A Research on Collaboration Knowledge Construction in the Virtual Learning Community by Social Network Analysis

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***Abstract*—This paper took the social knowledge construction as the perspective and "Introduction to Educational Technology" online course as an example to analyze knowledge construction level implied in those posts contributed by learners with the method of content analysis. Meanwhile, social network analysis (SNA) was adopted to explore the density, centrality, cohesion sub-group in this online learning community and to discuss strategies for effective collaborative learning in virtual learning community. Results indicated that the entire network centralization is comparatively low but still some points with higher betweenness centrality and some points functioned as bridges exist in our sample network.**

Keywords-component; virtual learning community; collaboration knowledge construction; content analysis; social network analysis

I. INTRODUCTION

According to Social Constructivism, knowledge could not exist without the social context, but could be constructed through the interaction of individuals and the communities. Therefore, learning is a process of socialization and solutions of many problems do not simply depend on an individual or single effort. Collaborative knowledge construction, which usually occurs in a community where the members have the same learning objects, contains three stages: input, collaboration and output. Thus, firstly, all the learners plan for the learning objects together and identify the requirements of collaborative learning. Then they learn collaboratively and share their study outcomes finally.

SNA represents Social network analysis for short. The research content of SNA is the social activity members and their relationships. It aims to describe the relationship model of these members and to investigate into the inner structure of the model and the model's influence to the entire community, thus why we adopt it here to analyze the characters of students' participation in learning. Learners communicate via online discussion in Web-based learning. We will employ SNA to look into the density, centrality, and cohesion sub-group to analyze the characteristics of those learners.

An online undergraduate course "Introduction to educational technology" will be taken as our example. The focus should be not only the interaction and but also the knowledge construction during the course learning. Research questions are:

Which level of collaboration knowledge construction did students achieve? Is there any relationship between the level of collaboration knowledge construction and the relations of learners?

II. PROCEDURES

A. Sample

"Introduction to educational technology" is a compulsory online course for students majored in educational technology provided by Shenzhen University, China. The sample selected is one class of students who took the course in 2009. With the combination of face-to-face learning and online learning, the face-to-face module is on once a week basis and off-class learning time refers to students' online assignment and discussion. During most of the off-line time, which would be more flexible, teachers and students communicate on an online course platform via internet. There are sixty-five students and one teacher altogether. All the participators must register with real information and log in with their favorite username. This article is going to investigate into their online learning and interaction to find more.

During the teaching process, the teacher, who must take the core function of guiding and monitoring, will propose the discussion topics and then assign students to search relevant information in order to join the online discussion with better preparation. Students may post a keynote post, reply others' posts or comment on other's opinions. They also can express their ideas on topics that suggested by the teacher. In this way, students could discuss on the topics while sharing resources, modifying opinions or commenting ideas. At last, the researcher collected all the posts and information to classify and record them for later research use. For example, individual user information, the number of posts in a certain time, the content of the posts and so on.

B. Methods

1) Content analysis

In this paper, we will adopt Guanawardena et al., (1997)'s IAM as the research instrument to analyze the samples' collaborative knowledge construction level as a whole. We will take the simplified one by Lu Wang et al, (See Table 1). The unit of content analysis we chose is one

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post. Then we will discuss the results according to research question.

TABLE I. THE CONTENT ANALYSIS TOOL[1]

Phase	Detailed Content	No.
PH 1 : Sharing/ comparing of information	A statement of observation or opinion	A1
	A statement of agreement from one or more other participants	A2
	Corroborating examples provided by one or more participants	A3
	Asking and answering questions to clarify details of statements	A4
	Definition, description, or identification of a problem	A5
PH 2: The discovery and exploration of dissonance or inconsistency among ideas, concepts or statements	Identifying and stating areas of disagreement	B1
	Asking and answering questions to clarify the source and extent of disagreement	B2
	Restating the participant's position and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view	B3
	Propose of alternative hypothesis	B4
PH 3: Negotiation of meaning/ co-construction of knowledge	Negotiation or clarification of the meaning of terms	C1
	Negotiation of the relative weight to be assigned to types of argument	C2
	Identification of areas of agreement or overlap among conflicting concepts	C3
	Proposal and negotiation of new statements embodying compromise, co-construction	C4
	Proposal of integrating or accommodating metaphors or analogies	C5
PH 4: Testing and modification of proposed synthesis or co-construction		D
PH 5: Agreement statement (s)/ Applications of newly constructed meaning		E

2) Social network analysis

The SNA method was considered to be the most convincing method to study the social structure after its first use in 1954 by Barnes, an Anthropologist to analyze the social structure of a fishing village.

