Enhancing the creative climate of a college course through computer-supported collaborative knowledge building

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Abstract. This study explored effects of engaging students in a knowledge building environment assisted by Knowledge Forum (KF) on their collaborative learning processes and their perceived creative climate of that environment. Participants were 30 teacher-education students who took a university course in which knowledge building theory and KF technology was integrally employed to foster a knowledge building environment. The main data sources came from: (1) student online discourse recorded in a KF database; (2) a modified Creative Climate Questionnaire (CCQ), and (3) course evaluation administered at the end of the course. Findings indicate that students were highly interactive and collaborative in working with knowledge in KF. Further, the CCQ results indicate that the participants tended to perceive the climate of the knowledge building environment they were engaged as highly supportive for knowledge creation. Additional evidence based on course evaluation ratings also showed a significant preference for the present course operated under knowledge-building pedagogy over other courses offered in a more traditional way of instruction. Implications for designing effective knowledge building environments are discussed.

Keywords. Knowledge building environment, creative climate, CSCL

Introduction

Our society is being transformed into a knowledge society (Drucker, 1968; UNESCO, 2005) in which the capacity for knowledge creation has become a critical factor for progressive organizations of all kinds (David & Foray, 2003; Florida, 2002; Homer-Dixon, 2006). In response to this change, many recent calls for education reform have been highlighting the importance of fostering knowledge creation and collaboration skills among learners, and transforming schools into knowledge creating organizations or communities (Bereiter & Scardamalia, 2003; Hargreaves, 1999; Sawyer 2006; 2007; Scardamalia & Bereiter, 1999). Accordingly, this change also transformed our perception of learning from viewing it as merely a means of knowledge acquisition and participation (Sfard, 1998) to viewing it also as a part of knowledge creation (Bereiter & Scardamalia, 2003; Author, 2009b; Scardamalia, 2002). Yet, while the argument for valuing collaborative knowledge creation as an important solution to 21st century education is well justified, it remains unclear as to what constitutes an effective learning environment in support of collaborative knowledge creation and how to design instruction accordingly to cultivate such environment (Author, accepted; Author, 2009; Hong & Sullivan, 2009b; Chai & Tan, 2009; Scardamalia & Bereiter, 2006). To address this question, this study attempts to engage students in a knowledge building environment and to examine whether doing so would help foster (1) more collaborative and creative learning processes, and (2) a more creative climate in this environment. To begin, in the following sections, a review of the literature on creative climate in organizations will be presented. This will be followed by a discussion of the rationale and design characteristics of a knowledge building environment in support of knowledge creation.

Creative climate in organizations

As evidenced in history, innovations were often derived from collaborative knowledge networks, rather than individual efforts (Gloor, 2006). Innovation may come from the development of so called “little-c” (everyday) creativity (Beghetto & Kaufman, 2007), e.g., ideas derived from improvised conversation among colleagues in workplaces (Sawyer, 2007). Alternatively, it may come from the development of so called big-C (eminent) creativity, e.g., the invention of a new medicine. A well known example of invention derived from synthesizing many little-c’s to eventually producing a breakthrough big-C is the invention of the aircraft by the 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, in a knowledge-based economy, collaborative networks have become a norm for teamwork. In the past, the concept of teamwork highlighted cooperation and division of labor (Slavin, 1980). Today, the concept of teamwork emphasizes creative collaboration (Sawyer, 2007), group cognition (Stahl, 2006), community knowledge (Author, 2008b), and collective cognitive responsibility (Scardamalia, 2002). Corporate culture has begun to realize the power of collaborative innovative teamwork (Gloor, 2006) and the importance of cultivating a more creative climate to support such teamwork and capitalizing on both intranets and the Internet to develop more creative working atmospheres. 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). Apparently, having a creative working climate would facilitate the creative capacity of an organization as a community (Ismail, 2005).

