The creative power of online collaborative environment: Using Knowledge Forum as an example

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Abstract

The purpose of this study was to investigate the impact of a collaborative knowledge building environment called "Knowledge Forum" (KF) on students' perceived creative climate in class. Participants were 30 college students who took a university course about living technology. Data analysis includes: (1) descriptive statistics which analyzed student online discourse activities recorded in a KF database, (2) social network analysis which explored how students collaborated online; and (3) a survey called "Creative Climate Questionnaire (CCQ)" which investigated the characteristics of KF as a creative learning environment. Preliminary findings indicate that students were able to generate, exchange, and elaborate ideas by, interacting and collaborating with one another in KF. Further, the results based on the CCQ suggest that of ten factors that characterize a creative environment, seven of them (including playfulness/humor; idea support; liveliness; debate; trust/openness; and freedom) were perceived as much superior than another two reference groups: (1) Taiwanese graduate students (N=703) and (2) Swedish company employees (N=245). The results showed that KF as a knowledge building environment is conducive to creative group collaboration.

Keywords

Knowledge building, group collaboration, creative climate

As evidenced in history, innovations were often derived from collaborative knowledge network, rather than individual efforts (Gloor, 2006). Innovation may come from the development of so called small c invention, e.g., ideas derived from improvised conversation between colleagues in workplaces (Saywer, 2007). Alternatively, it may come from the development of so called big C invention, e.g., the invention of a new medicine. A famous example of invention derived from synthesizing many small-c's to eventually producing a breakthrough, big C is the invention of aircraft by Wright brothers who brought together many small ideas from their predecessors and eventually came up with a big innovative idea of building an aircraft. This creative process was a social one as it consists of collective efforts among many people (e.g., repeated trials and errors, and sustained designs, tests, and re-designs).

Nowadays, knowledge-based economy and collaborative network have become a norm for teamwork. In the past, the concept of teamwork highlights cooperation and division of labor. Today, the concept of teamwork emphasizes creative collaboration (Sawyer, 2007). Corporate culture has begun to realize the power of collaborative innovative network (see Gloor, 2006). By capitalizing on intranet and Internet, many companies are able to develop more collaborative and creative working atmosphere. For example, Google's corporate culture is characterized by providing maximum possible opportunities for collaboration in order to stimulate innovative ideas, and to achieve what Sawyer (2007) called "group flow" (p43).

To cultivate such creative atmosphere, many researchers have dedicated to investigate different technological means to support more effective collaboration. Arguably, the capacity to make good use of Internet technologies for maximizing a group's creative potential holds the key to a successful future of collaborative team work (Hong, Scardamalia, & Zhang, accepted; Hong & Sullivan, 2009; West & West, 2009). Having the know-how to design proper digital environments will play a vital role in promoting group creativity and collaboration as this would greatly support the generation of innovative ideas, enhance group productivity, facilitate the development of group members' imaginative capacity, and thus making knowledge creation more effective.

Previous studies (e.g., Hargreaves, 1999; Scardamalia & Bereiter, 1999; Hong, Scardamalia & Zhang, accepted) indicate that with careful design, it is possible to transform a school learning environment into one resembling a creative working environment that is often observed in research, business, and science communities. Building

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on this line of arguments, the purpose of this study is to investigate the effects of engaging students to work in a collaborative environment called Knowledge Forum on their perceived creative atmosphere of this environment. In particular, we intend (1) to explore how college students use "Knowledge Forum" in their creative collaboration; and (2) to explore how these students perceive the atmosphere of "Knowledge Forum" as a creative environment.

Literature review

Collaborative innovation

Teamwork learning can take many forms. One of which is cooperative learning. Panitz (1996) defines it as a process to help people work together in order to achieve a shared goal or develop a product in the end. Zuckerman and D'Aunno (1990) define cooperation as an organization formed through the joint efforts of three or more people to pool resources together in order to achieve mutual objectives. With the rapid change in our post-modern society, however, such conventional form of teamwork, with a strong emphasis on division of labor, is become less relevant to the need of an organization that values innovation. By contrast, another form of teamwork highlights a bottom-up approach and greatly values improvisional collaborative knowledge work (Sawyer, 2007).

