行政院國家科學委員會專題研究計畫 期末報告

「知識翻新」理論與科技應用於師資培育之教學設計與實施策略(第 3 年)

計 畫 類 別 ： 個別型
計 畫 編 號 ： NSC 99-2511-S-004-002-MY3
執 行 期 間 ： 101 年 08 月 01 日至 102 年 07 月 31 日
執 行 單 位 ： 國立政治大學教育學系

計 畫 主 持 人 ： 洪煌堯

計畫參與人員： 碩士班研究生-兼任助理人員：花儷月
碩士班研究生-兼任助理人員：李佩蓉
博士班研究生-兼任助理人員：吳惠萍

報 告 附 件 ： 出席國際會議研究心得報告及發表論文

公 開 資 訊 ： 本計畫可公開查詢

中 華 民 國 102 年 10 月 31 日

中 文 摘 要 ： 本研究旨在探討修習師資培育的學生在知識翻新的學習環境裡，其協作歷程和創意氛圍的感受。研究對象為30名修習生活科技課程之大專師培學生，本課程在面授及線上互動皆採用知識翻新(Knowledge Building)教學理論，協助研究對象進行學習。資料來源包括學生對於想法的線上貼文討論以及創造氛圍問卷，用以評估學生對學習環境的感受。研究結果顯示，學生在知識翻新的學習環境裡，能透過團隊協作創新想法且在知識的共構與交流階段有顯著成長；此外，學生能對於學習環境的評估感受到信任與開放且對想法的支持能促進知識創新。

中文關鍵詞： 知識翻新、知識創新、創意氛圍、電腦支援協作學習

英 文 摘 要 ： This study explored the effects of teacher-education students’ engagement in a knowledge-building (KB) environment on their collaborative learning process and the perceived creative climate of that environment. The participants were 30 college students who undertook a living technology course in which KB were employed. The main data sources include students’ online discourse and a creative climate questionnaire. The findings indicate that the students became progressively more collaborative and productive over time, and they also tended to perceive the climate of the learning environment as highly supportive of knowledge creation. Implications for designing creative learning environments are discussed.

英文關鍵詞： Knowledge building； knowledge creation； creative climate； computer supported collaborative learning

行政院國家科學委員會補助專題研究計畫 □期中進度報告
■期末報告

「知識翻新」理論與科技應用於師資培育之教學設計與實施策略

計畫類別：□個別型計畫　■整合型計畫
計畫編號：NSC 99－2511－S－004－002－MY3
執行期間：2010/08/01~2013/07/31

執行機構及系所：國立政治大學教育系

計畫主持人：洪煌堯
共同主持人：無
計畫參與人員：李佩蓉、花儷月、吳惠萍

本計畫除繳交成果報告外，另須繳交以下出國報告：
□赴國外移地研究心得報告
□赴大陸地區移地研究心得報告
■出席國際學術會議心得報告及發表之論文
□國際合作研究計畫國外研究報告

處理方式：除列管計畫及下列情形者外，得立即公開查詢
□涉及專利或其他智慧財產權，□一年□二年後可公開查詢

中　華　民　國 102 年 10 月 25 日

目錄

中英文摘要及關鍵詞-- 第 03 頁
報告內容-- 第 05 頁
前言(Introduction) --- 第 05 頁
研究目的(Study purpose) -- 第 05 頁
文獻探討(Literature review) -- 第 05 頁
研究方法(Method) -- 第 09 頁
結果與討論(Results) --- 第 15 頁
參考文獻-- 第 20 頁
附錄一：計畫成果自評--- 第 24 頁
附錄二：國科會補助專題研究計畫項下出席國際學術會議心得報告 第 26 頁
附錄三：本計畫產出之論文發表-- 第 28 頁

摘要

本研究旨在探討修習師資培育的學生在知識翻新的學習環境裡，其協作歷程和創意氛圍的感受。研究對象為 30 名修習生活科技課程之大專師培學生，本課程在面授及線上互動皆採用知識翻新(Knowledge Building)教學理論，協助研究對象進行學習。資料來源包括學生對於想法的線上貼文討論以及創造氛圍問卷，用以評估學生對學習環境的感受。研究結果顯示，學生在知識翻新的學習環境裡，能透過團隊協作創新想法且在知識的共構與交流階段有顯著成長；此外，學生能對於學習環境的評估感受到信任與開放且對想法的支持能促進知識創新。

關鍵詞: 知識翻新、知識創新、創意氛圍、電腦支援協作學習

Abstract

This study explored the effects of teacher-education students' engagement in a knowledge-building (KB) environment on their collaborative learning process and the perceived creative climate of that environment. The participants were 30 college students who undertook a living technology course in which KB were employed. The main data sources include students' online discourse and a creative climate questionnaire. The findings indicate that the students became progressively more collaborative and productive over time, and they also tended to perceive the climate of the learning environment as highly supportive of knowledge creation. Implications for designing creative learning environments are discussed.

Keywords: Knowledge building; knowledge creation; creative climate; computer supported collaborative learning (CSCL)

報告內容

Introduction (前言)

In a knowledge-based society, the capacity for knowledge creation has become a critical factor for productive organizations of all kinds (David & Foray, 2003; Drucker, 1968; Florida, 2002; Homer-Dixon, 2006; United Nations Educational, Scientific and Cultural Organization, 2005). As such, many recent calls for educational reform have highlighted the importance of fostering knowledge creation and collaboration skills among learners and of transforming schools into knowledge-creating organizations or communities (Bereiter & Scardamalia, 2003; Hargreaves, 1999; Sawyer, 2006, 2007; Scardamalia & Bereiter, 1999). Accordingly, this change has also transformed our perception of learning, from merely a means of knowledge accumulation and participation (Sfard, 1998) to a means of knowledge creation (Bereiter & Scardamalia, 2003; Hong & Sullivan, 2009; Scardamalia, 2002). However, while the argument for valuing collaborative knowledge creation as an important solution to 21st-century education is well justified, it remains unclear what constitutes an effective learning environment which will support collaborative knowledge creation and how to design course instruction in order to cultivate such an environment (Hong, Scardamalia, & Zhang, 2010; Hong & Sullivan, 2009; Chai & Tan, 2009; Scardamalia & Bereiter, 2006). In order to address this question, this study examined student engagement in a knowledge-building (KB) environment and whether such engagement helped to foster a more collaborative and creative learning process and environment. In the following sections, a review of the literature on creative climates in organizations will be presented; this will be followed by a discussion of the rationale and design characteristics of a KB environment in support of knowledge creation. The focus of review on organizations is mainly because knowledge building and innovation in business or research organizations is fairly common and has been practiced for a long time, whereas, interest in knowledge building and innovation in school organizations has just started to grow (Bereiter, & Scardamalia, 2003; Hargreaves, 1999; Hong, Scardamalia, & Zhang, 2010).

Purpose of this study

The purpose of this study was to explore the effects of knowledge-building (KB) on students' collaborative learning process and their perceived creative climate of their learning environment.

Literature review

Creative climate in organizations

As evidenced throughout history, innovations are often derived from collaborative knowledge networks, rather than individual efforts (Gloor, 2006; Thagard, 1997). Innovation may come from the development of so-called "little-c" (everyday) creativity (Beghetto & Kaufman, 2007), e.g., ideas derived from improvised conversations between colleagues in the workplace (Sawyer, 2007) or within a discussion forum (Scardamalia, 1994). Alternatively, it may come from the development of so-called "big-C" (eminent) creativity, e.g., the invention of a new medicine or some breakthrough in the advancement of scientific theory in a research of science community. Little-c and big-C creativity are, however, closely related. A well-known example of an invention which was derived from synthesizing a great deal of little-c creativity to eventually produce a breakthrough big-C is the invention of the aircraft by the Wright brothers, who brought together many small ideas (e.g., bicycles) from their predecessors and eventually came up with the significant innovation of an aircraft. This creative process was a social one, as it consisted of a collection of ideas derived from many people's efforts through a sustained design and re-design process, as well as repeated trials and errors.

In a knowledge-based economy, collaborative networks have become the norm for teamwork. In the past, the concept of teamwork highlighted cooperation and the division of labor (Slavin, 1980). Today, the concept of teamwork emphasizes creative collaboration (Hong, 2011; Sawyer, 2007), group cognition (Stahl, 2006) and collaborative knowledge-building (Scardamalia, 2002). Corporate cultures have begun to realize the power of collaborative innovative teamwork (Gloor, 2006) and the importance of cultivating a more creative climate in order to support such teamwork. For example, Google's corporate culture is characterized by the provision of the maximum number of opportunities for collaboration in order to stimulate innovative ideas and achieve collaborative creation (Sawyer, 2007). Having a creative working climate facilitates the creative capacity of an organization or community (Ismail, 2005).

