks)	30.38710*	7.91415	.000	14.7707	46.0035
		Pre-research(14-20weeks)	69.41935*	7.91415	.000	53.8029	85.0358
	Formal (10-14weeks)	Formal (1-4weeks)	26.09677*	7.91415	.001	10.4803	41.7132
		Formal (5-9weeks)	-14.74194	7.91415	.064	-30.3584	.8745
		Pre-research(1-6weeks)	42.83871*	7.91415	.000	27.2223	58.4551
		Pre-research(7-13weeks)	15.64516*	7.91415	.049	.0287	31.2616
		Pre-research(14-20weeks)	54.67742*	7.91415	.000	39.0610	70.2939
	Pre-research (1-6weeks)	Formal (1-4weeks)	-16.74194*	7.91415	.036	-32.3584	-1.1255
		Formal (5-9weeks)	-57.58065*	7.91415	.000	-73.1971	-41.9642
		Formal (10-14weeks)	-42.83871*	7.91415	.000	-58.4551	-27.2223
		Pre-research(7-13weeks)	-27.19355*	7.91415	.001	-42.8100	-11.5771
		Pre-research(14-20weeks)	11.83871	7.91415	.136	-3.7777	27.4551
	Pre-research (7-13weeks)	Formal (1-4weeks)	10.45161	7.91415	.188	-5.1648	26.0681
		Formal (5-9weeks)	-30.38710*	7.91415	.000	-46.0035	-14.7707
		Formal (10-14weeks)	-15.64516*	7.91415	.049	-31.2616	-.0287
		Pre-research(1-6weeks)	27.19355*	7.91415	.001	11.5771	42.8100
		Pre-research(14-20weeks)	39.03226*	7.91415	.000	23.4158	54.6487
	Pre-research (14-20weeks)	Formal (1-4weeks)	-28.58065*	7.91415	.000	-44.1971	-12.9642
		Formal (5-9weeks)	-69.41935*	7.91415	.000	-85.0358	-53.8029
		Formal (10-14weeks)	-54.67742*	7.91415	.000	-70.2939	-39.0610
		Pre-research(1-6weeks)	-11.83871	7.91415	.136	-27.4551	3.7777
		Pre-research(7-13weeks)	-39.03226*	7.91415	.000	-54.6487	-23.4158

*. The mean difference is significant at the 0.05 level.

We can find that the cognitive depth of students' ideas in the formal research of class B has been effectively improved, and the indolence and inhibition was been avoided at the late stage of KB teaching in class B. For example, the Sig. value which is 0.064>0.05 between formal research (1-4 weeks) and pre-research (7-13 weeks) shows the cognition depth of students' ideas was increased much faster, the Sig. value which is 0.136>0.05 between formal research (5-9 weeks) and formal research (10-13 weeks) shows the cognition depth of ideas was well maintained.

The Interaction between the Members and Groups Was Significantly Improved

The social network analysis tools provided by the KF platform itself were used to analyze the notes of each member posted. Network density is an important indicator to measure and evaluate trend of social relations. The frequency of notes reading/being read in KF indicates the probability of community knowledge generation. For the same size of a social network, the higher the network density, the closer the relationship among nodes. It can be seen in the network structure that the members' interaction in Pre-research is more frequent and balanced than that in formal research (see Figure 14 and Figure 15).

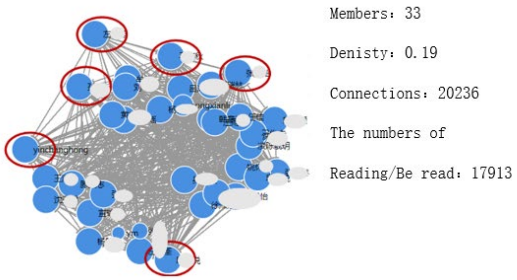

Figure 14. Pre-research

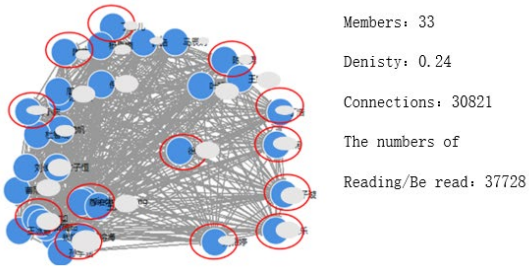

Figure 15. Formal Research

The social network among members cannot be comprehensively reflected the interaction between groups; it is necessary to conduct statistics manually and input the interaction data into the social network analysis tool to evaluate the interaction between groups. In some cases, the more frequent the interaction between groups, the more diverse views are. It can be seen from the network structure that the interaction among groups is more frequent and balanced (see Figure 16 and Figure 17).

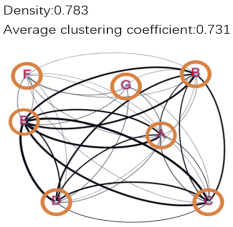

Figure 16. Pre-research

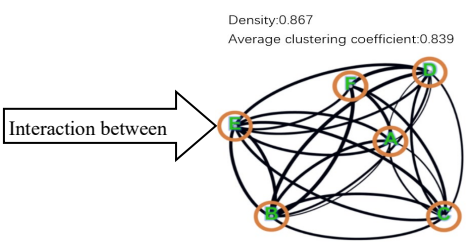

Figure 17. Formal Research

The Community Knowledge Has Been Improved

In addition to the increase of individual cognitive depth and inter group interaction, community knowledge has also been improved. By comparing the triangular evaluation map between the pre-research and formal research, it can be founded that the community knowledge has been improved. The coverage degree, amass degree and dispersed degree of community knowledge were shown in Figure 18.

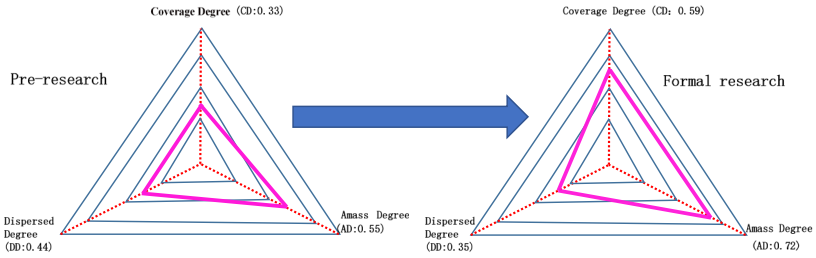

Figure 18. Community Knowledge

From the above data analysis, it can be concluded that the instructional strategies effectively improve the members' CCR. At the same time, these instructional strategies were designed and modified by the author according to the CCR model. Therefore, to a certain extent, it can be said that the CCR model is effective to improve students' CCR in KB teaching.

This study only evaluates students' CCR in behavioral dimension and cognitive dimension, and lacks subject dimension. At the same time, only two semesters of KB teaching practice have been carried out in this paper. In order to test the validity of the evaluation model and methods, the three-dimension model of CCR assessment should be carried out in more KB teaching in different schools and cities.

Conclusion

The paper draws two conclusions after two semesters of KB teaching. Firstly, the three-dimensional theoretical model of CCR is effective and it explains the internal mechanism of learners assuming CCR, and clarifies key factors that affect the community members taking CCR. Secondly, the teaching intervention strategies which were proposed by the research based on the key influence factor effectively promote learners to take CCR.

Next Steps

The researcher will use the word segmentation tools to segment students' ideas in each problem domain, and build knowledge map of views for measuring the members' CCR in the corresponding problem domain in the future research. On the other hand, how to construct an assessment method of evaluation KB culture will be the focus of follow-up research.

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