From a microscopic perspective, Sawyer (2007) used interaction analysis methods to explore the process of transforming individuals' creativity into collaborative creative power. In his findings, he identified several key characteristics that are required for developing a creative team (Sawyer, 2007). These characteristics can be summarized as follows: (1) The innovation emerges over time ; (2) People spend as much time listening to others as they do contributing themselves; (3) Team members feel free to build on each other's idea; (4) Judgment is suspended to some degree; (5) Unexpected questions arise; (6) The innovation process itself is highly inefficient; and (7) Good innovations tend to emerge from the bottom-up rather than top-down. Sawyer's findings confirm what is called "Medici Effect", which highlights the important role of multiculturalism, sustained conflict and integration, idea convergence in groups, and heterogeneous idea collisions, all of which are important in helping generate innovative ideas (Johansson, 2004). In the present study, Knowledge Forum platform serves as such a heterogeneous design space for divergent thinking and idea integration. It is posited engaging students in Knowledge Forum will help them achieve deeper collaboration.

Creative climate

With regard to creativity research, Sternberg (1999) proposed seven approaches, including mystical approaches, pragmatic approaches, psychodynamic approaches, psychometric approaches, cognitive approaches, social-personality approaches and confluence approaches. The former six research approaches mainly concerned with individual creativity and/or the impact of individual differences on creativity. In contrast, the seventh approach is inclined to regard creativity as generated by means of a combination of personal, environmental and socio-cultural factors. As such, when it comes to teamwork, the focus is not only on individual differences, but also on external environment systems and the interaction among team members and other converging factors.

Because of this, many creativity studies began to investigate working environments, for example, by trying to identify factors that affect team creativity and by designing surveys and scales to assess innovative climate within an organization. In particular, in developing instruments that measure creative atmosphere in an organization, Amabile (1996) and colleagues, from a socio-psychological point of view, investigated what possible factors may hinder or facilitate creativity in an organization. They found that organization's working motivation is affected by different environmental factors. Building on their research, a measurement scale called KEYS was developed, which consists of two factors that hinder creativity (workload pressures and organizational barriers) and six factors that enhance creativity (encouragements from organization, from leaders, or from team-workers, work autonomy, richness of resources, and the level of challenge at work). In addition, The Swedish scholar, Ekvall (1991) also proposed ten factors that influence creative atmosphere within an organization, including reflection time, freedom, support, openness, challenge, adventure, playfulness, liveliness at work, debates, and conflict. Using these factors, he further developed an instrument call Creative Climate Questionnaire (CCQ) to assess the creative climate of organizations. The above research pointed out the importance of designing a more creative working environment, as under an encouraging and supportive

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environment, it is more likely to promote knowledge interaction between individuals within groups and to inspire innovative ideas and produce more creative products.

Knowledge building theory and technology

"Knowledge Forum" (KF) is a computer-supported learning environment designed based on knowledge building theory and pedagogy. Knowledge building can be defined as a social process focused on sustained production and improvement of ideas of value to a community or an organization (Scardamalia, & Bereiter, 2003). KF enables community members to collectively reflect on the problems inquired in order to create new knowledge (Scardamalia, 2002; Scardamalia & Bereiter, 2003). By engaging students in working in KF, it is expected that students will become more self-directed learners and be able to co-structure their collective knowledge in the community. In a KF environment, students are guided to build their knowledge by generating and linking their ideas, and by deepening the concepts that they are constructing (Hong, Chen, Chang, Liao, & Chan, 2009).

