Exploring the Effectiveness of an Idea-centered Design to Foster a Computer-Supported Knowledge Building Environment

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Abstract: This paper compares the effectiveness of two multimedia environments—Blackboard Learning System™ and Knowledge Forum™—in terms of their underlying design approaches to support collaborative learning and knowledge work. The two design approaches are (1) a conventional theme-based approach, i.e., to center group collaboration and meaning interaction around themes, and (2) an idea-centered approach, i.e., to center group collaboration and meaning interaction around sustained idea exchange and improvement. Findings suggest that an idea-centered design approach seems more likely to construct an environment that fosters more dynamic group and meaning interactions, thus enabling more sustained collaborative learning and knowledge building.

Introduction

Society is being transformed into an information- or knowledge-based society (Drucker, 1986; ; UNESCO, 2005). The advances and ubiquity of information communication and technology (ICT) provide new forms of connectivity for supporting group work, and transform the traditional notion of learning as individual endeavors into one that also values collective knowledge work (Scardamalia, 2002; Hong & Scardamalia, & Zhang, 2007). In response to this shift in perspective, an emerging line of research on educational technology has been focusing on the design of effective computer-supported collaborative learning (CSCL) environments. The key concept of CSCL is that shared digital environments can be used to foster meaning interactions that produce deeper understanding for the group and its participants; and, as such, the uniqueness of CSCL designs consists in their techniques for supporting effective group collaboration and meaning interaction (Stahl, 2007). Nevertheless, while scholars in general agree the value of CSCL for modern education in a digital age, as an emerging field, there is still much to learn about the nature of CSCL in order to keep designing more effective CSCL environments (Stahl, Koschmann, & Suthers, 2006). As noted by Kreijns, Kirschner and Jochems (2002), "contemporary CSCL environments do not completely fulfill expectations on supporting interactive group learning, shared understanding, social construction of knowledge, and acquisition of competencies" (p.8; see also Kirschner, Strijbos, Kreijns, & Beers, 2004). The question of what constitutes an effective design to support CSCL remains an important challenge in the field.

A conventional design approach to support online collaboration in most CSCL environments has been a theme-based one, i.e., to center group discussion or meaning interaction around themes. A theme can be defined as the subject matter of a conversation or discussion. Oftentimes, themes are pre-determined based on curriculum guideline in order to better structure group interaction. To support theme-based collaboration, many CSCL environments tend to adopt a standardized, threaded discussion design in their discussion boards or forums, with each theme being constructed or represented by means of a thread of continual discussion. For example, as one of the most widely used online learning environments, Blackboard Learning System is designed to support such theme-based collaboration by employing threaded discussion board. Arguably, an important strength of a theme-based design is to help group members focus their discussion and interaction on a specific theme so that deeper understanding of a theme can be achieved. Accordingly, the effectiveness of group collaboration may be measured up by means of the length and quality of thread, e.g., by looking into how and why a discussion thread sustains or dies (Hewitt, 2005). The downside of a theme-based design, however, is that when a theme is being placed at the center of discussion in a thread, the potential meaning interactions or group collaboration between themes (or threads) becomes limited (cf. Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008). To transform this limitation (while keeping its strength) of a theme-based design, below we propose an alternative idea-centered design approach.

Unlike a theme (which represents a broader area of inquiry), an idea can be thought of as a fundamental unit of information that may be represented by a thought, a cognitive concept, or a proposed solution to a problem, and is formed by the consciousness through the process of ideation (i.e., idea generation). The essential notion of an idea-centered design is to center group discussion or meaning interaction around sustained idea exchange and improvement (Hong & Florence, accepted; Hong, Scardamalia, Messina, & Teo, 2008; Scardamalia, 1999), regardless of whether idea are located in the same thread or not. Doing so is thus able to

transform conventionally theme-based threaded discussion into more dynamic meaning interaction. An example of an environment designed as such is Knowledge Forum—a computer-supported knowledge building environment. Knowledge building, as defined by Scardamalia and Bereiter (2003), is a social process focused on the production and continual improvement of ideas of value to a community. In other words, Knowledge Forum as an environment is designed to support group collaboration at a fundamental idea level, rather than at a broader theme level.