Because of this, many creativity studies began to investigate creative climate in working environments (see, e.g., Amabile & Conti, 1999; Ekvall & Tangeberg-Anderson, 1986; Zain & Rickards, 1996). In particular, researchers started to try to identify factors that affect team creativity by designing surveys and scales to assess the innovative climate within an organization (e.g., Amabile, Conti, Coon, Lazenby, & Herron, 1996; Ekvall, 1996). For example, Amabile et al. (1996) developed instruments that measure the creative atmosphere in an organization by looking into what possible factors may hinder or facilitate creativity. They found that an organization’s productivity is affected by two factors that hinder creativity (workload pressures and organizational barriers) and six factors that enhance creativity (encouragement from the organization, from leaders, or from team-workers, work autonomy, richness of resources, and the level of challenge at work). Similarly, Swedish scholar Ekvall (1991; 1996) also proposed ten factors that influence the creative atmosphere within an organization, including challenge, freedom, idea support, trust/openness, dynamism/liveliness, playfulness/humor, debates, conflicts, risk-taking, and idea time. Using these factors, he further developed an instrument called the Creative Climate Questionnaire (CCQ) to assess the creative climate of organizations.

The above research argues for the importance of designing a more creative learning and working environment. An encouraging and supportive environment is more likely to promote knowledge interaction among individuals within groups and to inspire innovative ideas that result in more creative products. To cultivate a more creative climate, many researchers have also investigated different technological means to support more effective collaboration and knowledge creation. 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 learning and team work (Author, in press; Author, 2009b; West & West, 2009). Having the instructional 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 make knowledge creation more effective.

Knowledge building theory and environment

A theoretical approach to transform conventional school learning environments into more creative ones that are often utilized in research, business, and science communities is Bereiter and Scardamalia's knowledge building theory (see Bereiter & Scardamalia, 2003; Scardamalia & Bereiter, 1999; 2003; 2006). In brief, knowledge building is a social process that highlights sustained production and improvement of ideas of value to a community (Scardamalia & Bereiter, 2006) and is supplemented by the use of a technological platform called Knowledge Forum, which helps facilitate a knowledge-building environment. As a fundamental approach to education reform in the learning sciences field (Sawyer, 2006), knowledge building is featured with a principle-based approach to innovation (Zhang, Hong, Scardamalia, Teo, & Morley, accepted) which emphasizes learning as a complex system (Barab, et al., 1999) and learning processes as emergent, guided only by general learning principles. This is in sharp contrast with conventional reform efforts highlighting ritualistic instructional activities defined by pre-specified procedures, classroom scripts and rules, or componential learning tasks, which lead to achieving pre-specified content mastery rather than creating knowledge (cf. Author, 2009b).

To foster a knowledge building environment, Scardamalia (2002) has conceptualized a set of 12 knowledge building principles. They include: (1) Real Ideas, Authentic Problems; (2) Idea Diversity; (3) Epistemic Agency; (4) Improvable Ideas; (5) Community Knowledge, Collective Responsibility; (6) Democratizing Knowledge; (7) Symmetric Knowledge Advancement; (8) Pervasive Knowledge Building; (9) Constructive Uses Of Authoritative Sources; (10) Knowledge Building Discourse; (11) Embedded, Concurrent and Transformative Assessment; and (12) Rise Above (see Scardamalia, 2002, for details of each principle). These principles represent ideals and guidelines for the design of an effective knowledge building environment. To give a few examples, the principle of Real Ideas, Authentic Problems emphasizes the importance of regarding student ideas as conceptual artifacts/objects (Bereiter, 2002) that are as real as things (e.g., a cup) tangible and improvable, and that knowledge problems should arise from efforts in the community to understand the real-life world. The principle of Idea Diversity emphasizes that diversity is vital to the development of knowledge advancement as it can help create a rich environment for ideas to evolve into more refined forms. Moreover, the principle of Epistemic Agency emphasizes that participants should play the role of independent learners to deal with the full range of knowledge problems, including even problems normally left to teachers or managers.

With the knowledge building principles serving as conceptual guidelines, a software program called Knowledge Forum (KF) was created to support the development of a knowledge building environment. In brief, KF represents a technology-enhanced environment designed to assist actual knowledge building activities in a multimedia community knowledge space. It enables community members to collectively reflect on problems of interest in order to create new knowledge (Scardamalia, 2002; Scardamalia & Bereiter, 2003). In KF, participants can contribute their ideas in the form of notes to "views," which are virtual spaces for collaborative problem solving among community members. In addition, Knowledge Forum also allows participants to co-author notes, build-on, annotate, and reference the work of others, add keywords, set problem fields, and "rise above" previous notes to bring greater coherence to the content of the knowledge space. All these features are designed to foster dynamic idea interaction and in-depth collaboration. All these online operations can be automatically recorded in a KF database, and can be statistically represented by means of an Analytic Toolkit (Burtis, 2002). The Knowledge Forum designs are in line with the overarching commitment to sustained knowledge advancement in order for community members to continually exchange and improve ideas. As an example, Figure 1 shows the interface of a Knowledge Forum note with some design features such as using authentic real-life problems to guide the generation of real ideas and improvable ideas; using the text body to elaborate ideas; using keywords to help identify, search for, and relate ideas; and using customizable scaffolds to frame ideas. By engaging students in working in KF, it is expected that students will become more self-directed problem solvers and be able to co-structure their knowledge in the community.