Several studies (e.g., Sawyer, 2006; Hong & Sullivan, 2009) show that appropriately designed knowledge construction activities can help transform traditional teaching methods that have been emphasizing individual learning and knowledge growth. As our society is rapidly changing, many problems are so complex (e.g., environmental issues) that most of these problems cannot be solved by any single person. Instead, solving these problems will require collective knowledge and efforts. One way to support such collaborative learning and knowledge building process is to apply knowledge building theory. Knowledge building basically sees knowledge as tentative and ideas as the basic unit for constructing meaning or knowledge. In a knowledge building environment, students are encouraged to take collective responsibility for knowledge construction (Scardamalia, 2004). To this end, a set of 12 knowledge building principles were proposed by Scardamalia (2002), including: (1) Real Ideas, Authentic Problems; (2) Improvable Ideas; (3) Idea Diversity; (4) Epistemic Agency; (5) Community Knowledge, Collective Responsibility; (6) Democratizing Knowledge; (7) Symmetric Knowledge Advance; (8) Pervasive Knowledge Building; (9) Constructive Uses Of Authoritative Sources; (10) Knowledge Building Discourse; (11) Embedded, Concurrent and Transformative Assessment; and (12) Rise Above. For example, the principle of Real Ideas, Authentic Problems highlights the importance of viewing student ideas as conceptual artifacts (Bereiter, 2002) that are as real as tangible things, and that knowledge problems arise from efforts to understand the world in the community. The principle of Epistemic Agency underscores that participants deal with the full range of knowledge problems (goals, motivation, evaluation, planning, etc.), including knowledge problems normally left to teachers or managers. Previous research indicates that integral use of knowledge building theory and technology can effectively help students learn and build collective knowledge (Hong, Scardamalia, Messina & Teo, 2008; Scardamalia, 2002; Scardamalia, Bereiter & Lamon, 1994). Figure 1 shows the design of a note interface and “theory building” scaffolds (on the left side), including, (1) My theory; (2) I need to understand; (3) New information; (4) This theory cannot explain; (5) A better theory; and (6) Putting our knowledge together. They are designed to promote collaborative knowledge building.

Figure 1: The designed interface of a note and its scaffolds in KF

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Method

Participants

Participants(N = 30) in the present study were students from a university course about "Introduction to Living Technology." The main purpose of this course was to understand technological knowledge and the intricate relationship between technology and human life. The course was also intended to arouse students' interest in living technology; to develop independent thinking and problem-solving skills, and to stimulate their creative thinking. Curricular activities mainly included class discussion and online interaction. The teacher played a role as a facilitator. The main online activities were initiated by students' proposing real life problems of interest and exchanging ideas through Knowledge Forum environment in order to solve these problems. Students were also encouraged to imagine what future technologies may be possible to solve various problems of their interest. The duration of this course is 18 weeks.

Data sources

Data source includes student online discourse recorded as notes in a KF database, and a survey called "Creative Climate Questionnaire (CCQ)". In terms of student discourse, all online behaviors were automatically recorded in KF, including numbers of notes posted, annotations, build-on notes, and so on. In order to assess the effectiveness of students' online discussion, we used an Analytic Toolkit (ATK) embedded in the Knowledge Forum database for analysis. In particular, when writing a note, information such as note title, use of scaffolds, use of keywords, identification of problems, were constructed by students. In the present study, we particularly looked into the frequency of keywords used by students to represent their main ideas.

Second, to assess the creative atmosphere in KF, we employed a modified version of Creative Climate Questionnaire (CCQ) (see Zeng & Wu, 2002). The original CCQ was designed by Swedish scholar Ekvall (1987). There are in total 50 question items with 10 dimensions, including: (1) challenge, (2) freedom, (3) idea support, (4) trust/openness, (5) playfulness/humor, (6) conflict, (7) debate, (8) risk-taking, (9) liveliness, and (10) reflection time. Each dimension consists of five question items (see Table 1 for samples). All items adopt a four-point Likert scale. The original scale has an internal-consistency reliability of Cronbach α =. 87 (N = 703), with sub-scales ranging from .70 to .86. In the present study, the CCQ was administered at the end of course.

Table1: The dimensions/factors of Creative Climate Questionnaire and sample items

Dimension	Sample items
Challenge	"Most people here think that their job or school work is meaningful so that they feel excited and stimulated."
Freedom	"People here are self-motivated to find information and to solve problems." "Most people here value their work and put their work high on their priority."
Idea support	"People here are always willing to share their ideas because they are encouraged to do so and people also pay attention to each other's ideas."
Trust/open	"Communications among members are very open and straightforward here." "Everybody trusts each other in this place."
Liveliness	"The atmosphere here makes people feel excited." "People here are full of ideas."
Playfulness/humor	"The atmosphere here is casual, comfortable, and relatively less formal." "the atmosphere here is playful."
Debate	"There are always many different views and ideas being expressed and circulated here." "Innovative ideas are often generated for discussion in this place."
Conflict	"Due to conflicts in hierarchy, there is always a considerable sense of tension." "A lot of people here cannot tolerate each other."
Risk-taking	"Although the outcomes may not clear, people here still willing to take initiative and try." "Innovative ideas are adopted and implemented quickly in this place."
Reflection time	"Here people are encouraged to think and discuss new ideas in a deeper sense." "People here are given plenty of time to think about their new ideas."