To better understand the nature and effectiveness of this idea-centered design approach, the present study compares two digital environments, Knowledge Forum and Blackboard. Our main research question focused on looking into how different design features of each environment might affect how students learn and develop their understanding in the community they belonged.

Method

Context and participants

The present research was conducted in a university course titled "Integrating Instructional Theory and Practice" in Taiwan. The course was offered by the university's Center of Teacher Education as part of its Teacher Education program. It is also the last required course designed to help deepen students' understanding of the relationships between learning theory, teacher expertise, and teaching practice. As their teaching practicum would start right after this course, such understanding became crucial for preparing them to work in authentic teaching context. The university is ranked as one of the best universities in the nation. As such, the students enrolled in the subject university are all academically high-achievers. Based on the test results of the national Basic Competence Test for Senior High School Students (BCTSHSS), in order to enroll in the target university, students' test scores in BCTSHSS need to be ranked above 95 percentile nationwide. However, not all students entered in the subject university are automatically qualified to enter its Teacher Education program. As teaching was a highly respected profession in this country in tradition, there is an additional application and selection mechanism and only limited students with exceptional academic achievements are accepted into the program. Participants in this study were 49 students (25 females and 24 males). Their ages range from 21 to 31 (M=24.02; SD=2.47).

Research design

An essential purpose of this study was to investigate how different design approaches in these two environments, Knowledge Forum (KF) and Blackboard (BB), might affect how students learn and develop their understanding under the same coursework. Knowledge building concept and pedagogy that underlies the design of Knowledge Forum was introduced in class to help students better understand how the activities are designed and what kind of experience of idea improvement they will encounter throughout the whole semester. Except for the difference in the adoption and use of online discussion environments, throughout the whole semester, the teaching conditions and learning activities were purposefully maintained to be as similar as possible (e.g., regular whole-class lecture, group learning activities, individual reading assignments, and invited guest talks, etc.). Therefore, a between-subject design was employed, with about half of participants assigned to the KF group (N=24) and the other half to the BB group (N=25). The KF group was required to use only Knowledge Forum for all online group discussion while the BB group was required to use only Blackboard for their online group discussion.

One thing to note is that Blackboard learning system has been used in the participating university for many years so students were fairly familiar with the interface design and usage of its discussion board. Figure 1 shows two snapshots of the Blackboard learning environment excerpted from the present study. As noted above, threads represent an essential design feature to support group collaboration and meaning interaction in the Blackboard learning environment. As such, much of group interaction mainly occurs within a thread (or a theme[1]), rather than between threads (or themes).

In contrast, it is the very first time that Knowledge Forum was introduced to the students in this course so students were not familiar with its design and use for group collaboration. Therefore, in the beginning of the semester, a tutorial lesson was held in a computer lab. Students were demonstrated the basic design features of Knowledge Forum in order to perform necessary functions, for example, how to create a note or a view (i.e., a multimedia space for group discussion and collaboration) or how to build-on (or reply) to an existing note. Then, they were encouraged to try out themselves. Figure 2 shows a snapshot of a Knowledge Forum view excerpted from the present study in a "basic" text-based mode[2]. It should also be noted, however, that, unlike Blackboard, in which group collaboration can be limited within in a given theme or thread. The idea-centered design of Knowledge Forum allows multiple ways of dynamic group interaction and collaboration, including build-on, reference, annotation, rise-above, co-author, and publication. First, building-on or referencing (i.e., to quote other members' text) is similar to replying notes in a Blackboard discussion board. However, in addition to these tow

design features, group discourse and collaboration in Knowledge Forum can also be supported by means of "annotation", which allows users to give short comments within an existing note; "rise-above", which allows users to gather ideas that have already been presented and synthesize or transform these previous ideas into new understandings; "co-author", which means shared authorship of a note; and "publication", which allows users to collaboratively select a note (of high quality) for published status.