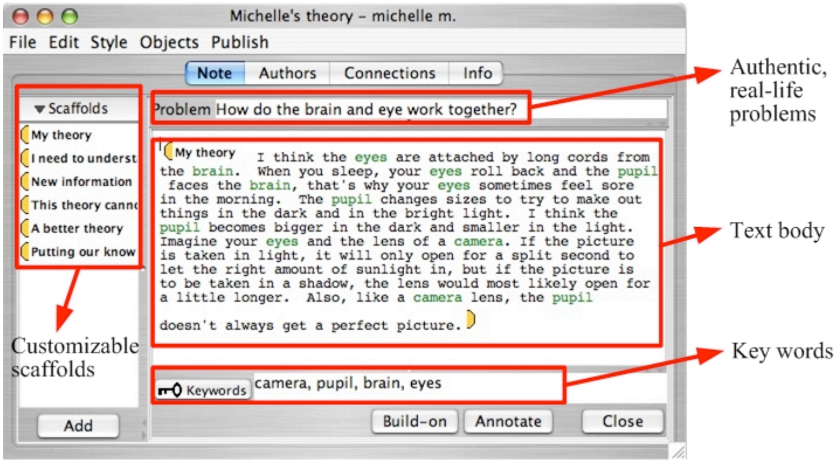

Figure 1. Some design features of the note interface (source: adapted from Knowledge Forum 4.6 online manual at http://ikit.org/kf/46/help/)

The present study

Previous research indicates that integral use of knowledge building theory and Knowledge Forum technology can effectively help students learn (Author, 2008a; Scardamalia, 2002; Scardamalia, Bereiter & Lamon, 1994; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007). However, the question of whether the knowledge building environment indeed provides a creative climate for knowledge work remains to be answered. Thus, the purpose of this study is to investigate the effects of engaging students to work in a knowledge building environment (as assisted by Knowledge Forum) on their perceived creative climate of this environment. In particular, this study intends to investigate: (1) whether students could actually work collaboratively and creatively with knowledge in Knowledge Forum (i.e., a process evaluation); and (2) whether they perceived the climate of this knowledge building environment as creative after engaging it for a semester (i.e., an outcome evaluation), and (3) finally, as a way of triangulation, the present study also examined the overall quality of this course that was designed based on knowledge building theory and technology, as compared with other courses also offered in the same university.

Method

Context and participants

The present research was conducted in a university course about living technology in Taiwan. The course was offered by the university's teacher education program to students who plan to teach natural sciences or living technology at the elementary school level in the future. The university is ranked as one of the top six universities in the nation. As such, the students enrolled in the subject university are all academically high-achievers. Over the past few years, supported by a grant from the nation's Ministry of Education, the university has been deeply dedicated to improving its instructional quality, with a reform preference towards transforming traditionally more didactic mode of teaching into more constructivist-oriented teaching practices. This reform movement rendered an opportunity for knowledge building theory and technology to be introduced in this course as an alternative way of teaching and learning. Participants in this course were 30 pre-service elementary education students (20 females). Their ages ranged from 18 to 20. The duration of this course was 16 weeks.