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Results

Students' interaction in Knowledge Forum

During the 18-week course, students not only discussed various living technologies in class, but also spent time identifying and solving future technology problems on the KF platform. Students posted notes and shared ideas. If an idea was not clear, they ask for clarification by using annotations or they helped elaborate the idea by using build-on notes. In so doing, ideas are enriched through sustained interaction and discussion. As Table 2 shows, in terms of online contribution, students (N=30) established a total of 508 notes (M = 16.9; SD = 6.66). In terms of online interactivity, the mean percent of notes linked was 51.90% (SD = 25.04%); and the mean percent of notes read was 40.50% (SD = 24.44%). In terms of complementary feedback, students in total created 279 build-on notes (M = 9.3; SD = 5.64); and they used annotation features for a total of 279 times (M = 9.3; SD = 13.33). In terms of idea diversity, students in total created 327 keywords (M = 10.7; SD = 10.16). This suggests that students' online discussion was fairly substantive and frequent.

On the whole, students' activities in KF not only showed initiatives in proposing problems of their interest, generating their own ideas, but also proved that they were able to actively interact with each other's different points of view. Further, the frequent use of keywords suggests that students were able to make use of focal concepts to advance knowledge and promote deep reflection. The high interactivity also suggests that students were engaged in frequent idea exchange. Additional social network analysis as shown in Figure 2 also suggests that students engaged in intensive reading, cross-referencing and discussing. The following two examples (translated from Chinese) further illustrate how students identified problems related to their daily life and further revised their initial ideas for improvement. The first example shows preliminary thoughts generated by a group of students interested in designing new transportation vehicles and the second example shows further diversification and improvement of ideas by the same group of students, after the group went through extensive exchange of divergent views on transportation technology:

Example 1:

> **The problem**: how to improve the current means of transportation (car)?
> **Keywords**: transportation, vehicles, problems, ideas
> **Seven problems observed in our daily life**: (1) When riding a car, some people tend to get motion sickness; (2). When entering a car long-exposed under the Sun, it's usually very hot and uncomfortable; (3) After we use up the oil, what might be the next generation of energy for cars; (4) Is there any better way to prevent car accidents; (5) It is always very hard to find a parking space in Taipei; (6) Is it possible to avoid to slam car doors; (7) how to keep the car always clean?
> **Diversified ideas**: (1) A car that can change colors whenever we want it to; (2) An extendable car that can change from a two-seater to a perhaps 25-seater bus; (3) A very light car that you can move it by hands when it breaks down on the road; (4) A car with a anti-theft function; (5) A car that monitors a driver's physical conditions to avoid, for example, drunk driving or some sudden heart attack and can thus auto-pilot itself; (6) An transportation system using magnetic power.
> **Rise-above idea**: In fact, our overall idea is not limited to cars; we are interested in designing a completely new kind of "vehicle". (S16)

Example 2:

> **The problem**: What constitutes an ideal transportation technology?
> **Keywords**: Transportation, ideas for transportation
> **Putting our knowledge together**: (1) Highly effective and time-efficient; (2) High capacity, e.g., a car that can stretch and transform itself; (3) Environmentally friendly, energy-saving, and carbon-reducing; (5) Comfortable, understanding human needs, non-oppressive, making us feel like at home; (6) cheap and affordable to most people; (7) recreational and entertaining.
> **Diversified ideas**: Below are some more special ideas for new transportation functions: (1) Autopilot, automatic navigation (device that helps design best trip or route for traveling from place to place; (2) Technology that can automatically detect available parking spaces, and part the car for you; (3) High mobility [that can move in all direction]; (5) Easy to use for physically

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challenged; (5) Underground transportation system; (6) combination of mobile communication technology with most updated public transportation information. (S16, S23, S8)

In addition, after 18 weeks of interaction and discussion, students gradually shifted from generating many diversified ideas to integrating and synthesizing these ideas. As shown in Figure 3, each square box represents a note generated by an individual. If other students wish to give feedback or comments, they can build on to this note, so as to elaborate or enrich ideas. This action would create a new square box and a link between the two square boxes. The open space here represents a view, namely, a group problem-solving space for sustained idea improvement.