Previous studies of creativity have investigated creative climates in working environments (Amabile & Conti, 1999; Ekvall & Tangeberg-Anderson, 1986; Isaksen & Ekvall, 2010; Zain & Rickards, 1996). In particular, researchers have tried 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 the factors that may hinder or facilitate creativity. They found that an organization's productivity is affected by two factors that hinder creativity (workload pressure 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). Ekvall (1991, 1996) proposed 10 factors such as freedom, idea support, trust, risk-taking, and idea time that influence the creative atmosphere within an organization (see Table 2 below for details description of the 10 factors). Using these factors, he developed an instrument called the Creative Climate Questionnaire (CCQ) in order to assess the creative climate of organizations. Recently, Hunter, Bedell and Mumford (2007) performed a review on creativity climate survey and they identified 14 categories of factors across 42 studies. These factors include positive peer group, positive supervisor relations, resources, challenges, mission clarity, autonomy, positive interpersonal exchange, intellectual stimulation, reward orientation, flexibility and risk taking, product emphasis, top management support, participation and organizational integration. As examples, 'positive peer group' is defined as "perception of a supportive and intellectually stimulating peer group. Relationships are characterized by trust, openness, humor, and good communication." (p.74); 'challenge' is defined as "perception that jobs and/or tasks are challenging, complex, and interesting—yet at the same time not overly taxing or unduly overwhelming." (p.74) (see Hunter, Bedell, & Mumford, 2007, for a complete list of description for all factors). Their meta-analysis concluded that while different surveys may be employing different dimensions, they are generally effective predictors of creative performance with medium to large effect sizes. As claimed by Hunter, Bedell & Mumford (2007), "all of the dimensions commonly examined in the climate studies produced sizable effects with respect to measures of creativity and innovation" (p. 76). In other words, creative climate exert important influences on creative performances.

As is argued by these studies, an encouraging and supportive environment is more likely to promote knowledge interaction among individuals within and between groups and to inspire innovative ideas that result in more creative products. In order to cultivate a more creative climate, many researchers have also investigated different technological means to support more effective collaboration and knowledge creation. The capacity to make good use of Internet technologies in order to maximize a group's creative potential holds the key to a successful future for collaborative learning and teamwork (Hong, Scardamalia, & Zhang, 2010; Hong & Sullivan, 2009; West & West, 2009). Having the pedagogical know-how to design a proper digital environment 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

Paavola, Lipponen and Hakkarainen (2004) reviewed recent models of knowledge creation and identified the knowledge spiral (Nonaka, & Takeuchi, 1995), expansive learning (Engestrom, 1999) and the KB community (Bereiter & Scardamalia, 2006) as three key models that could enhance knowledge creation. Among these three models, the KB approach focuses on transforming conventional school learning environments into more creative ones. Bereiter and Scardamalia's KB theory draws upon and re-contextualizes knowledge creation practices and principles that are often utilized in research, business and scientific communities to transform classrooms (see also Bereiter & Scardamalia, 2003; Scardamalia & Bereiter, 1999, 2003, and 2006). KB is defined as a social process that highlights sustained production and the improvement of ideas which are of value to a community (Scardamalia & Bereiter, 2006). As a fundamental approach to educational reform in the field of learning sciences (Sawyer, 2006), KB features a principle-based approach to innovation (Hong & Sullivan, 2009; Zhang, Hong, Scardamalia, Teo, & Morley, 2011) which emphasizes the nature of learning as a complex system (Barab et al., 1999) and learning processes as emergent and guided by general learning principles. This is in sharp contrast with conventional reform efforts, which highlight ritualistic instructional activities defined by pre-specified procedures, classroom scripts and rules, or componential learning tasks, which lead to the mastery of pre-specified content rather than knowledge creation (Hong & Sullivan, 2009).

In order to foster a KB environment, Scardamalia (2002) conceptualized a set of KB principles. Fundamentally, these KB principles are designed to guide the behaviors of, and to enhance relationships between, three essential knowledge-building entities: 'idea' (as basic unit for knowledge building), 'agent' (as knowledge worker), and 'community' (as a knowledge sharing and building space), in order to facilitate a more creative learning and working environment. For example, regarding the 'idea' entity, the principle of 'idea diversity' highlights that "[i]dea diversity is essential to the development of knowledge advancement, just as biodiversity is essential to the success of an ecosystem. To understand an idea is to understand the ideas that surround it, including those that stand in contrast to it. Idea diversity creates a rich environment for ideas to evolve into new and more refined forms" (p. 79). These principles help build strong relationships among the above mentioned three knowledge-building entities for sustained knowledge advancement.

To facilitate a more creative learning environment, a multimedia platform–Knowledge Forum (KF)–was designed to assist with KB activities, providing community members with scaffolding to help them to collectively solve problems of interest and to create new knowledge (Scardamalia, 2002; Scardamalia & Bereiter, 2003). Within KF, participants can contribute their ideas in the form of notes to "views," which are virtual spaces for collaborative problem-solving. In addition, KF 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 in order to increase the coherence of the content of the knowledge space. All of these features are designed to foster dynamic idea interaction and in-depth collaboration. All of 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 KF designs are in line with the overarching commitment to sustained knowledge advancement and the need to enable community members to continually exchange and improve ideas as epistemic agents. As an example, Figure 1 shows the interface of a KF 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 connect ideas and using customizable scaffolds to frame ideas. By enabling students to engage in sustained 'idea' improvement within KF, they can be guided to become more self-directed epistemic 'agents' and to co-structure their knowledge within the 'community'.

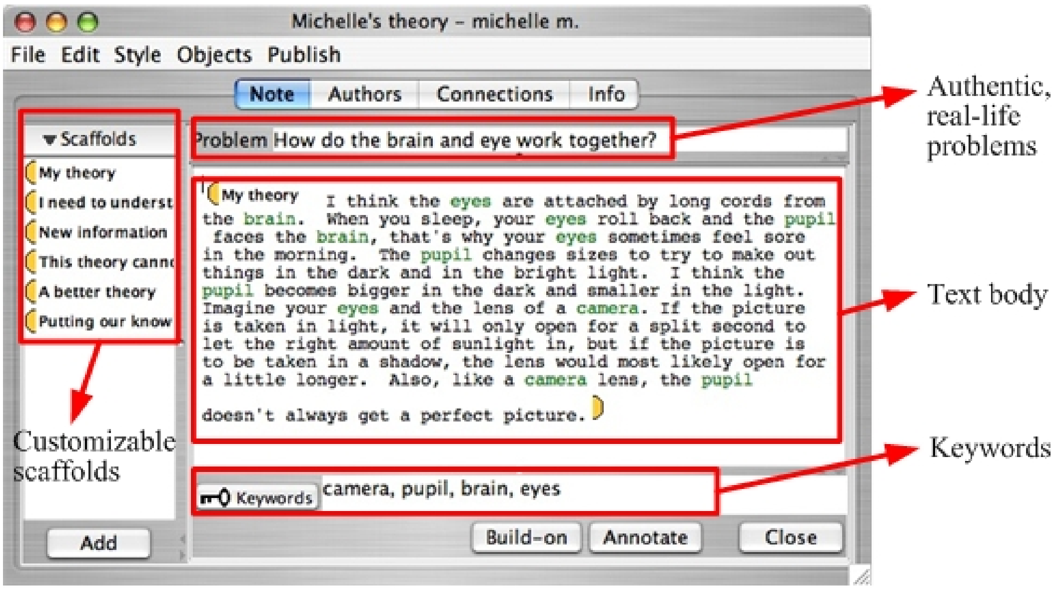

Figure 1. Some design features of the note interface (source: adapted from KF 4.6 online manual at http://ikit.org/kf/46/help/)

The present study

Scardamalia and Bereiter (1999) argue that an effective learning environment which is operated under KB pedagogy and technology should closely resemble an innovative design, research or business working environment. Previous research indicates that the integral use of KB theory and KF technology can help students to learn effectively (Scardamalia, 2002; Scardamalia, Bereiter & Lamon, 1994; Zhang, Scardamalia, Lamon, Messina, & Reeve, 2007). Teacher educators have also pointed out the gap in research pertaining to the development of future teachers' capacity to create and refine ideas and practices, which would directly influence their capacity to bring about knowledge creation in the students they teach (see Chai & Lim, 2011; Hong, Chen, Chai, & Chan, 2011). However, the question of whether a class operated under KB pedagogy and technology would indeed enable a more creative climate that resembles an innovative workplace environment for students' knowledge work remains to be answered. Accordingly, the main research question in the present study is:

to what extent can a college course, operated under KB pedagogy and technology, be cultivated to become a more creative learning environment such as an innovative workplace environment? In particular, this study intends to investigate: (1) the extent to which students could actually work collaboratively with knowledge in KF; (2) the extent to which they would perceive the climate of a university course as creative after engaging in KB for a semester; and (3) the extent to which they would rate the quality of this knowledge-building (KB) course as compared with other non-KB courses.

Method

Context and participants

The present research was conducted in Taiwan on a university course which focused on living technologies. The course was offered by the university's teacher-education program to students who planned to teach living technologies at elementary-school level in the future. The university is ranked as one of the top 10 universities in the nation. 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 course quality, with a reform preference toward transforming traditionally more didactic modes of teaching into more constructivist-oriented teaching practices. This reform movement created an opportunity for KB theory and technology to be introduced into this course as an alternative method of teaching and learning. The participants in this course were 30 teacher-education students (20 females). Their ages ranged from 18 to 20. The duration of this course was 18 weeks.

Instructional design

One main instructional goal of this course was to foster a creative class climate by encouraging the students to engage in KB in order to solve real-world technology problems while developing collaborative and creative skills. To this end, KB pedagogy and KF technology were employed in the course design. At the start of the course, a tutorial workshop on the use of KF for KB was given at the beginning of the semester. This was implemented by walking students through some of the basic design features and functions of KF, for example, how to create a note in a "view" (i.e., a virtual problem-solving space in KF) or "build on" an existing note. Figure 2 shows a screenshot of a KF view, in which each square box represents a note generated by a community member or a group of co-authors. In order to elaborate, enrich, exchange or improve ideas, members can provide suggestions or comments by building on existing notes. This action creates a new square box with a link between two square boxes.