Figure 1. Two snapshots of the Blackboard learning environment excerpted from the present study

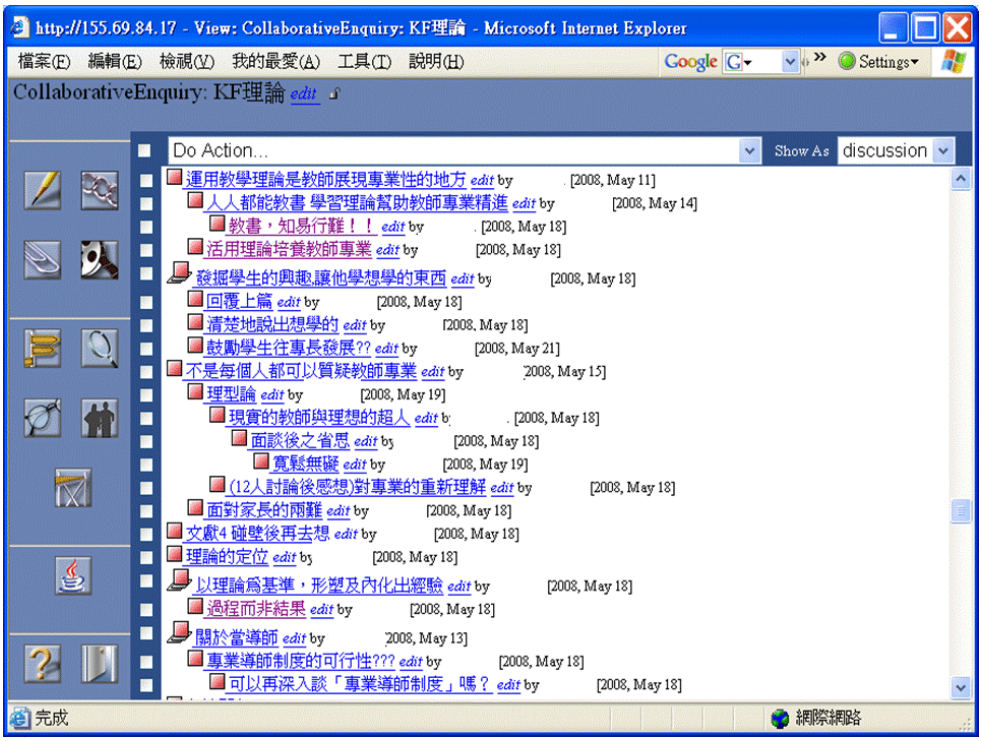


Figure 2. A snapshot of a Knowledge Forum view excerpted from the present study

Instructional design

As an essential instructional goal in this course was to help students gain better understanding of the nature and roles of learning theory and teacher expertise in relation to teaching practice, within each group (KF or BB), students were further divided into two sub-groups: the theory group and the expertise group. As a result, there were four sub-groups being formed in this study: KF-theory, KF-expertise, BB-theory, and BB-expertise. To ensure both "theory" and "expertise" topics were covered for student learning, the two sub-groups within each main group were encouraged to independently pursue the general topic of inquiry (either learning theory or

teacher expertise) and then to reciprocally share what they learned with the other sub-group of students (see, e.g., Palincsar & Brown, 1984). The purpose of doing so was to provide a general structure for collaborative knowledge work within each main group, and to ensure not to introduce undesired confounding variables between the two main groups, as the main focus of this study was to compare between the KF and BB environments, in terms of how their different designs scaffold or support group collaboration. Therefore, for the most part of the semester, each of the four sub-groups worked quite independently of one another to advance their group understanding of the overall topic of inquiry.