Instructional Design

There were two main instructional goals in this course. One was to help students acquire some basic knowledge in order for them to teach technology related subject matter at the elementary school level in the future. The other was to engage students in actual knowledge building by solving real-world technology problems while developing collaborative and creative skills. To these ends, a tutorial workshop about how to use Knowledge Forum for knowledge building was given at the commencement of the semester. This was implemented by demonstrating some basic design features and functions of Knowledge Forum to students, for example, how to create a note in a "view" (i.e., a virtual problem-solving space in Knowledge Forum) or how to "build-on" to an existing note. Figure 2 shows a screenshot of a Knowledge Forum view, in which each square box represents a note generated by a community member or a group of co-authors. To elaborate, enrich, exchange, or improve ideas, members can provide suggestions or comments by building onto existing notes. This action would create a new square box with a link between two square boxes. Further, an idea-centered, principle-based instructional approach designed based on knowledge building pedagogy was adopted to help translate knowledge building theory into practice (see Author, 2009b, for details). Specifically, the following four instructional activities were facilitated: (1) problem-finding and defining activities, in which students were required to look for real-life technology problems and then identify a particular problem of interest for further investigation; (2) idea generation activities, in which students were asked to generate ideas or solutions to solve their problems of interest; (3) idea diversification and elaboration activities, in which students were guided to explore various living technologies (e.g., information and communication technology), to discuss and exchange ideas, and to engage in sustained idea improvement; (4) design and presentation activities, in which students engaged in continual design and redesign for better technological solutions and at the end of this course, students share what they learned from their knowledge building process with others in the community by giving a presentation.

The instructor, who was the author in this study, was familiar with knowledge building theory and pedagogy, and has been using Knowledge Forum in his college teaching for two years. Throughout the semester, the instructor tried as best as he can to follow the guidance of the 12 knowledge building principles—as design ideals—in cultivating an authentic knowledge building environment, in order to allow students to work collaborative and creatively with their own problems of interest for sustained idea improvement. There was no pre-assigned grouping in this course; instead, students planned their own learning by opportunistically deciding whom to collaborate with, or what ideas to interact with, based on the nature and types of problems they were working with at the moment (Author, 2009b; Zhang, et al., 2007)

Figure 2. A sample knowledge building view (Source: excerpted from the present study)

Data sources and analysis

This research is exploratory in nature and employed a multi-method approach to collecting and analyzing data. The main data sources include: (1) student online discourse recorded in a Knowledge Forum database, (2) a modified Creative Climate Questionnaire (CCQ) by (Zeng & Wu, 2002), and (3) a course evaluation survey. First, to assess knowledge building process, a descriptive analysis was performed on the recorded dataset in Knowledge Forum to describe students' overall online discourse and learning activities. To this end, five key indicators automatically recorded in the Knowledge Forum database were examined to quantitatively illustrate the overall online knowledge building processes. They include: (1) number of notes posted, (2) number of keywords generated, (3) number of build-on notes, (4) number of annotations contributed, and (5) percent of notes with connection. In addition, correlations among these indicators were calculated to examine the consistency of participants' online knowledge building behaviors. Moreover, case examples in the form of excerpts from student notes are presented to demonstrate how students actually worked collaboratively with ideas.

Second, to assess knowledge building outcomes, i.e., the perceived creative climate in this knowledge building community, a modified version of Creative Climate Questionnaire (CCQ) by Zeng and Wu (2002) was employed. The original CCQ was developed by Swedish scholar Ekvall (1987; 1996) to be used in business organizations. Minor textual modification was made by Zeng and Wu (2002) for better use in school organizations. The CCQ contains ten dimensions (see Table 1 for description and sample item of each dimension). Laurer (1994) has demonstrated that the ten dimensions of the CCQ were theoretically supported in the creativity literature. In addition, the CCQ was also proven to be a valid and reliable instrument by means of field research, factor-analytic studies, and organizational consultancy work (Ekvall, 1996). Each dimension consists of five question items. All items adopt a four-point Likert scale. The original scale has an internal-consistency reliability of Cronbach $\alpha=.87$ (N=703), with sub-scales ranging from .70 to .86. For analysis purpose, two comparisons were made. First, a MANOVA test was conducted that compared the statistical differences of the mean value between the knowledge building environment (KBE) group (i.e., the student group in the present study) and a non-KBE group. This non-KBE group consisted of 30 students who were randomly selected from the same teacher education program (N=189) and were asked to complete the same CCQ survey based on their course-taking experiences in the same teacher education program. The second comparison was made between the KBE students in the present study and another reference group of subjects (enterprise employees) surveyed in Ekvall's (1987) using the same CCQ survey.

Third, as a means of triangulation, a course evaluation survey was used to assess the overall instructional quality of this course operated under knowledge building pedagogy. The survey is designed by the university's Center for Teaching and Learning Development with a central purpose of assessing and improving the quality of every course offered in the university. The administration of this survey is mandatory and is routinely done at the completion of every course. The survey contains 20 response items; similar to the following: the course was conducive to independent thinking; the course was adaptive to students' different aptitude; the course encouraged questioning or discussing; I learned a lot from this course; and I would recommend this course to other students. All items employed a 5-point Likert scale (1=strongly disagree; 5=strongly agree). Using a convenience sample of 175 students from 10 different courses offered by the university's teacher education program, the Cronbach Alpha reliability was calculated to be 0.95. To analyze, an independent-samples t-test was computed to see if there is any difference between the mean evaluation rating of this course and that of other courses offered by the university.