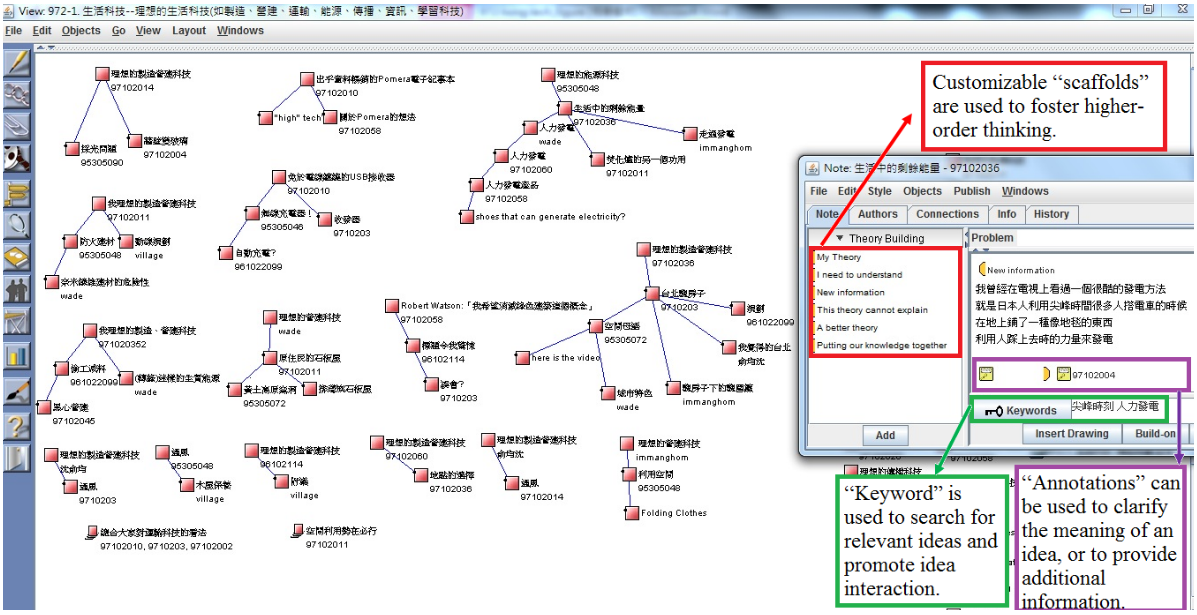

Figure 2. A screenshot of the Knowledge Forum platform where participants' interaction is reflected. In this figure, each note is represented by a square box and each link between two square boxes represents a build-on activity; and the concept-map like KB view shows the collective effort by community members to build knowledge together. In addition, the design features of customizable 'scaffolds', 'keywords', and 'annotations' are also illustrated with explanations.

As argued by Papert (2000), conventional instructional approaches tend to highlight acquisition of textbook knowledge and to deemphasize student work with ideas, and thus fostering a learning climate of idea aversion (i.e., dislike of ideas) in class. In contrary, this course engaged students in knowledge building, and to this end, an idea-centered instructional approach (Hong & Sullivan, 2009) was adopted in this course. Working innovatively with ideas is essential to knowledge advancement (Scardamalia & Bereiter, 2006), and arguably, ideas can be improved in two dimensions: quality and quantity. The quality of ideas is a function of how learners as knowledge workers collaboratively work with ideas, and the quantity of ideas is a function of how ideas are exchanged and diversified in a community. Building on Popper's (1972) conceptualization of evolutionary epistemology, the quality of ideas can be considerably enriched by means of constructive elaboration, and the quantity of ideas can be substantially increased by means of continued diversification. More importantly, ideas need to be improved over time by means of a productive course that enables the transformation of ideas both in quality and quantity through an emerging or self-organizing process enabled by simple rules (e.g., idea elaboration and exchange) in order to gradually help form a complex network of ideas in a community (Prehofer & Bettstetter, 2005). Building on this instructional approach, participants were guided to engage in the following four different instructional activities.

<u>Idea generation</u>. In order to encourage students to generate and work with ideas, students were first guided to search for their problem of interest. They were guided to look for as many real-life problems as possible, and then identify a particular problem of interest for later exploration. Examples of real-life technology problems in which students engaged in this course are such as designing a water-saving toilet, an intelligent closet management system, and a human energy generator. Then, students were guided to generate initial ideas or solutions in order to solve their problems of interest.

<u>Idea exchange/diversification</u>. Students were guided to read each other's ideas recorded

in notes, to discuss and exchange ideas/solutions for solving their identified problems both in KF and online, using keywords in their notes, in order to diversify their ideas.

Idea elaboration/reflection. Students were guided to further elaborate their ideas, by providing explanations as to how and why their ideas were workable and of value to their class community, and then they reflected on, and evaluate, support or negate certain ideas based on their explanatory coherence (Thagard, 1997).

Idea improvement. Students collaboratively try to improve their ideas by summarizing and synthesizing the explanatorily more powerful ideas and, based on these selected ideas, they tried to design a technology product or solution. Then, at the end of this course, the students shared what they had learned from their KB process with others in the community by giving a presentation about the technology product.

One thing to note is that although students were required to design technology products, no actual products needed to be made; it was the process of working with ideas, rather than producing actual products that was highlighted in the instructional design. As for the four instructional activities, the first two activities mainly focused on fostering students' divergent thinking, while the other two activities focused on convergent thinking (Guilford, 1967). Another thing to note is that the four activities were not necessarily implemented by the students in the order given, but in general students were guided to engage in the first two activities before the mid-term exam and the other two activities after the mid-term. And in line with the spirit of knowledge building, the process of student work with ideas was completely emergent, rather than pre-determined. As an example, Figure 3 shows a student note, in which diverse ideas about ideal transportation technology (e.g., autopilot and automatic navigation) were being contributed and shared.

The instructor was familiar with KB theory and pedagogy, and had been using KF in his college teaching for four years. Throughout the semester, the instructor tried to serve as a facilitator in guiding students to work in the four knowledge building activities, in order to allow the students to work collaboratively and creatively with their own problems of interest for sustained idea improvement. There was no pre-assigned grouping in this course; instead, the students planned their own learning by opportunistically deciding with whom to collaborate or with what ideas to interact, based on the nature and type of the problems they were working with at the time (Hong, 2011; Zhang et al., 2007).

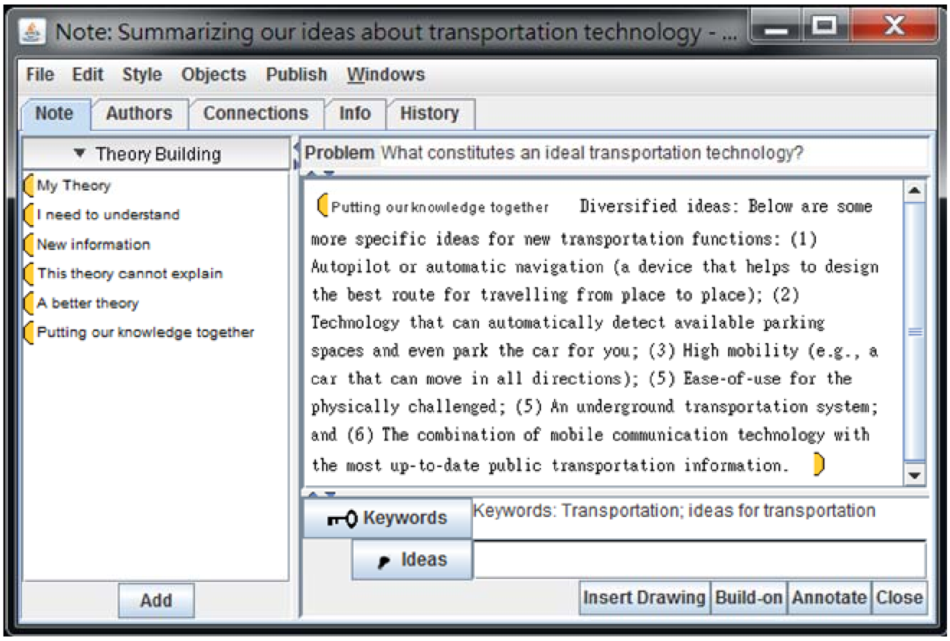

Figure 3. An example of a student note that shows some diverse ideas contributed

Data sources and analysis

This research employed a mixed approach to collecting and analyzing data. The main data sources included: (1) students' online discourse recorded in a KF database; (2) a modified version of the CCQ by Zeng (2002); and (3) a course evaluation survey.

Students' online discourse in the database. First, in order to assess the learning process, a descriptive analysis was performed on the KF dataset in order to describe the students' overall online discourse and learning activities. Key indicators recorded in the KF database were examined to quantitatively illustrate the overall online performance, for example, the number of notes contributed and built on. In addition, to explore the changing process of KB activities in KF, the semester was divided into two stages, using the mid-term exam as a separation point. T-tests were employed to compare whether there was any difference between the two stages. Next, Gunawardena, Lowe and Anderson's (1997) Interaction Analysis Model (IAM) was adapted to examine how students collaborate online and the quality of online knowledge work. As Table 1 shows, more advanced phases imply more challenging collaborative activities for knowledge construction. To ensure the quality of coding, two researchers independently coded all of the passages and categorized each of them into a level of the IAM. The inter-rater reliability (Cohen's kappa) was calculated to be 0.81.