Table 2: the statistic of students' active on KF

	Sum	M	SD
Number of notes	508	16.9	6.66
Note-linking	-	51.9(%)	25.04(%)
Percent read	-	40.5(%)	24.44(%)
Number of annotations	279	9.3	13.33
Number of build-ons	279	9.3	5.64
Number of keywords	327	10.7	10.16

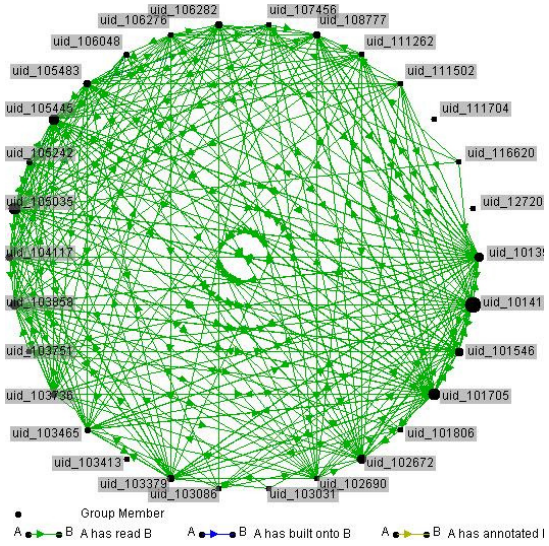

Figure 2: students' social network on KF

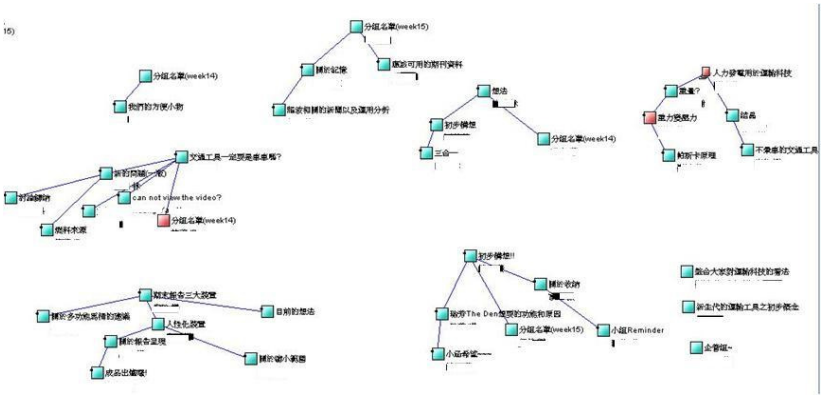

Figure 3: the collaborative process in different working groups

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Students' perceived creative climate in Knowledge Forum

So whether the inclusion of a KF environment represents an additional burden of course work or an opportunity for students to freely collaborate and create new ideas? To answer this question, we administered "Creative Climate Questionnaire" at the end of this course. As there is no control group in this study, we compared our results with Ekvall's (1987) and Zeng's (2002) findings in their studies, respectively. In Ekvall's study, he used CCQ to measure the creative atmosphere in business communities. Specifically, he measured employees of SMEs company in Sweden (N = 245). In contrast, in Zeng's study, she modified Ekvall's (1987) original CCQ to assess the creative atmosphere of graduate institutes in Taiwan, using graduate students as subjects (N = 703). The modified scale by Zeng was found reliable and was validated by using factor analysis, item analysis and other statistical treatments.

Based on comparing our findings with Ekvall's and Zeng's findings, it was found that only three indicators, including "challenge" (M = 3.03; < 3.44), "reflection time" (M = 3.07; <3.42), and "risk-taking" (M = 2.83; <3.38) were lower than the means in Ekvall's or Zeng's studies. In terms of the "challenge" and "reflection time" dimensions, when examining students' answers, it was found most answers fell between "not consistent" and "fairly consistent". This suggests that students were still quite uncertain or had a more reserved attitude towards these two dimensions. It implies that the use of the KF environment can still be improved by giving more time for students to think deeply, and to take on more challenging tasks.

In terms of the "risk-taking" dimension, it was found that the means was quite low. Most students' answers fell in the "not consistent with" category. The fact that students conveyed a quite conservative and passive attitude towards this dimension implies that there is still room for improvement in terms of the use of KF as a more risk-taking environment. Nevertheless, this is understandable, as it is a school learning environment, rather than a real-life business environment.