Table 1: Ten dimensions of Creative Climate Questionnaire (Source: adapted from Ekvall, 1996)

Dimension	Description	Sample item
Challenge	The emotional involvement of the members of the organization/community in its operations and goal.	- Most people here think that their job or school work is meaningful so that they feel excited and stimulated.
Freedom	The independence in behaviour exerted by the members in the organization/community.	- People here are self-motivated to find information and to solve problems.
Idea Support	The ways new ideas are treated and supported.	- 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/ Openness	The emotional safety in relationships among members.	- Everybody trusts each other in this place.
Dynamism/ Liveliness	The eventfulness of life in the organization/community.	- People here are full of ideas.
Playfulness/ Humor	The spontaneity and ease that is displayed in the organization/community.	- The atmosphere here is playful.
Debates	The occurrence of encounters between viewpoints, ideas, and differing experiences and knowledge in the organization/community.	- Innovative ideas are often generated for discussion in this place.
Conflicts	The presence of personal and emotional tensions in the organization/community (in contrast to conflicts between ideas).	- A lot of people here cannot tolerate each other.

Risk Taking	The tolerance of uncertainty in the organization/community.	- Innovative ideas are adopted and implemented quickly in this place.
Idea Time	The amount of time people can use for elaborating new ideas in the organization/community.	- People here are given plenty of time to think about their new ideas.

Results and discussion

1. Online learning and knowledge building: A process perspective

Overview of online performance. To examine how students learn and work with knowledge online, a descriptive analysis was performed. As Table 2 shows, overall, in terms of individual contribution, students generated a total number of 460 notes (M = 15.3; SD = 5.74) and 340 keywords (M = 11.3; SD = 10.2) in the community. In terms of complementary contribution, students in total created 279 build-on notes (M = 9.3; SD = 5.64) and used annotation features a total of 282 times (M = 9.4; SD = 12.66). In terms of connectivity, the mean percent of notes linked was 51.90% (SD = 25.04%). As an example, Figure 3 illustrates the connectivity pattern within the community at the end of the course. Overall, the results indicate fairly substantial and frequent online activities as compared with previous research using subjects with similar backgrounds (Author, 2010). In addition, correlations (Spearman's rho) among the five knowledge building indicators were computed to see how consistent various knowledge-building activities are among participants. As noted in Table 3, it was found that students who contributed more notes/ideas also tended to be consistently more active in other contributive activities (all significantly correlated). Moreover, it was found that there were no significant correlations among number of annotations, number of keywords, and percent of notes with connections. This may be because annotations and keywords were usually used to elaborate and identify key ideas/concepts within a note and they are contributed as part of a note rather than a different posting connected to a note. Nevertheless, the specific correlation results still indicate fairly coherent community activities among participants.

Table 2. the statistic of students' active on KF (N=30)

	Sum	M	SD
# of total notes contributed	460	15.3	5.74
# of keywords	340	11.3	10.2
#of build-on notes contributed	279	9.30	5.64
#of annotations contributed	282	9.40	12.66
% of notes with connections	-	51.90(%)	25.04(%)

Table 3. Correlations (Spearman's rho) among five knowledge building indicators (N=30)

	# of total notes contributed	# of keywords	# of annotations	# of build-on notes
# of notes total contributed	-			
# of keywords	0.60**	-		
# of annotations	0.43*	0.33	-	
# of build-on notes contributed	0.85**	0.59**	0.39*	-
% of notes with connections	0.46*	0.3	0.17	0.74**