Table 1. Interaction analysis model adapted from Gunawardena et al. (1997) for the analysis of discourse activity

Phase	Description	Example
0: Not-on-task talking*	Utterances that are not directly concerned with the task of improving ideas	- Living in the dormitory is inconvenient. - I also want to see the picture.
I: Sharing/ comparing of information	Statement of initial proposal or idea	- Using a plastic mask may be helpful, because moisture in the cloth mask causes mould to grow. In contrast, the plastic mask can be dried immediately after cleaning. - It is really hard to find a parking space downtown. If there was a gadget that could show us whether a car is leaving a nearby parking lot, we could save lots of time spent searching by driving directly to that parking space.
II: Discovery and exploration of dissonance or inconsistency among ideas, concepts or statements	Identifying the feasibility, strengths and weaknesses of proposed ideas; stating areas of disagreement	- I like the second idea. If a camera can send photos directly to another camera wirelessly, that would be awesome; it is really inconvenient to upload photos online from one camera and then download them to another camera. - Why can such a device prevent dizziness? It is because there is liquid in between the two layers which serves as a buffer, so our vehicle design can reduce the shaking motion while maintaining its balance during movement.

III: Negotiation of meaning/ co-construction of knowledge	Negotiation or clarification of ideas; identification of areas of improvement; proposal and negotiation of new ideas embodying compromise; co-construction	- Although this technology sounds ideal for construction, it would take up a lot of space. In addition, the concept of environmental protection is very good, but its cost is too high. - Making a microchip as a sticker that can paste onto the surface of a cell phone is good, but why not just implant it directly into the cell phone?
IV: Testing and modification of proposed synthesis or co-construction	Testing against an existing cognitive schema, personal experience, formal data or contradictory information in the literature	- When testing this idea, one should take into consideration the resistance produced by this [transportation] technology when its tires are made into a shape like a cylinder. - Have you ever considered applying siphon principles in the design of your new bathtub? Doing so can help to evaluate whether extra mechanical power is necessary.
V: Agreement statement(s)/ application of newly-constructed meaning	Summarization of agreement(s) and metacognitive statements that illustrate the construction and application of new knowledge	- Other special design features [for this transportation technology] include: (1) it can change its capacity according to the number of passengers; (2) when the vehicle breaks down, it can be manually pushed to the roadside; (3) there is an alarm system to wake up a sleepy driver and an auto-pilot system to park the vehicle [on the roadside] if the driver cannot be woken up. - The underground water-heating and circulation device is a system that collects and stores warm water when one takes a bath and then reuses the heat to warm the bathroom floor during winter time.

Note: * This phase was added by the authors.

Modified version of the Creative Climate Questionnaire (CCQ). Second, Ekvall's (1987, 1996) CCQ was employed to assess the students' perceived creative climate in this KB class. The original CCQ was developed for use in business organizations. Minor textual modifications were made by Zeng (2002) for its use in school organizations. The CCQ contains 10 dimensions (see Table 2 for a description and sample item of each dimension). Laurer (1994) has demonstrated that the 10 dimensions of the CCQ are supported theoretically in the creativity literature. In addition, the CCQ has also been tested as a valid and reliable instrument by means of field research, factor-analytic studies and organizational consultancy work (Ekvall, 1996). Based on the fact that CCQ has been validated and used in school context (Zeng, 2002), its comprehensiveness (10 dimensions), and that the dimensions are generally congruent to the knowledge building classroom environment that we tried to foster, the CCQ is assessed to be relatively the most appropriate instrument for the current study. Each dimension consists of five question items. All of the items adopt a four-point Likert scale. The original scale has an internal consistency reliability level of Cronbach's $\alpha = .87$ ($N = 703$), with sub-scales ranging from .70 to .86. To understand how the participants perceived the climate change, two analyses were made. One is a MANOVA test that was conducted to compare the statistical differences in the mean values between the KB environment (KBE) group (i.e., the group of students in the present study) and a non-KBE group/condition/class. To make the two groups more comparable: (1) first, this non-KBE class (n=28) was selected from the same teacher education program with similar academic background. The students had a very similar achievement-level based on their grades in the previous semester ($F=1.81$, $p<.05$, $M=84.55$ for the KBE class, $M=85.92$ for the non-KBE class); (2) this is a new course that does not require the students to have pre-requisite knowledge, i.e. pre-existing knowledge is unlikely to determine the outcome of the research since we are not measuring learning achievement in terms of knowledge acquisition; (3) third, major learning content was concerned with pedagogical knowledge (e.g., how to design and teach living technology to pupils); (4) fourth, students were both engaged in self-directed learning, participated in Knowledge Forum, and were interacting with one another while developing problem-solving capacity; (5) fifth, the same instructor taught both courses; and (6) the main difference between the two conditions was the instructional approaches and it was expected that with knowledge building pedagogy, students would perceive the climate of their learning environment as more creative. So, both groups of students were asked to complete the same CCQ at the end of the course. As it is only sensible to assess the creative climate of a class after a course is finished, no pre-test was conducted.

Table 2. Ten dimensions of the CCQ (source: adapted from Ekvall, 1996)

Dimension	Description	Sample item
Challenge	The emotional involvement of the members of the organization/community in its operations and goals	- Most people here think that their job or school work is meaningful, so they feel excited and stimulated.
Freedom	The independent behavior exerted by the members of the organization/community	- People here are self-motivated to find information and to solve problems.
Idea support	The ways in which new ideas are treated and supported	- People here are always willing to share their ideas because they are encouraged to do so and people pay attention to each other's ideas.
Trust/ openness	The emotional safety in the relationships between 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.

Conflict	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 to elaborate new ideas in the organization/community	- People here are given plenty of time to think about their new ideas.

Course evaluation survey. Third, a course evaluation survey was used to further assess the overall instructional quality of this course operated under KB pedagogy. The survey was designed and validated by the university's Center for Teaching and Learning Development with the main aim of assessing and improving the quality of the university's courses (the University's Office of the Registrar, personal communication). The administration of this survey is mandatory and is routinely performed at the completion of every course. The survey contains 20 response items, such as: "The course was conducive to independent thinking"; "The course was adaptive to students' different aptitude levels"; "The course encouraged student inquiry and discussion"; "I learned a lot from this course"; and "I would recommend this course to other students." All of the items employed a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). Using a randomly selected sample of 175 students from 10 different courses offered by the university's teacher education program, Cronbach's alpha for reliability was calculated to be 0.95. For the purpose of analysis, an independent samples t-test was computed to ascertain whether there was any difference between the mean evaluation rating of this KB course and that of all the non-KB courses offered by the university.

Results

Online learning behaviors

Figure 4 shows the overall pattern of note-linking at the end of the semester to illustrate the highly collaborative nature of this course in terms of its quantity. In order to further examine how students learn and work with knowledge in the community, a descriptive analysis was performed. Table 3 shows data regarding basic KB activities which was used to show the intensity of collaborative learning activities over the semester, with two stages--each lasting for nine weeks--divided using the mid-term exam as a separation point. Overall, the paired-sample t-tests indicate that there were no significant differences between the two stages in terms of, for instance, the number of notes contributed, built on, read and linked, the number of annotations and the number of scaffold support structures. In terms of the quantity of online activities, the above analysis suggests that the time and effort spent on learning and using KF for discussion purposes was equally distributed between the two stages (i.e., students were able to work together online in a consistent and sustained manner). This quantitative comparison analysis, however, only shows the amount of online activity in a general sense. It does not specifically reveal the quality of the online collaboration. To provide more in-depth information, the quality of student interaction and collaboration was further analyzed.

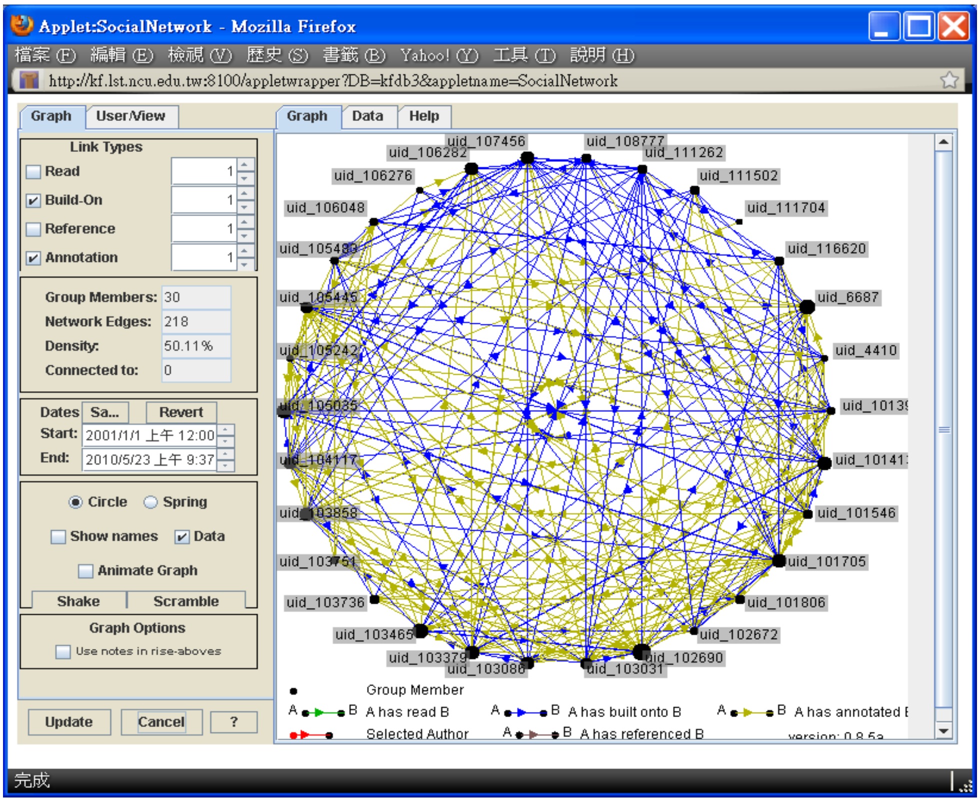

Figure 4. Illustration of online connectivity patterns (including build on and annotation) for the whole class community at the end of the course