Data source and analysis

This research employed a mixed approach for data collection and analysis. The rationale is that "the quantitative data and results provide a general picture of the research problem; more analysis, specifically through qualitative data collection, is needed to refine, extend, or explain the general picture" (Creswell, 2005, p.515). Data mainly came from student notes recorded in a Knowledge Forum database (for the KF group) and in a Blackboard database (for the BB group). There were two general types of notes collected. In addition to notes generated from weekly collaborative learning and knowledge-building activities, each participant was also asked to keep a portfolio note. This portfolio note basically served as a high-level thinking scaffold, through which participants were invited to reflect on major changes in their thinking that contributes to their deeper understanding the topic inquired. Another purpose of employing portfolio notes is to make students' own thinking visible for self-assessment (Lee, Chan, & van Aalst, 2006). Further, from a research perspective, these portfolio notes also represent an important data source for evaluating whether there is any important change in student thinking during and after taking this course while using two different online discussion platforms. In terms of procedure, students were required to first re-read all their notes contributed during the semester and then to identify events or activities (e.g., whole-class lecture, reading assignments, guest talks, or online group discussion) that had influence on their conceptual understanding of the topic inquired (e.g., their understanding of the role of teacher expertise in teaching practice).

Regarding data analysis, first, for the quantitative data, a descriptive analysis and a social network analysis were applied to explore participants' online note-contributing behaviors and patterns of social dynamics. Then, an in-depth content analysis was followed to look specifically into participants' portfolio notes, in order to further explore whether and how participants actually deepen their understanding of the topic inquired. Specifically, this content analysis used key concepts identified from students' notes as the unit of analysis. An open-coding procedure based on grounded theory (Strauss & Corbin, 1990, chapter 5) was adopted, with one researcher independently coding all student notes. Resulted from this coding process are nine major themes, which were then further categorized, based on two pre-determined dimensions of change: source and quality. Table 1 shows the nine themes. The occurrences of each theme were then computed for descriptive analysis (Chi, 1997) in order to compare between the KF and BB groups. One thing to note is that the second, third, and fourth major sources of change in Table 1 also represent the primary learning activities originally designed for this course, which are responsible for secondary learning activities (i.e., the first major source of change—peer discussion).

Table 1. Coding scheme based on two dimensions of change: source and quality

Main category		Theme
Source of change	1.	Peer discussion
	2.	Teacher interview transcripts
	3.	Invited guest speaker, instructor and teaching assistant's influence
	4.	Weekly reading assignment
	5.	Others (e.g. individual personal experience and learning processes)
Quality of change	1.	More sophisticated understanding (of the topic inquired)
	2.	Refined understanding
	3.	Naïve or limited understanding
	4.	No sign of understanding demonstrated

Preliminary Findings

Baseline analyses

This study reports preliminary results from partial analysis based on the comparison between two sub-groups: the KF-theory group and the BB-theory group (henceforth the KF group and the BB group). First, for baseline comparison, it was found that the KF group (N=12) in total posted 348 notes (M=29.0) and that the BB group

(N=13) posted 378 notes (M=29.1); there was no significant difference found between the two groups ($F_{(23, 1)}$=.001, p=.973). Moreover, when comparing the total number of words each student produced throughout the whole semester, it was also found there is no significant difference ($F_{(23, 1)}$=2.47, p=.129; M=7231.6 for the KF group and M=6530.1 for the BB group). However, when more specifically looking into how each participant links his or her notes with other participants' notes (i.e., by replying notes in BB vs. by building-on or referencing notes in KF), it was found that there was a marginally significant difference between the two groups ($F_{(23, 1)}$=407, p=.055). In the KF group, there were 263 notes (76% of all notes) that were linked (M=21.9), whereas in the BB group, there were 219 notes (58% of all notes) that were linked (M=16.8). Table 2 summarizes the above results. While the result suggests that there were more note links in the KF environment, this does not really tell us about the group dynamics or social configurations within each sub-group. For example, the pattern of these links can be highly concentrated on a few people in a group, thus indicating a centralized social network structure, or it can be quite the other way around. To resolve this puzzle we further conduct social network analysis (SNA).