* p<.05 ** p<.01

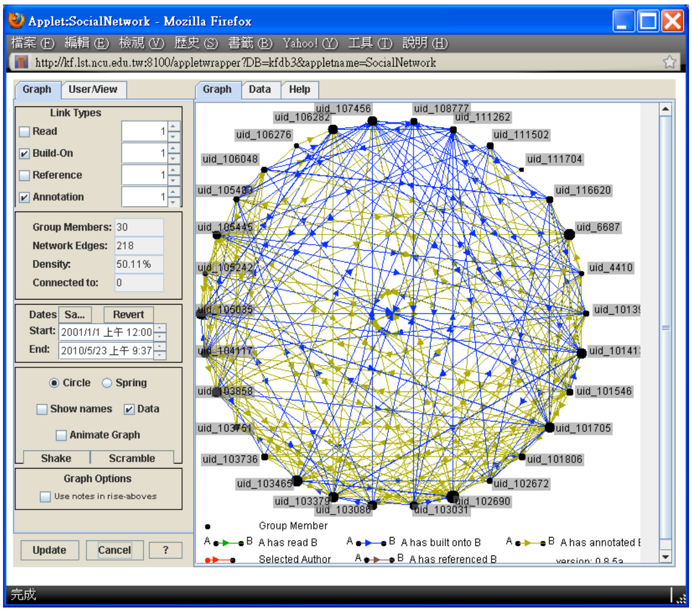

Figure 3. Illustration of online connectivity patterns (including build-on and annotation) at the end of the course

<u>A case illustration.</u> The above descriptive analysis, however, did not tell much about how students developed and worked with ideas within the community. To address this question, this study further examined students' notes to see how they learned through building knowledge together in the Knowledge Forum. As a result, there were in total 134 problems and 213 ideas recorded in the database. To explore further the nature of these problems and ideas, illustrated below are two notes excerpted from student discourse (translated from Chinese). The first note shows initial thoughts generated by a group of students interested in designing new transportation vehicles and the second note 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 (e.g., a car)?
> **Keywords**: transportation, vehicles, problems, ideas
> **Seven problems observed in our daily life**: (1) When riding in 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) Are there any better ways to prevent car accidents; (5) It is always very hard to find a parking space in Taipei; (6) Is it possible to avoid slamming 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) A 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 time-efficient; (2) Flexible occupancy seat design, e.g., a car that can transform its space; (3) Environmentally friendly, energy-saving, and carbon-reducing; (5) Comfortable, understanding human needs, non-oppressive, making us feel 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 even park the car for you; (3) High mobility [e.g., a car that can move in all directions]; (5) Easy to use for the physically challenged; (5) Underground transportation system; (6) Combination of mobile communication technology with most updated public transportation information. (S16, S23, S8)

In short, the findings suggest that students' online learning activities in Knowledge Forum not only showed initiative in identifying problems of interest to them, generating various ideas, but also proved that they were able to actively interact with each other for continuous knowledge advancement. Overall, from a process perspective, it was found that students not only discussed various living technologies in class, but also spent time collectively advance their knowledge pertaining to living technology. Their learning processes were clearly different from the traditionally more didactic ways of instruction.

2. Creative climate of knowledge building environment: An outcome perspective
As an outcome measure, the present study also assessed how students perceived the creative climate of the knowledge building environment at the end of the semester. To do so, A MANOVA test was first conducted that compared the statistical differences of the mean rating of CCQ surveyed between the knowledge-building environment (KBE) group and the Non-KBE (comparison) group as mentioned above. The results indicated an overall significant difference between the two groups (Wilk's $\lambda=0.29$, $F=11.89$, $p = .000$, $\eta^2=.70$), in that students who were engaged in learning and working in the knowledge-building environment tend to give more favorable ratings on the CCQ. Specifically, it was found that significant differences occurred on all ten dimensions of creative climate assessed. Table 4 shows further detailed results regarding the mean value, standard deviation, F value, and Eta Square between the two groups. The findings suggest that the knowledge-building environment approach to teaching provides a more creative climate for students than does traditional teaching approaches.

Table 4. Perceived creative climate between two different learning environments: A MANOVA test

	Knowledge-building environment (N=30)		Non-knowledge-building environment (N=30)		F value	η^2
	M	SD	M	SD		

Challenge	3.04	0.39	2.47	0.51	12.10***	0.17
Freedom	2.99	0.43	2.66	0.45	8.80**	0.13
Idea support	3.44	0.39	2.5	0.43	60.93***	0.51
Trust/openness	3.29	0.35	2.61	0.44	38.91***	0.40
Dynamism/liveliness	3.39	0.34	2.35	0.37	81.70***	0.58
Playfulness/humor	3.44	0.39	1.85	0.59	101.86***	0.64
Debates	3.4	0.37	2.31	0.49	67.43***	0.54
Conflicts	1.34	0.35	2.41	0.48	16.97***	0.23
Risk-taking	2.86	0.45	2.67	0.44	25.13***	0.30
Idea time	3.1	0.38	2.59	0.51	39.61***	0.41