Table 3. Basic KB activities

	Stage 1		Stage 2		t-value
	M	SD	M	SD	
# of notes contributed	7.63	3.44	7.70	4.14	-0.07
# of notes built on	4.39	2.29	5.43	3.54	-1.22
# of annotations	4.90	5.01	4.50	8.80	0.35
# of scaffold supports	4.30	4.25	3.67	4.01	1.23
# of problems worked on	0.73	1.36	1.17	2.51	-1.54
# of notes read	111.83	58.40	133.83	94.31	-1.45
% of notes linked	0.49	0.23	0.52	0.30	-0.45
% of notes with keywords	0.46	0.29	0.42	0.35	1.00

Note: The data presented above were based on number of notes (or annotations or problems) posted per student.

Table 4 further provides an overview of the distribution of students' online discourse between the two KB stages, according to the phases of knowledge construction adapted from Gunawardena et al.'s (1997) Interaction Analysis Model. It was found that there was a statistically significant drop in the mean values from Stage 1 to Stage 2 in terms of not-on-task talking (Phase 0) and that there was no significant difference between the two stages in terms of Phase I (sharing/comparing of information). On the other hand, there were statistically significant increases in the mean values from Stage 1 to Stage 2 in Phases II-V. As mentioned above, more advanced phases imply more meta-cognitively and collaboratively demanding activities when they feature as part of the knowledge construction process. The findings, therefore, suggest that the students gained KB momentum over time when working in KF. It is worth noting that the mean value in Phase IV is relatively lower than the equivalent in the other three phases (Phases II, III and V). This is perhaps because the students on this course were required to produce a technology prototype on paper, rather than to design an actual technology object that would require practical testing, and so the number of testing activities was low. Nevertheless, the findings still suggest that there was an overall high intensity of collaborative knowledge construction activities as the course unfolded. There is some evidence of a relationship between the intensity of discussions (based on the number of coded ideas) and the quality of contributions to the collaborative construction of knowledge. In short, from a process perspective, the findings show that the students were able to interact in a collaborative manner for the purpose of continuous knowledge advancement.

Table 4. Knowledge co-construction activities in KF between two KB stages

Phase	KB Stage 1		KB Stage 2		t-value
	M	SD	M	SD	
0: Not-on-task talking	1.6	2.37	0.77	1.92	2.98**
I: Sharing/comparing of information.	3.63	2.94	2.8	3.03	0.99
II: Discovery and exploration of dissonance or inconsistency among ideas, concepts or statements	1.2	1.3	7.83	3.75	-9.88***
III: Negotiation of meaning/ co-construction of knowledge	1.47	1.7	7.24	4.48	-8.89***
IV: Testing and modification of proposed synthesis or co-construction	0.07	0.25	1.53	1.16	-6.73***
V: Agreement statement(s)/applications of newly-constructed meaning	0	0	5.2	4.08	-6.97***

** p<.01; ***p<.001

Note: The data presented above were based on number of notes (or annotations or problems) posted per student.

Creative climate of the KB environment

As an outcome measure, the present study assessed the students' perceptions of the creative climate of the KB environment at the end of the semester. A MANOVA test was conducted that compared the statistical differences between the mean ratings of the CCQ survey in the KBE group/class and in the non-KBE (comparison) group/class. The results indicated an overall significant difference between the two groups (Wilk's $\lambda = 0.19$, $F = 20.40$, $p = .000$, $\eta^2 = .81$), in that students who were engaged in KB tended to give more favorable ratings on the CCQ. Specifically, it was found that significant differences occurred on all 10 assessed dimensions of the creative climate. Table 5 shows further detailed results regarding the mean value, standard deviation, F-value and eta-squared of the two groups. The findings suggest that idea-centered KB, as a pedagogical approach, provides a favorable, creative climate for students than non-KB pedagogical approaches.

Table 5. Perceived creative climate between two different learning environments: A MANOVA test

	KB environment	Non-KB environment	F-value	η^2

	(N = 30)		(N = 28)			
	M	SD	M	SD		
Challenge	3.04	0.39	2.49	0.40	28.81***	0.34
Freedom	2.99	0.43	2.61	0.40	12.40***	0.18
Idea support	3.44	0.39	2.55	0.38	80.13***	0.59
Trust/openness	3.29	0.35	2.54	0.44	54.11***	0.49
Dynamism/liveliness	3.39	0.34	2.38	0.32	141.41***	0.72
Playfulness/humor	3.44	0.39	2.24	0.35	159.03***	0.74
Debates	3.4	0.37	2.61	0.42	60.99***	0.52
Conflict	1.34	0.35	1.79	0.52	15.58***	0.22
Risk-taking	2.86	0.45	2.36	0.32	25.05***	0.31
Idea time	3.1	0.38	2.38	0.37	54.48***	0.49

*** $p < .001$

An essential instructional goal of this study is to foster an innovative environment that is characterized by knowledge creation. The results outlined above confirm that students engaged in a KB environment are more likely to perceive it as a creative environment. As such, a further question worth asking may be: To what extent is the current KB environment similar to or different from other more commonly observed creative working environments, such as an innovative business working environment? To answer this question will for sure require a different study specifically focusing on comparing a KB environment and a working environment.

Course quality evaluation

Further, the university's course evaluation survey, which used a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), was employed at the end of the course. This additional investigation was conducted to compare the overall perceived quality of this course, designed based on KB theory and technology, with other non-KB courses offered: (1) by the university's teacher education program in particular; and (2) by the university as a whole. As a general description, a total of 51 courses were offered by the teacher education program in the university in the given semester, and the mean course evaluation rating for all of these courses was 4.09 (SD = 0.48)—the mean value '4.09' was calculated by averaging all ratings obtained from the 20 question items. In contrast, there were a total of 1797 courses offered by the whole university in the given semester, and the mean course evaluation rating of all of these courses was 4.14 (SD = 0.36). As regards 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 by either the teacher education program or the university as a whole. The findings indicate that the participating students' perception of learning in the present course was generally positive.

Discussion and conclusion

The scholarly literature on 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 findings of this study further substantiate that it is possible to cultivate, within a classroom setting, a creative climate (see also Zhang et al., 2011). In summary, from a process perspective, it was found that the participating students were able to work more collaboratively and productively with ideas when addressing their identified problems of interest within a KB environment. This was evidenced by the descriptive analyses of the participants' online discourse activities, as the participants were able to consistently create notes, and build on the work of others, add keywords, etc., in order to collectively enrich and deepen their ideas and address the technology-related topics at hand. Furthermore, an assessment using the Interaction Analysis Model showed that students become more collaborative over time when constructing collective knowledge. From an outcome perspective, the results of the CCQ survey suggest that after working in a KB environment for a semester, the participants tended to perceive the climate of this environment they were working in as relatively more creative (M = 2.97, SD = .82; as compared with the mean value of 2.5 out of a four-point Likert scale). In addition, the course evaluation results indicated that the participants' perceptions of the quality of this course also tended to be more positive. This is in sharp contrast with the lower course evaluation ratings reported for all the other non-KB courses provided by the university. Together, the findings indicate a desirable change in the present course implemented under the support of the idea-centered KB instruction.

In the fields of learning sciences and organizational science, 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 (businesses and schools) are striving to find ways to design effective learning and working environments in support of group work and innovation (Hong, Scardamalia, & Zhang, 2010; 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., global warming) to be solved by an individual genius. Instead, in order to solve these issues effectively, society must rely on more effective collaborative knowledge creation (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 often been regarded as a trait belonging to an exceptional genius (i.e., only the selected few who are able to carry out innovative work). Accordingly, in order to better prepare students to enter a knowledge-based society that values collaborative creativity, it is critical to help foster within conventional school environments a more creative climate that values collaborative knowledge construction. It is also equally important for educators to help to transform the conventionally-held belief in education that it is best 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 KB environments at all levels of school organizations will be possible. As Chai and Lim (2011) argued, for teacher education to be effective in the next century, it is important to encourage teachers to work on ideas and cognitive artifacts. Given that teachers are the key to transforming the classroom, they should have first-hand experience of improving ideas in a collaborative setting. This study provides a case example of how teacher educators may cultivate the knowledge co-construction capacity of future teachers. It is argued that teachers who are equipped with experience of collaborative KB are more able to support the transformation of a school into a knowledge creation organization.