In contrast, the means of the remaining seven factors are all higher than the means in Ekvall's and Zeng's studies, including "Playfulness/Humor" (M = 3.45; > 2.86) (which indicates the KF platform represented a fairly free space for students to discuss and embraces diversified ideas); "idea support" (M = 3.4> 2.9) (which shows that students were encouraged to generate ideas and express thoughts in KF, and ideas are being widely spread and heard; "liveliness" (M = 3.37; > 2.35) (which shows that discussion in KF is lively and energized); "debate" (M = 3.36; > 3.34) (which suggests KF not only allow students to voice new ideas, but their ideas were being examined and debated); "trust/openness" (M = 3.3; > 3.2) (which demonstrates that the atmosphere of this online community permits a high degree of openness and encourages candid communication); "freedom" (M = 3.02; > 2.51) (which implies students did feel free and motivated to actively seek information and solve problems).

Table 3: the students' feeling of online creative climate, compared with the criteria

	Students who work in KF (N=26)		Graduate students of Taiwan (N=703)		Employees of enterprise in Swedish (N=245)	
	M	SD	M	SD	M	SD
Freedom	3.02	0.44	2.51	0.66	2.83	0.52
Risk-taking	2.83	0.45	2.81	0.72	3.38	0.72
Trust/openness	3.3	0.38	2.98	0.52	3.2	0.45
Reflection time	3.07	0.41	3.42	0.65	2.96	0.56
Idea support	3.4	0.41	2.86	0.56	2.9	0.61
Debate	3.36	0.36	3.3	0.62	3.34	0.52
Challenge	3.03	0.38	3.44	0.52	3.28	0.65
Playfulness/humor	3.45	0.37	2.86	0.6	2.56	0.6
Liveliness	3.37	0.35	2.33	0.62	2.35	0.63
Conflict	1.36	0.38	1.21	0.52	1.32	0.51

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Summary and discussion

Organizations nowadays are seeking ways to design collaborative networks in support of group innovation. This is extremely important because the most creative ideas usually come from interaction between group members with very different disciplinary knowledge (Hong, Scardamalia & Zhang, accepted; Johansson, 2004). To better understand what constitutes a good online learning environment, the present study employed Knowledge Forum, an online multimedia platform designed based on knowledge-building theory, and investigated whether it helps provide students with a collaborative environment with creative atmosphere. As a result, after 18 weeks of using Knowledge Forum and working to identify and solve various technology related problems, it was found that students were able to generate a lot of creative ideas, and continually share and improve them. Moreover, our social network analysis also revealed that there was a strong group dynamics in term of idea interactivity. In addition, as assessed by the "Creative Climate Questionnaire" (CCQ), students' perception about Knowledge Forum as a creative knowledge-creating environment was also quite strong. It was found that of the ten factors defined in the CCQ, there are seven factors that was found to be rated higher by the students in the present study as compared with another two studies by Zeng (2002) and Ekvall (1991). These seven factors were: "Playfulness/humor", "idea support", "lively", "debate", "trust/open", "conflict", and "free". In other words, our results suggest that KF platform was able to provide students with a fairly comfortable and open discussion environment; therefore students could express diversified views, and continually exchange and improve each other's ideas.

Rhodes (1961) proposed the use of 4P perspectives (see also Wu, 2000) to assess creativity. The 4P stands for: (1) Process, (2) Person, (3) Place, and (4) Product. In the present study, KF platform as a learning environment was evaluated by the third P (Place). In particular, we investigated whether it represents a good environment that provides a creative atmosphere. In the future studies, it may be fruitful to further look into group collaboration from other perspectives.

Arguably, a concern in the present study may have to do with the use of CCQ. Creativity literature has shown that instruments measuring organizational atmosphere for creativity such as the KEYS scale or the CCQ questionnaire were originally designed for use in business environments, not in learning environments. Nevertheless, As John Dewey cogently pointed out, a school is a miniature of the society. Therefore, if cultivating a knowledge-creating culture in school settings is considered an important task in a knowledge-based society, use of CCQ in a school setting should be acceptable.

Finally, this study still has many quantitative and qualitative data yet to be analyzed (e.g., students' online discourse recorded in the KF database and technological products that students designed in this course). Further exploration will focus on analyzing these data sets and products in order to triangulate our preliminary findings and also to fully understand the nature of KF as a creative collaborative environment.

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