* p<.05 ** p<.01

An essential instructional goal in this study is to transform traditional learning environments into a more innovative environment that features knowledge creation. As such, while the above results confirm that students engaged in a knowledge building environment are more likely to perceive it as creative, a further question to ask is: How is the current knowledge building environment similar to or different from other more commonly observed creative working environments such as an innovative business working environment. To address this question, a further comparison was conducted between the present KBE and an enterprise's working environment, using the findings derived from Ekvall's (1987) study.

Table 5 shows the comparison results. In brief, in Ekvall's study, he used CCQ to measure the creative atmosphere in business working environments, specifically, using employees of small-to-medium enterprises in Sweden (N=245). To analyze, an ANOVA test was conducted that compared the statistical differences of the overall mean rating of CCQ (all ten dimensions combined with the score of the "Conflicts" dimension being inversely computed) between the above two groups. As a result, it was found there are no significant differences (F=.249, df=27, p=.78) between the present KBE group (M=2.97, SD=.82) and the enterprise employees group (M=2.76, SD=.77). In summary, Figure 4 summarizes all comparison results between the three groups.

Table 5: Creative climate perceived by different subject groups between three different environments

	Knowledge building environment (N=30)		Enterprise's working environment (N=245)	
	M	SD	M	SD
Challenge	3.04	0.39	3.28	0.65
Freedom	2.99	0.43	2.83	0.52
Idea Support	3.44	0.39	2.90	0.61
Trust/Openness	3.29	0.35	3.20	0.45
Dynamism/Liveliness	3.39	0.34	2.35	0.63
Playfulness/Humor	3.44	0.39	2.56	0.6
Debates	3.40	0.37	3.34	0.52
Conflicts	1.34	0.35	1.32	0.51
Risk-Taking	2.86	0.45	3.38	0.72
Idea Time	3.1	0.38	2.96	0.56

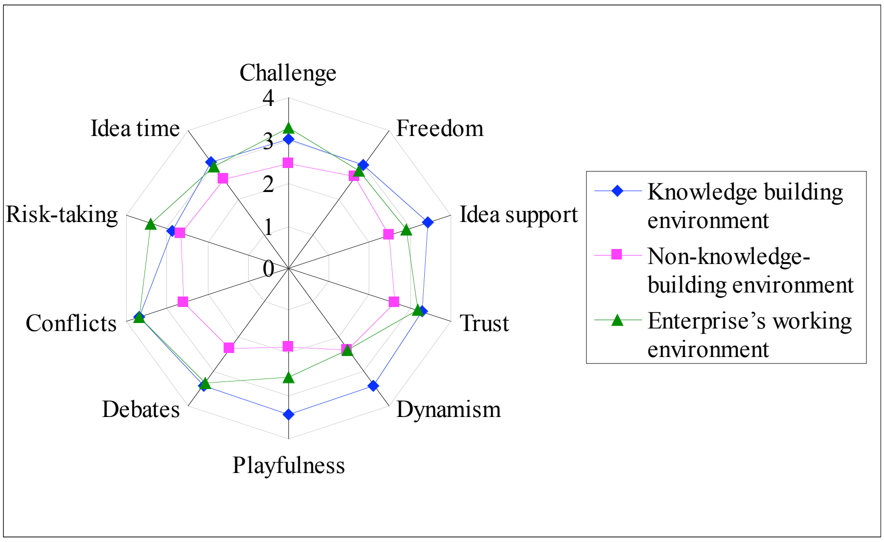

Figure 4. Comparisons among different environments in terms of creative climate
(Note: the rating of conflicts was reversely calculated)

3. Overall course evaluation

Finally, as a way of triangulation, an additional investigation was conducted to examine the overall quality of this course which was designed based on knowledge-building theory and technology, as compared with other non-knowledge-building courses offered (1) by the university's teacher education program in particular and (2) by the university as a whole. As a general description, there were in total 51 courses offered by the teacher education program in the university in the given semester, and the mean course evaluation rating for all these courses was 4.09 (SD=0.48). In contrast, there were in total 1797 courses offered by the university in the given semester, and the mean course evaluation rating of all these courses was 4.14 (SD=0.36). As for the present course, the mean course evaluation rating was 4.46 (SD=0.19). The mean evaluation rating of the present course is higher than that of the courses offered either by the teacher education program or by the university as a whole. Further independent-samples t-tests indicated that there were significant differences in terms of the mean course evaluation rating, both between the present course and courses offered by the teacher-education program ($t=-5.63$, $df=50$, $p<.0001$), and by the university ($t=-37.60$, $df=1796$, $p<.0001$). The findings indicate a positive impact of knowledge building theory and technology on the overall course quality as perceived by the participants.