The present study provided an initial look at teacher education students' perceptions of the creative climate in a KBE enabled by KF technology. Admittedly, there are limitations of this study. One concerns the generalizability of results derived from a single class setting. Although some scholars (e.g., Cobb, 2001; Steffe & Thompson, 2000) argue that studies grounded in classroom analyses can be generalizable, as insights gained from such analyses can inform the interpretation of instruction in a similar context, future research should be conducted using a bigger sample size. Moreover, this study investigated the collaborative learning process and creative atmosphere of a course. It may be fruitful to further explore the question of whether student engagement in KB would also affect students' knowledge-creating capacity and problem-solving ability, while taking into account of other related variables (such as students' prior knowledge, learning goals, self-efficacy expectations, interest, etc.), in order to assess in detail who may benefit more from such a learning environment. Moreover, the present study used the CCQ to measure the creative climate. The creativity literature notes similar instruments that also measure the creativity of an organizational atmosphere (for example, see Amabile et al., 1996; Watkins & Marsick, 1999). Future research may use other types of creativity instruments to triangulate the findings of the present study. Future studies may also look into the correlations between the perceived creative climate and other more affective or domain-specific measures such as students' interest in the topic of the course, students' level of satisfaction with the course and platform, students' perceived enjoyment, and students' perception of difficulty, to better understand how to foster a more creative learning environment. Admittedly, as no highly controlled comparison groups were employed in this study, it remains unclear whether or not KB instruction and technology alone are fully accountable for all of the changes observed in the current case study. To make up for this deficiency, a comparison between a KB and non-KB environment was intentionally conducted as an analysis in this study. Although the comparison was made to be as comparable as possible, students' prior knowledge may still play a role in influencing how they may participate and perform in the respective environment. In the future, better-controlled comparative research should be employed in order to fully answer the research questions. Relatedly, it may also be interesting to compare how students' actual online performance (e.g., contribution and interactions) with the self-assessment of their interactions, and whether they are aware of their personal knowledge growth and improvement of knowledge-building capacity.

References

Amabile, T. M., Conti, R. (1999). Changes in the work environment for creativity during downsizing. *Academy of Management Journal, 42*(6), 630-641.

Amabile, T. M., Conti, R., Coon, H., Lazenby, J., & Herron, M. (1996). Assessing the Work Environment for Creativity. *Academy of Management Journal*, 39, 1154-1184.

Barab, S. A. (2003). Designing for Virtual Communities in the Service of Learning. *Information Society 19*(3), 1-7.Stahl, G. (2009). *Studying virtual math teams*. New York, NY: Springer.

Barab, S. A., Cherkes-Julkowski, M., Swenson, R., Garrett, S., Shaw, R. E., & Young, M. (1999). Principles of self-organization. *Journal of the Learning Sciences, 8*(3/4), 349–390.

Beghetto, R. A., & Kaufman, J. C. (2007). Toward a Broader Conception of Creativity: A Case for “mini-c” Creativity. *Psychology of Aesthetics, Creativity, and the Arts, 1*(2), 73-79.

Bereiter, C., & Scardamalia, M. (2003). Learning to work creatively with knowledge. In E. D. Corte, L. Verschaffel, N. Entwistle & J. v. Merrienboer (Eds.), *Unravelling basic components and dimensions of powerful learning environments* (pp. 55-68). Oxford, UK: Elsevier Science.

Burtis, J. (2002). *Analytic Toolkit for Knowledge Forum* (Version 4.0). Toronto, ON: Institute for Knowledge Innovation and Technology, Ontario Institute for Studies in Education/University of Toronto.

Chai, C. S. & Lim, C. P. (2011). The Internet and Teacher Education: Traversing between the Digitized World and Schools. *The Internet and Higher Education, 14*, 3-9.

Chai, C. S., & Tan S. C. (2009). Professional development of teachers for computer-supported collaborative learning (CSCL) through knowledge building. *Teacher College Records, 111*(5), 1296-1327.
Cobb, P. (2001). Supporting the improvement of learning and teaching in social and institutional context. In S. Carver & D. Klahr (Eds.), *Cognition and instruction: 25 years of progress* (pp. 455–478). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
David, P. A., & Foray, D. (2003). Economic fundamentals of the knowledge society. *Policy Futures in Education, 1*(1), 20-49.
Engestrom, Y. (1999). Innovative learning in work teams. In Y. Engestrom, R. Miettinen & R. L. Punamaki (Eds.), *Perspectives on activity theory* (pp. 377-404). Cambridge: Cambridge University Press.
Ekvall, G. (1987). The climate metaphor in organizational theory. In B. M. Mass & P. Drenth, Advances in organizational psychology, 177-190. Beverly Hills, CA: Sage. Ekvall, G. (1991). The Organizational culture of idea management: A creative climate for the management of ideas. In J. Henry & D. Walker (eds.). *Management innovation* (pp.73-79). Beverly Hills, CA: Sage.
Ekvall, G. (1996). Organizational climate for creativity and innovation. *European Journal of Work and Organizational Psychology, 5*(1), 105-122.
Ekvall, G., Tangeberg-Anderson, Y. (1986). Working climate and creativity: a study of an innovative newspaper. *Journal of Creative Behavior, 20*(3), 215-225.
Florida, R. (2002). *The rise of the creative class and how it's transforming work, life, community and everyday life*. New York: Basic Books.
Gloor P. A. (2006) *Swarm creativity: competitive advantage through collaborative innovation networks.* New York: Oxford University Press.
Guilford, J. P., (1967). *The nature of human intelligence*. New York: McGraw-Hill.
Gunawardena, C. N., Lowe, C. A., & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research, 17*(4), 397-431.
Hargreaves, D. H. (1999). The knowledge-creating school. *British Journal of Educational Studies, 47*(2), 122-144.
Homer-Dixon, T. (2006). *The Upside of Down: Catastrophe, Creativity, and the Renewal of Civilization.* Washington, DC: Island Press.
Hong, H.-Y. (2011). Beyond group collaboration: Facilitating an idea-centered view of collaboration through knowledge building in a science class of fifth-graders. *The Asia-Pacific Education Researcher, 20*(2), 248-262.
Hong, H.-Y., Chen, F. C., Chai, C. S., & Chan, W. C. (2011). Teacher-education students' views about knowledge building theory and practice. *Instructional Science, 39*(4), 467-482.
Hong, H.-Y., & Sullivan, F. R. (2009). Towards an idea-centered, principle-based design approach to support learning as knowledge creation. *Educational Technology Research & Development, 57*(5), 613-627.
Hong, H.-Y., Scardamalia, M., & Zhang, J. (2010). Knowledge Society Network: Toward a dynamic, sustained network for building knowledge. *Canadian Journal of Learning and Technology, 36*(1). Available online at: http://www.cjlt.ca/index.php/cjlt/article/viewArticle/579
Hunter, S. T., Bedell, K. E., & Mumford, M. D. (2007). Climate for creativity: A quantitative review. *Creativity Research Journal, 19*(1), 69-90.
Isaksen, S. G., & Ekvall, G. (2010). Managing for innovation: the two faces of tension in creative climates. *Creativity and Innovation Management, 19*(2), 73-88.

Ismail, M. (2005). Creative climate and learning organization factors: their contribution towards innovation. *Leadership & Organization Development Journal, 26*(8), pp. 639-654.

Johansson, F. (2004). *The Medici Effect*. Client Distribution Services.

Laurer, K. (1994). *The assessment of creative climate: An investigation of the Ekvall Creative Climate Questionnaire*. Buffalo: Stale University College at Buffalo.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. New York: Oxford University Press.

Papert, S. (2000). What's the big idea: Towards a pedagogy of idea power. *IBM Systems Journal*, *vol. 39*, no. 3-4.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*(4), 557–576.

Prehofer, C., & Bettstetter, C. (2005). Self-organization in communication network: Principles and design paradigms. *IEEE Communications magazine, 43*(7), 78-85.

Rhodes, M. (1961) An Analysis of Creativity, *Phi Delta Kappa, 42*, 305–10.

Sawyer, K. (Ed.). (2006). The Schools of the Future. *Cambridge handbook of the learning sciences*. Cambridge: Cambridge University Press.

Sawyer, R. K. (2007). *Group Genius: The Creative Power of Collaboration*. Perseus Books Group.

Sawyer, R. K. (Ed.). (2006). *Cambridge handbook of the learning sciences*. Cambridge: Cambridge University Press.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.

Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building Communities. *Journal of the Learning Sciences, 3*(3), 265-283.

Scardamalia, M., & Bereiter, C. (1999). Schools as knowledge-building organizations. In D. Keating & C. Hertzman (Eds.), *Today's children, tomorrow's society: The developmental health and wealth of nations* (pp. 274-289). New York: Guilford.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 97–118). New York: Cambridge University Press.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, *27*(2), 4–13.

Slavin, R. E. (1980). Cooperative learning. *Review of Educational Research, 50*(2), 315-342.

Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.

Steffe, L. P., & Thompson, P. W. (2000). Teaching experiment methodology: Underlying principles and essential elements. In R. Lesh & E. Kelly (Eds.), *New methodologies in mathematics and science education* (pp. 267–307). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Sternberg, R. J. (1999). *Handbook of Creativity*. NY: Cambridge.

Thagard, P. (1997). Collaborative knowledge. *Nous, 31*(2), 242-261.

United Nations Educational, Scientific and Cultural Organization (UNESCO) (2005). *Towards knowledge societies*. UNESCO.

von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation*. New York: Oxford University Press.

Watkins, K. E. & Marsick, V. J. (1999). *Dimension of the Learning Organization Questionnaire*. Warwick, RI: Partners of the learning organization.