Dots and lines are used to express the network or relationship between all the community members when a community member is represented by a point. It is a good method to simplify the relationship of learners in virtual learning community. Social network analysis includes the following basic elements: Point: The points of social networks (nodes) are social activity participator.

According to the analysis of different focus, social network analysis is divided into two basic orientations: relations orientation and location orientation. Relational orientation focuses on the relationship between members, such as density, strength, symmetry and scale to explain the behavior of members; location orientation concerns the existence of the members, and the same position in the structure of social relations, role of members, and so on.

3) Data and Coding

In this study, the point represents one topic of this online course and their response, each post was coded to one item in the sixteen items from IAM. And in this paper, we assume that as long as a response was made, a kind of relationship was connected between these two posts. Number "1" represents this connection and "0" means no relation, see the table followed. While the link of the response type is directional, the relationships could also be described by directed graph, the horizontal axis from the vertical point.

TABLE II. KNOWLEDGE CONSTRUCTION OF SNA CODE EXAMPLE

Knowledge Building Code symbol	*A1*	*A2*	*A3*	*A4*	*A5*
A1	0	0	0	0	1
A2	1	0	1	0	0

III. RESULTS

A. Data coding results

This study was focused on knowledge building process in a virtual learning community, so the data sample that we had selected were the main issues of Discussion Topics Posts, and we chose a topic with relatively hot topic as our sample.

Figure 1 is a coded data of discussion on the topic "What is Educational Technology?".

Knowledge Building Code Symbol	A1	A2	A3	A4	A5	B1	B2	B3	B4	C1	C2	C3	C4	C5	D	E
A1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
A2	1	0	1	0	0	1	0	0	1	0	0	0	1	0	1	0
A3	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	1	0	1	0	0	1	0	0	0	0	1	0
A5	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
B1	1	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0
B2	1	0	0	1	1	1	0	0	0	0	0	0	1	0	0	0
B3	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0
B4	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0
C1	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0	0
C2	0	1	0	0	0	0	1	1	0	0	0	0	0	0	1	0
C3	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
C4	0	0	0	1	1	1	1	0	0	1	0	0	0	0	0	0
C5	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0
D	1	0	1	1	0	1	0	0	0	1	0	0	1	1	0	0
E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 1. Discussion on Topic "What is Educational Technology?"

B. SNA Community Map of theme

Social network analysis method adopts the community map to demonstrate the social relationship in the community described. The community map could help us to understand better the interaction of the sixteen knowledge construction item. We used the SNA analysis software Ucinet to analyze the encoded data. With Net Draw tool in Ucinet, we can easily get the community map, shown in Figure 2.

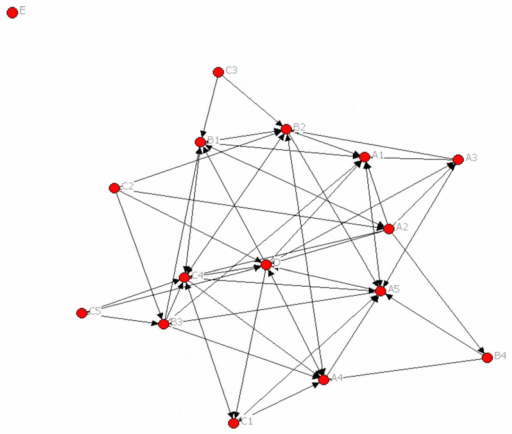

Figure 2. Community maps of collaborative knowledge construction

C. *Network density*

Density of the community map is the proportion of the existing lines and the possible lines. In general, affinity groups with thick density must be a group with more cooperative behavior, resource must flow more easily and emotional support must be better. During the communication of members in virtual learning communities, the density reflects the degree of their participation or engagement and the correlation between their posts. By using UCINET calculation, the density of the matrix results in obtained matrix density (matrix average) = 0.2333. It can be seen that 0.2333 is between 0 and 1, so it is small.

Therefore, we could say the connection here is not very close or the knowledge construction occurring here is not very deep. Meanwhile, although the entire density of network is not thick, it is reflected a greater dispersion of knowledge construction items. It means that members had discussed with multiple prospective and the discussion covered a more extensive related area. It was verified that students' engagements were active.