Table 2. Online note posting activities between the KF and BB groups

	BB (N=13)		KF (N=12)		F-value	P-value
	M	SD	M	SD		
Number of notes posted	29.10	5.71	29.00	6.84	0.00	0.973
Total Number of words produced	6530	1674	7231	3104	2.47	0.129
Number of notes linked	16.80	0.21	21.90	0.21	4.07	0.055*

* < .10

Social Network Analyses (SNA)

How does idea-centered design support group discourse and collaboration in the KF environment? Table 3 shows how additional design features were exploited by the students in the KF group. As it shows, "annotation" was fairly frequently used by students. A relational analysis further indicates that there was a significant correlation existing between the number of notes linked and that of notes annotated (r =.60, p<.05). This basically suggests that the "annotation" feature has played a supplementary role to support group interactions in the KF environment. As for the "rise-above" feature, while it is less frequently used, as noted above, it played an important role in synthesizing different ideas (regardless where these ideas are located) to form a deeper understanding of an issue or problem. As we manually calculated the total notes being synthesized in each rise-above note, it was found that on average, each rise-above note contains 4.09 notes.

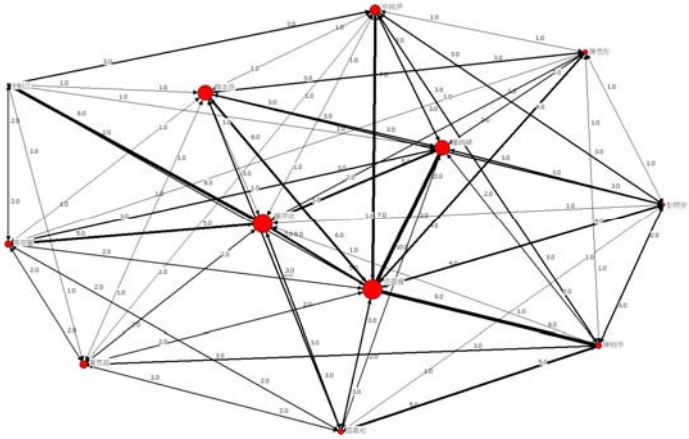
On the other hand, it was found that the remaining two functions, "coauthor" and "publication", were rarely being utilized, which suggests that there is still potential for the participants to develop more sophisticated group interaction and collaboration in the KF environment. Nonetheless, even though all the design features of Knowledge Forum to support collaboration were not fully utilized, based on the results in Table 3, it is still quite obvious that Knowledge Forum served a better environment for facilitating group interactions and collaboration as compared with the Blackboard enabled environment.

Table 3. Additional design features in support of social interactions in Knowledge Forum

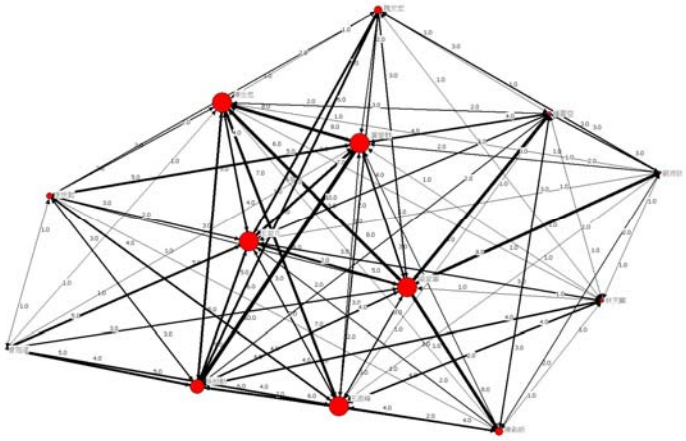
	N	Sum	M	SD
Annotations created	12	48	4.00	3.25
Rise-aboves created	12	11	0.92	0.79
Coauthored	12	1	0.08	0.29
Published	12	0	0	0

To find out if this is the case, we further perform a Social Network Analysis (SNA) to compare the two environments. Figure 4 depicts the group configurations in the KF and BB groups. As expected, both the groups show fairly strong group interactions. But when looking specifically into group dynamics in terms of "betweenness centrality" measure (which basically means an actor's centrality in regulating interaction within a community) and "closeness centrality" measure (which means that the author is close to many others in the network), it was found that the KF group has both a higher "betweenness centrality"[3] value (un-normalized centralization = 23.886; network centralization Index = 1.97%) and a higher "closeness centrality"[4] value (network in-centralization = 35.76%), as compared with the BB group (un-normalized centralization = 23.213, network centralization index = 1.47%; and network in-centralization = 27.41%). Clearly, students in the KF group had more dynamic and close interactions between each other. The next question to ask is whether more

dynamic social interactions in the KF group actually produced any quality changes in terms of students' understanding of the topic inquired in this course.