West, J. A. & West, M. L. (2009). *Using Wikis for Online Collaboration: the power of the read-write web*. San Francisco, CA: Jossey-Bass.

Zain, M., Rickards, T. (1996). Assessing and comparing the innovativeness and creative climate of firms. *Scandinavian Journal Management, 12*(2), 109-121.

Zeng, J. M. (2002). *The Relationship Between Taiwanese Graduate Students' Playfulness, Humor, Creative attitude, Creative Climate and the Creativity*. Unpublished master's thesis, National Cheng-chi University. Taipei, Taiwan.

Zhang, J., Hong, H.-Y., Scardamalia, M., Teo, C. L. & Morley, E. A. (2011). Sustaining knowledge building as a principle-based innovation at an elementary school. *Journal of the Learning Sciences, 20*(2), 262-307.

Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2007). Socio-cognitive dynamics underlying knowledge building. *Educational Technology Research & Development, 55*(2), 117-145.

Zuckerman, H. S. & D'Aunno, T. A. (1990). Hospital Alliances: Cooperative Strategy in a Competitive Environment. *Health Care Management Review, Vol. 15*(12), pp.21-30.

附件一

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估 ■ 達成目標 □ 未達成目標（請說明，以 100 字為限） □ 實驗失敗 □ 因故實驗中斷 □ 其他原因 說明：
2. 研究成果在學術期刊發表或申請專利等情形： 論文：■已發表（3 篇 SSCI 文章） □未發表之文稿 □撰寫中 □無 專利：□已獲得 □申請中 □無 技轉：□已技轉 □洽談中 □無 其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

在知識社會中，「知識創造」逐漸受到重視。然而，教學方法應如何設計才可以有效支持以創新為中心的教學，則仍待進一步探討。本研究發現「知識翻新」理論與科技是一可行方案。本研究將知識翻新理論與科技逐漸地引入大學師資培育課程之中。研究方法主要採用個案研究法或設計本位研究法，針對三種相互關聯的教學設計(包括「以想法為中心」、「以社群為基礎」、和「以原則作導引」)進行實驗。研究中收集了兩大類資料：包括歷程與結果資料。主要資料包括：(1) 師培生在知識論壇(知識論壇係一以知識翻新理念所設計的多媒體網路平台)上的線上討論內容；(2) 教室活動；以及 (3)教室觀察。透過質化與量化並呈的混合分析（如內容分析法、對話分析和語料分析等），本研究逐步找出了一些知識翻新理論與科技可以應用在師資培育課程中的教學設計與實施策略，其結果亦對未來培育具創造力與適應性的 21 世紀優質教師有些許啟示。

附件二

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：102 年 10 月 25 日

計畫編號	NSC 99-2511-S-004-002-MY3		
計畫名稱	「知識翻新」理論與科技應用於師資培育之教學設計與實施策略		
出國人員姓名	洪煌堯	服務機構及職稱	國立政治大學教育系/副教授
會議時間	2012/08/06~2012/08/09	會議地點	Toronto, Canada
會議名稱	The 2012 Knowledge Building Summer Institute		
發表論文題目	Hong, H.-Y. (August, 2010). Fostering Constructivist-Oriented Mathematical Beliefs through Knowledge-Building. Paper presented at the 16th Knowledge Building Summer Institute. Toronto, Canada.		

一、參加會議經過

The main theme of this conference (The 16th Annual Knowledge Building Summer Institute) was about building cultural capacity for innovation initiative. This year, the conference was organized using a different format that divided the conference into seven sub-themes, including the following: Theme 1--Intellectual Engagement and an Inclusive Knowledge Society; Theme 2--Creative, Sustained Work with Ideas; Theme 3--Knowledge Building Partnerships & Professional Development; Theme 4--Technology for Knowledge Creation -International Open Source Initiative; Theme 5--Social Innovation and Systemic Change; Continuing Education, Credentialing, & Policy Making; Theme 6: Assessment for

Knowledge Creation; and Theme 7: Research Based Innovation; Sustainability and Scalability. A plenary session was assigned to each theme using a format called Design Challenge, and conference participants were broke into smaller groups to collaborative work on different design challenges. In addition, there were also parallel paper sessions, workshops and poster sessions, etc. The conference was quite a success.

二、與會心得

Overall, my most important gain from this conference is concerned with learning from diversified perspectives from experts from different countries, as well as learning about many different interesting study topics in the area of knowledge building and computer-supported collaborative learning. More details can be found in the website as follows: http://ikit.org/SummerInstitute2012/. This time, my paper presentation was assigned in the second design theme (Creative, Sustained Work with Ideas) and the design challenge for this theme is called "develop knowledge practices and technology". The goal of this challenge is to engage students directly in knowledge practices that are commonly found in knowledge-creating enterprises, and to encourage continual idea improvement in ways that can lead students to increasingly deeper understanding.

三、考察參觀活動(無是項活動者略)：無。

四、建議

An important shift of research focus seems to focus on computer-supported collaborative learning (CSCL) and knowledge building. Also, it can be found that more and more research has started to pay attention to practical issues regarding how to put CSCL and knowledge building theories into practices. I personally also think research topics in relation to these fields are very important and can be influential for the education in the future. I would recommend more people to consider these fields for their future research.

五、攜回資料名稱及內容

All information (e.g., all conferences papers; photos) is available online at:
http://ikit.org/SummerInstitute2012/

附件三

本計畫目前為止所產出之論文

1. Hong, H.-Y. (accepted). Exploring college students' perceptions of learning and online performance in a knowledge building environment, *Asia-Pacific Education Researcher*. (SSCI)
2. Hong, H.-Y., Chang, Y.-H. & Chai, C. S. (in press). Fostering a collaborative and creative climate in a college class through idea-centered knowledge-building. *Instructional Science*. (SSCI)
3. Chai, C. S., Ng, E. M. W., Li, W., Hong, H.-Y., & Koh, J. H. L. (2013). Validating and modelling technological pedagogical content knowledge framework among Asian preservice teachers. *Australasian Journal of Educational Technology. 29*(1), 41-53. (SSCI).
4. Hong, H.-Y. & Lin-Siegler, X. (2012). How learning about scientists' struggles influences students' interest and learning in Physics. *Journal of Educational Psychology, 104(2), 469-484. (SSCI)*

出席國際學術會議心得報告

計畫編號	NSC 99-2511-S-004-002-MY3
計畫名稱	「知識翻新」理論與科技應用於師資培育之教學設計與實施策略
出國人員姓名 服務機關及職稱	洪煌堯/國立政治大學教育系/副教授
會議時間地點	2012/08/06~2012/08/09 Toronto, Canada
會議名稱	The 2012 Knowledge Building Summer Institute

參加會議經過、與會心得

The main theme of this conference (The 16th Annual Knowledge Building Summer Institute) was about building cultural capacity for innovation initiative. This year, the conference was organized using a different format that divided the conference into seven sub-themes, including the following: Theme 1--Intellectual Engagement and an Inclusive Knowledge Society; Theme 2--Creative, Sustained Work with Ideas; Theme 3--Knowledge Building Partnerships & Professional Development; Theme 4--Technology for Knowledge Creation -International Open Source Initiative; Theme 5--Social Innovation and Systemic Change; Continuing Education, Credentialing, & Policy Making; Theme 6: Assessment for Knowledge Creation; and Theme 7: Research Based Innovation; Sustainability and Scalability. A plenary session was assigned to each theme using a format called Design Challenge, and conference participants were broke into smaller groups to collaborative work on different design challenges. In addition, there were also parallel paper sessions, workshops and poster sessions, etc. The conference was quite a success.

Overall, my most important gain from this conference is concerned with learning from diversified perspectives from experts from different countries, as well as learning about many different interesting study topics in the area of knowledge building and computer-supported collaborative learning. More details can be found in the website as follows: http://ikit.org/SummerInstitute2012/. This time, my paper presentation was assigned in the second design theme (Creative, Sustained Work with Ideas) and the design challenge for this theme is called “develop knowledge practices and technology”. The goal of this challenge is to engage students directly in knowledge practices that are commonly found in knowledge-creating enterprises, and to encourage continual idea improvement in ways that can lead students to increasingly deeper understanding.

I have learned quite a lot from these conference activities which allowed me to generate new ideas for future research. Being able to talk with experts from different cultures and countries also allows me to get a feel of what new research topics are emerging in the field of learning sciences and computer-supported collaborative learning. Inspired by these experiences, I believe that I can now better relate my own current work to new research challenges and possibilities in the field in the future. I hope I will have another chance to visit this conference in the future. And finally, I attached a picture below and the full paper I presented in the conference as Appendix 1 as follows.

Appendix 1

Hong, H.-Y. (August, 2010). Fostering Constructivist-Oriented Mathematical Beliefs through Knowledge-Building. Paper presented at the 16th Knowledge Building Summer Institute. Toronto, Canada.

Fostering constructivist-oriented mathematical beliefs through knowledge-building

Abstract: This case study investigated the impact of engaging teacher-education students in knowledge building on their mathematical beliefs. In particular, an idea-centered instructional design was introduced to facilitate knowledge-building processes. Data analyses focused on (a) idea improvement process as documented in a Knowledge Forum database, and (b) a mathematical beliefs survey. Results showed that idea-centered knowledge building was able to help the participants develop more constructivist-oriented mathematical beliefs.