Conclusion and Implications

Scholarly literature in school reform and innovation has argued for the importance of transforming schools into knowledge creating organizations (Bereiter & Scardamalia, 2003; Hargreaves, 1999; Sawyer 2006; 2007; Scardamalia & Bereiter, 1999). The empirical data from this study further substantiates this claim and suggests that it is possible to cultivate within a school setting a creative climate that resembles innovative research or business environments (see also Zhang, et al., accepted). In summary, from a process perspective, it is found that the participating students were also able to work more collaboratively and creatively with ideas when addressing their identified problem of interest, within the intentionally designed knowledge-building environment. As evidenced by the descriptive and case analyses on participants' online discourse activities, the participants were able to create notes, build-on and annotate the work of others, set problem fields, add keywords, etc., in order to collectively enrich and deepen their ideas of some technology-related topics at issue. Moreover, from an outcome perspective, the results from the CCQ survey suggested that after working in a knowledge building environment for a semester, the participants also tended to rate the climate of this environment as creative. Finally, as a way of triangulation, the course evaluation results also indicated that introducing knowledge building theory and technology into a college course had a positive affect on the participants' perceived quality of this course. This is in sharp contrast with the course evaluation ratings reported in other courses of the university that were operated under more traditional pedagogical approaches (i.e., non-knowledge-building courses). Together, the findings indicated an overall desirable change in the present course implemented under the support of knowledge building theory and technology.

In the organizational science and learning sciences fields, there has been an intensive focus on ways to foster knowledge creation at a group level rather than at an individual level (von Krogh, Ichijo, & Nonaka, 2000; Sawyer, 2007). As such, organizations of all kinds (business or school) nowadays are striving to seek ways to design effective learning and working environments in support of group work and innovation (Author, in press; Gloor, 2006; Stahl, 2006). This is especially important as the world is changing so rapidly that many real life issues have become too complex (e.g., environmental issues) to be solved by any individual genius. Rather, to effectively solve these issues we must rely more on the effectiveness of creative collaboration (Sawyer, 2007). In a knowledge society, the ability to develop new knowledge has become more and more important as a necessary skill for daily work. This is in contrast with the traditional notion of creativity which has been often regarded as the trait of an exceptional genius (i.e., only the selected few who are able to do innovative work). Accordingly, to better prepare students to enter a knowledge-based society that values collaborative creativity, it is critical to help foster within conventional learning environments a more creative climate. It is also equally important for educators to help transform the conventionally held belief in education, that is, to learn first (e.g., through K-12 schooling) and to innovate later (e.g., during graduate study or after going to work), so that the cultivation of knowledge building environments in school organizations will be possible.

The present study provided an initial look at students' perceptions of the creative climate in a knowledge building environment enabled by Knowledge Forum technology. For future research, a few suggestions are provided as follows: First, Rhodes (1961) proposed the use of 4P perspectives to assess creativity as a psychological construct. The 4P stands for process, person, place, and product. The present study mainly evaluated knowledge creation in a class setting from the place perspective. In particular, the study investigated the creative atmosphere of a course. It may be fruitful to further examine knowledge creation in a knowledge building environment from the other perspectives and see if engaging students in knowledge building would also affect students' knowledge creating capacity, personal qualities, and creative work products or projects. Second, the present study used CCQ to measure creative climate. Creativity literature indicates similar instruments that also measure organizational atmosphere for creativity such as the KEYS scales (Amabile, et al, 1996) and the DLOQ questionnaire (Watkins & Marsick, 1999). Future research may use other types of creativity instruments to triangulate the findings in the present study. Admittedly, as there was no highly controlled comparison groups employed for experiment in this study, it remains inconclusive as to whether knowledge building theory and technology alone is fully accountable for all the changes observed in the current study. Further comparative research will be employed to help fully answer the research questions.

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