a. Social dynamics within the KF group (N=12)



b. Social dynamics within the BB group (N=13)

Figure 4. The social configurations between the KF and BB groups, both illustrating intense group interaction

Analysis on depth of understanding of the topic inquired

To further look into changes in students' knowledge growth, we further analyze students' portfolio notes. As baseline information, we first compare the total number of words generated in each student's portfolio note and it was found that there was no significant difference between the two groups (F=0.056, P=0.484; M=1307.8 and SD=214.2 for the KB group; M=1470.4 and SD=298.7 for the KF group). We then specifically investigated the following two dimensions of change, i.e., source and quality.

In terms of source, as noted above in "Method," there were five main sources of change, including: (1) peer discussion; (2) teacher interview transcripts; (3) invited guest speaker, instructor and teaching assistant's influence; (4) weekly reading assignment; (5) others (e.g., individual personal experience and learning processes). Table 4 shows the differences between the KF and BB groups in terms of the frequency, percentage, and rank of each source of change. As it shows, as the major source of change, "Peer discourse" accounts a higher percent (42.7%) of changes in the KF group, as compared with 38.6% in the BB group.

Second, in terms of the quality of change, emerged from an open coding procedure were the following four main categories: (1) more sophisticated understanding, (2) refined understanding, (3) naive or limited understanding and (4) no signs of understanding demonstrated. As Table 5 shows, there were more reflective instances (N=56) observed in students' portfolio notes in the KF group that demonstrated deeper change, whereas there were relatively fewer instances (N=41) observed in the BB group (N=41) that demonstrated deeper change.

Table 4. Major sources of change referred by students between the KF and BB groups

Source	KF Group			BB Group		
	Freq.	%	Rank	Freq.	%	Rank
Peer discussion	29	42.7%	1	22	38.6%	1
Teacher interview transcripts	14	20.6%	2	12	21.1%	2
Invited guest speaker, instructor and teaching assistant's influence	13	19.1%	3	10	17.6%	3
Weekly reading assignment	12	17.7%	4	8	14.0%	4
Others (e.g. personal experience)	0	0.0%	5	5	8.8%	5

Table 5. Quality of change in students' depth of understanding (reflective instances as unit of analysis)

Quality of change	KF Group		BB Group	
	Freq.	%	Freq.	%
1. More sophisticated understanding	56	82.4%	41	71.9%
2. Refined understanding	12	17.6%	16	28.1%
3. Naive or limited understanding	0	0%	0	0%
4. No signs of understanding demonstrated	0	0%	0	0%

One may, however, argue that these instances occurred only among a few students who actually attain deeper understanding in the KF group. To find out if this was the case, we reanalyzed the above dataset, by using "person" as unit of analysis. Table 6 shows the results. As it suggests, 10 out of 12 students (83.3%) in the KF group clearly demonstrated more sophisticated understanding of the main topic inquired during this course. In contrast, there were only 38.4% of students (five out of 13) in the BB group who demonstrated deeper conceptual change in terms of their understanding of the same topic inquired.

Table 6. Quality of change in students' depth of understanding (person as unit of analysis)

Quality of change	KF Group (N=12)	BB Group (N=13)
Deeper change	Students #1, #2, #3, #5, #6, #7, #8, #9, #11, and #12 (10 persons)	Students #1,2,10,12,13 (5 persons)
Preliminary change	None	Students #2, #7, #6, #9 (4 persons)
No change claimed	Student #10 (1 person)	Students #4, #5, #8, #11 (4 person)
Uncertain if there was any change	Student #4 (1 person)	None