D. *Analysis of Centrality*

We analyze this problem discussing the situation-type construct knowledge post by three characteristics of central values.

1) *degree centrality*

If a point is directly connected with the number of points, we say the store has a higher point degree centrality. A point has the highest degree, claimed that change is in the center point. The results from Figure 3 to see the different categories of knowledge constructs with different degree centrality, with the highest for the D, followed by A5, C4, B2, etc., illustrate several points in the network living in the center of the entire the core of the network knowledge construction. These fronts a deeper and more extensive discussion, the discussion can lead to more good knowledge construction. Construction of the knowledge network's overall central potential 32.38%, indicating the concentration of the whole network around the middle, the convergence point at the middle level, The final solution to their problems tend to integrated multiple perspectives or ways, not just one.

	1 Degree	2 NrmDegree	3 Share
15 D	10.000	66.667	0.109
5 A5	9.000	60.000	0.098
13 C4	9.000	60.000	0.098
7 B2	8.000	53.333	0.087
2 A2	7.000	46.667	0.076
4 A4	7.000	46.667	0.076
6 B1	7.000	46.667	0.076
8 B3	7.000	46.667	0.076
1 A1	7.000	46.667	0.076
3 A3	5.000	33.333	0.054
10 C1	4.000	26.667	0.043
11 C2	4.000	26.667	0.043
14 C5	3.000	20.000	0.033
9 B4	3.000	20.000	0.033
12 C3	2.000	13.333	0.022
16 E	0.000	0.000	0.000

Figure 3. Degree centrality

2) *Betweenness Centrality*

Betweenness Centrality means a person's role as the media, like a 'bridge'. A higher Betweenness Centrality shows a members' stronger function to connect two other members or the others' posts over the network. As can be seen from Figure 4, D, A5, B1, A2 betweenness centrality is higher, they played an important role as a bridge in the network of Construction knowledge and there was a great control of other types of knowledge links between the points. Without these items, the network connection could not be connected as a whole. Therefore, in order to guide the members in the learning community to get a higher knowledge construction level, we must attach great importance to these four items: D, A5, B1, and A2. The knowledge construction network, (Network Centralization Index = 13.85%) is smaller as compared to 100% of the intermediate central potential, indicating an overall knowledge of the trend of constructing the network of mutual control is low. Therefore, we can say, the discussion is not focused on one aspect, but all aspects of the problem involved.

	1 Betweenness	2 nBetweenness
15 D	38.826	18.489
5 A5	32.533	15.492
6 B1	28.988	13.804
2 A2	20.083	9.563
7 B2	18.117	8.627
4 A4	16.288	7.756
13 C4	14.805	7.050
8 B3	9.474	4.511
1 A1	1.650	0.786
3 A3	1.519	0.723
14 C5	1.200	0.571
9 B4	0.783	0.373
10 C1	0.733	0.349
12 C3	0.000	0.000
11 C2	0.000	0.000
16 E	0.000	0.000

Figure 4. Betweenness centrality

3) *Closeness centrality*

If the "distance" between one point and other points in the network is very short, it means the point has a high closeness centrality and it may be in the center of the network. Knowledge building is a process of convergence of members' opinions. We will concern about the closeness centrality of the points. The results can be seen from Figure 5: point A1, A5 showed the highest closeness centrality, followed by point A4, C4, B1, D and B2. We can see the

points were highly dependent with very close connection with other points. Almost all the points could be related directly to another point by only one bridge point.

Therefore, in the process of knowledge construction, the emphasis on closeness to the center of knowledge content will be benefiting by better guiding the knowledge networks to build a broader level.

	1 inFarness	2 outFarness	3 inCloseness	4 outCloseness
1 A1	37.000	84.000	40.541	17.857
5 A5	37.000	73.000	40.541	20.548
4 A4	39.000	71.000	38.462	21.127
13 C4	39.000	70.000	38.462	21.429
6 B1	40.000	70.000	37.500	21.429
15 D	40.000	66.000	37.500	22.727
7 B2	41.000	70.000	36.585	21.429
10 C1	44.000	74.000	34.091	20.270
8 B3	44.000	71.000	34.091	21.127
3 A3	49.000	74.000	30.612	20.270
2 A2	51.000	67.000	29.412	22.388
14 C5	53.000	72.000	28.302	20.833
9 B4	61.000	76.000	24.590	19.737
12 C3	240.000	63.000	6.250	23.810
11 C2	240.000	54.000	6.250	27.778
16 E	240.000	240.000	6.250	6.250

Figure 5. Closeness centrality

E. *cliques*

The results from Figure 6 cliques analysis, The points D, A5, C4, B2, and other points, which repeated in a number of different factions, Shows the level of interaction between posts was very close. And the fact that different types of knowledge content were closely related resulted in a deeper knowledge construction level. We can also infer that knowledge was well constructed within this discussion topic.