An essential purpose of this course is to help students gain deeper understanding of the relationships between learning theory, teacher expertise and teaching practice, and it was frequently observed that students tended to view and describe these three concepts or variables as independent of one another in the beginning of the semester. But towards the end of the semester, the majority of them (see Table 6) were able to elaborate the complex and complementary relationships between these concepts. To demonstrate such quality change in students' thinking, below is an example excerpted from a student's portfolio note:

> After our first group discussion...I realize that theories are a starting point to handle a problem in practice because theories are synthesized from so many cases. Rather than considering theories as a what-to-do tool, we should consider them as a way of seeing problems. We as teachers should learn to use theories properly so that we can improve teacher professional development. Therefore, theories and practices are not separable, they complement each other. (student #6, KF group)

Summary and Discussion

The preliminary results of this study point out different performance patterns between students using Knowledge Forum and Blackboard. In summary, there was a marginally significant difference between the two groups in terms of the number of notes linked. The two indices of group dynamics generated from SNA further showed that there is a stronger interaction pattern in the KF group than in the BB group. Moreover, quantified qualitative difference was also found in terms of the source and quality of change in students' knowledge

growth. Overall, the KF group capitalized more frequently on peer discussion than the BB group in pursuit of their new understanding. This is of great importance to an effective CSCL environment in that peer discussion plays an essential role in further deepening and transforming what students learned (e.g., via reading in-service teacher interview transcripts and listening to a talk by an experienced teacher in the present case) into more reflective and refined understanding. One important thing to note is that although the class was composed of a hybrid communication with 2-hour-or-so face-to-face gatherings and intensive online forum discussions on a weekly basis, it was the peer interaction that played the key role to foster students' understanding. As assessed in the present study, by categorizing the degree of changes in student thinking, we found that more students in the KF group than in the BB group demonstrated more sophisticated understanding of the main topic inquired towards the end of this course.

But, to be exact, what might be the mechanism that triggers the depth of idea improvement in Knowledge Forum? Building on the findings, it is conjectured that the rise-above function may have played a key role in this. There are two reasons. Firstly, students in KF group used it nine times and synthesized a total of 57 notes to convert their ideas into more comprehensive viewpoints at the last week. Secondly, rise-above notes congealed the meaning of their discussion when such discussion gradually became too diversified (or too messy). These synthesizing notes turned out to be the collective products as well as a token of community growth in knowledge improvement activities. This conjecture however remains to be further explored and examined. In future and ongoing work, we will employ design-based research to continue looking into how this specific rise-above design feature helps students learn and build knowledge.

An important aim of the present study is to probe into the meaning of the difference under which the two groups utilizing Knowledge Forum and Blackboard environment respectively. As such, this study was largely conducted in a naturalistic situation rather than in a highly controlled experiment setting. Therefore, it remains to be further investigated whether an idea-centered design can be truly held responsible for the effectiveness observed in the present study. To this end, additional ethnographic and video-taping data based on orchestrating the entire classroom activity for at least two hour per week for eight weeks have also been collected. These datasets need to be further analyzed to solve the overall puzzle. For example, these video data consist of many small group face-to-face discussions in class for both the KF and BB groups, which were presumably as critical as many design features in Knowledge Forum. In addition, the whole class presentations took place at the end of the semester (which includes 12 sub-groups) can also serve a rich data source and a great opportunity for further analysis. Admittedly, simply counting the frequencies of notes or links online provides only an incomplete picture of the group dynamics in reality. Further data analyses will be conducted to fully answer the research question.

Endnotes

(1) In the present paper, the terms "thread" and "theme" are used interchangeably to refer to the theme-based design.
(2) Knowledge Forum can also be run under an "enhanced" graphical mode. But in the present study, we only use "basic" mode, in order to make the two environments more comparable.
(3) For betweenness centrality, it is degree a student lies between other students in the community; the extent to which a node is directly connected only to those other nodes that are not directly connected to each other; an intermediary; liaisons; bridges. Therefore, it's the number of people who a person is connecting indirectly through their direct links.
(4) For closeness centrality, it is the degree a student is near all other students in a community (directly or indirectly). It reflects the ability to access information through the "grapevine" of community members. Thus, closeness is the inverse of the sum of the shortest distances between each student and every other person in the community.

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