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18 cliques found.

  1:   A4  A5  C1  C4  D
  2:   A2  B1  C4  D
  3:   C4  C5  D
  4:   A1  A2  A3  D
  5:   A1  A3  A5  D
  6:   A2  C2  D
  7:   A1  A2  B1  D
  8:   A4  A5  B2  C4
  9:   A1  A3  A5  B2
 10:   B1  B2  C3
 11:   B1  B2  C4
 12:   A1  B1  B2
 13:   A4  A5  B3  C4
 14:   B1  B3  C4
 15:   B3  C4  C5
 16:   A1  A5  B3
 17:   A1  B1  B3
 18:   A4  A5  B4
```

Figure 6. Cliques found

IV. CONCLUSIONS

One main characteristic of Social Network Analysis is that all the data could be quantified, at the same time, vivid and intuitive graphs and matrix could be generated. By adopting SNA into the analysis of the connection of students' posts in this virtual learning community proved again the advantage of SNA in investigating relationships:

A. *SNA can contribute to knowledge construction research*

SNA could help researchers to understand the process of collaborative knowledge construction through analysis of centrality, cohesion sub-group, etc. With this method, we can easily reveal members' knowledge construction level and their inner network in the community. Especially, Community map could help us to reveal the intrinsic relationship between the sixteen items of knowledge construction.

B. *The network core of Collaborative Knowledge construction*

During the topic based discussion in virtual learning community, the continued communication, repeated modification of members' opinions, further questions presenting and reflection are the main line of collaborative knowledge construction. And the core of network refers to the points closer to the centrality. They were A5, A4, C4, B1, D and B2 in our sample. So in order to enhance the quality of virtual learning community and to ensure a high level of collaborative knowledge construction, we should put much more emphasis on the following: A statement of observation or opinion, Definition, description, or identification of a problem, Asking and answering questions to clarify details of statements, Identifying and stating areas of disagreement, Asking and answering questions to clarify the source and extent of disagreement, Proposal and negotiation of new statements embodying compromise, co-construction, Testing and modification of proposed synthesis or co-construction.

C. *Knowledge construction is a cyclic, spiral process*

The five stages of Collaborative Knowledge Construction are gradually ascending, the improvement may not obey the routine: from the first stage to the second, then to the third, then to the fourth and finally to the fifth stage. And in this cycle, movements will not necessarily be antagonistic from the last stage of the construction phase return to the low stage.

That is to say constant communication, the progressive elimination of all parts of the difference, problem solving of a certain degree in knowledge construction and the ultimate progressive convergence the formation of a consistent point of view are needed in collaborative learning construction.

In this sense, collaborative knowledge building is a process based on the five stages of the cycle, spiral process.

In this sense, all the community members try to conflict, dispute, and defense, evaluate and judge during the process of joint construction of the collaborative knowledge. This is a spiral process whish processes again and again to promote knowledge construction to a higher level of quality.

V. REFLECTIONS AND PROSPECTS

SNA provides a very useful and unique analysis perspective for investigating learners' social and participatory characteristic. It also allows researchers to study the communication features of learners from a new perspective. With SNA method, researchers may discover the obstacles of group interaction and find ways to improve the effectiveness of online learning.

However, teachers should take the bridge role or the inspirer role of some students into consideration when designing online course in order to protect students from

complete silence and to make sure every student had benefited from the online course. Then, teacher is a very important factor in virtual learning community.

Many factors should be considered in analyzing computer supported collaborative learning in virtual learning community. This study is just a small piece of work on the participation characteristics with only direct response connection was concerned. Besides, due to some shortcomings of SNA, more methods, such as interviews, focus group interviews, observation, questionnaires, etc. It will be needed to compensate for its drawbacks to enhance the research in collaborative knowledge construction in virtual learning community

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