Research shows that beliefs are closely related to learning experiences (Pajares, 1992; Richardson, Anders, Tidwell, & Lloyd, 1991; Schommer, 1994; Wilson, 1990). If students' learning experiences are related to more didactic instructional approaches, it is more likely that they will develop more absolutist-oriented beliefs. As commonly observed in conventional mathematics classrooms, such belief tends to be fostered through encouraging students to rely on textbooks or teachers as authoritative knowledge sources (Cooney, Shealy, & Arvold, 1998; Green, 1971; Schoenfeld, 1989; Szydlik, Szydlik, & Benson, 2003). In contrast, when learners are prompted to learn through more discovery-guided instructional approaches, they are more likely to develop constructivist-oriented beliefs. Similarly, teacher-education students' beliefs can also closely relate to their learning-to-teach (teaching practices) experiences. To help teacher-education students cultivate more productive mathematical beliefs, the present study employed 'knowledge-building' in a mathematics teaching course.

Knowledge building, also known as "deep constructivism" (Scardamalia, 2002, p. 4), is defined as a social process focused on sustained production and improvement of ideas of value to a community (Scardamalia & Bereiter, 2006). Unlike the conventional view of education that highlights learning through acquiring and accumulating well-established knowledge (Paavola, Lipponen, & Hakkarainen, 2004; Sfard, 1998), knowledge-building employs ideas as building blocks for deeper knowledge around a specific topic. The importance of valuing ideas as basic units of thought or objects of inquiry can be manifested by means of Popper's (1972) 3-World epistemic conceptualization. Popper refers to World-1 as an objective, natural/physical/material world, World-2 as a subjective psychological world constructed within the human mind, and World-3 as a conceptual world constituted mainly by ideas (e.g., theories, models). He argues that ideas are the creative results of human beings (such as engineers, scientists, researchers, artists, and the like) and that all forms of human knowledge are related to the creation of ideas in a human community (Scardamalia, 2002). Bereiter (2002) further argues that ideas are conceptual objects which, once produced in a public domain, can possess a social life of their own and can be continually tinkered with, modified, and improved.

Unfortunately, conventional views of education tend to focus on learning through knowledge acquisition and accumulation (e.g., understanding World-1 by changing students' mind in World-2), but not working creatively with ideas (e.g., transforming students into knowledge workers in World-3) (Bereiter, 1994; Paavola, Lipponen, & Hakkarainen, 2004; Sfard, 1998). Similarly, teacher-education students are unaccustomed to the ways of assuming the role of theory-builder or knowledge-worker as teaching professionals. Instead, they are often encouraged to pursue exemplary teaching practices after some model teachers. If teacher-education students do not know how to work innovatively with ideas as knowledge-workers, it is questionable that they will be able to guide school pupils to develop the kind of innovative competencies essential in knowledge-based societies (Hong, 2011; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). Thus, in addition to learning about content-based knowledge and exemplary teaching practices, it is equally important to provide teacher-education students with opportunities to learn to work with ideas for building knowledge.

Previous research on in-service teachers who have been practicing knowledge-building pedagogy for years suggests that such practice may stimulate epistemological growth among these teachers (Chai, Wong, & Bopry, 2009; Chai & Tan, 2009; Zhang, Hong, Scardamalia, Teo, & Morley, 2011). Building on this line of research, it is posited that engaging teacher-education students in collaborative knowledge-building should also have effects on their views about the subject matter they are to teach and their teaching capacity. Yet such assumption remains to be examined, especially in the domain of mathematics.

Method

Study Design, Participants and Instructional Context

This case study attempts to gather rich data embedded in a course context. The participants were nine teaching-education students (four females and five males) and their age ranged from 19 to 23 years ($M = 21$; $SD=1.59$). They were planning to become middle-school mathematics teachers in Taiwan after graduation, so took a university-level course entitled Middle School Mathematics Teaching. The course was offered by the university's Center of Teacher Education; the university is ranked as one of the top 10 universities in the nation. The course served a practical purpose as it represented a final course requirement before students graduate and begin their student-teaching internship. Before taking this course, students needed to complete most theory-based courses—for instance, instructional theories and adolescent psychology—as prerequisites. The main instructional goal of this course was to foster adaptive practices and dispositions in mathematics teaching. Major instructional and research activities throughout the academic year were organized as follows:

(1) A pre-post belief survey was conducted at the beginning and end of the study to measure participants' mathematical belief changes. This was done using open-ended questions concerning the nature of mathematics and that of ideal mathematics teaching and learning (see below for details).

(2) A tutorial workshop about how to use Knowledge Forum (KF) was administered in the first two weeks of the school year. Students were introduced to some basic functions of KF, for instance, creating a note in a KF "view" (i.e., an online problem-solving space) or building on a note.

(3) For the remaining time in the academic year, the participants were engaged in knowledge-building. In particular, an idea-centered instructional approach, proposed by Hong and Sullivan (2009), was employed to foster sustained knowledge-building. This instructional approach was developed based on a review and has yet to be empirically tested; the present study was the first to examine this approach. Under this approach, ideas are improved in two dimensions: quality and quantity. From a social perspective, the quality of ideas is a function of how knowledge workers (epistemic agents) collaboratively work with ideas, and the quantity of ideas is a function of how ideas (conceptual objects) are shared and/or exchanged in a community. Building on Popper's (1972) evolutionary epistemology, ideas may be substantially refined in quality by means of constructive elaboration, or significantly enriched in quantity by means of continued diversification. One thing to note is that one-sidedly focusing on either idea elaboration or idea diversification may lead knowledge-building activities into a less productive path. For example, research shows that keeping ideas as one's intellectual property without sharing with, or obtaining new perspectives from, other members can impede knowledge creation in a company or a community (Chubin 1976; Granovetter 1983). On the other hand, merely sharing ideas or information with others in a community (e.g., social networking) does not warrant the transformation of ideas into deeper understanding (Kling & Rosenberg 1986). A more balanced and productive trajectory to sustained idea-improvement relies on the transformation of ideas both in quality and quantity through an emerging process of self-organization that is enabled by simple rules (e.g., idea elaboration and exchange) to gradually form a complex network of ideas (Prehofer & Bettstetter, 2005). Based on this instructional design approach, participants were explicitly guided to engage in the following three idea-improvement activities:

(a) Idea generation: Participants were guided to generate and work on their initial teaching ideas; accordingly, they worked on lesson plans, set instructive goals, prepared learning materials and worksheets, etc. Then, based on their ideas, they performed their teaching practices in class, with the other classmates serving as the audience and critical reviewers.

(b) Idea exchange and diversification: This activity facilitated idea diversity and sharing from multiple perspectives. To generate ideas for feedback, participants were guided to ask questions such as: "If you were to teach this same lesson, how would you do differently to improve the teaching practices?"; "What is your main idea?"; "Why is it useful?"; "How is it going to improve teaching?", etc. They then posted their ideas in the form of a note in the Knowledge Forum.

(c) Idea elaboration and reflection: Next, the student who completed his or her teaching practice would go online to review and summarize all ideas and feedback provided by peers, reflect on previous teaching practice, and try to improve and prepare for the next teaching practice. In addition, the participants were required to write reflection notes at the end of each practice and a reflection paper at the end of the course.

In summary, the activities were designed to support sustained knowledge building. It is important to note, however, that the order of the three activities was not at all fixed, as the process of idea generation, exchange, and elaboration could occur at any time during the knowledge building process.

Knowledge Forum—an Online Knowledge-Building Environment

In addition to tutorial workshop activity and teaching practices, which were held physically in class, all other activities (e.g., contribution of teaching ideas, peer-feedback, peer-assessment, and self-reflection, etc.) were held in the Knowledge Forum (KF). KF is an online platform that runs on a live database. It allows users to simultaneously create and post their ideas in the form of a note on a database, read others' postings, watch videos, reply to others' notes, search and retrieve records, and organize notes into more complex knowledge representation. KF runs in both a text and a graphics mode. In the graphics mode, it shows linkages of postings as a way to represent the interconnectivity and dialogical nature of knowledge. Within the KF, users are guided to work as a community by making explicit their problem of interest, producing initial teaching ideas, sharing and connecting ideas, synthesizing ideas, and deepening collective understanding of the problems at issue. Specifically for this study, a key problem of interest in the course was concerned with improving teaching practices and attaining deeper understanding of the nature of mathematics, mathematics teaching, and mathematics learning.

Data Source and Analysis

The main datasets came from (a) participants' teaching ideas posted online as notes, and (b) a pre-post belief survey. First, online data were recorded in a Knowledge Forum database. Using ideas (defined as distinct suggestions for improving teaching practices) as units of analysis, content analysis was performed to examine patterns of peer-feedback and self-reflection for the improvement of students' teaching practices (Strauss & Corbin, 1990). What emerged from open coding was three areas of improvement (including learning content, instructional method, and personal performance) and two courses of idea improvement (i.e., ideas generated for improving either teacher-centered or student-centered practices). For the purpose of analysis, the three idea improvement stages were divided into: stage 1 (between the first and second practices), stage 2 (between the second and third practices), and stage 3 (between the third and fourth practices). A repeated-measures ANOVA was computed to test if there were any significant changes among the three stages of idea improvement. To compute inter-rater reliability, two coders independently categorized each idea. A Kappa coefficient was calculated to be .77.

Second, the pre-post belief survey was developed based on Handal's (2003) conceptualization of mathematics beliefs in three aspects: views of the nature of mathematics, views of mathematics teaching, and views of mathematics learning (see also Ernest, 1991). A previous study by Tsai (1998) investigating students' epistemological beliefs in natural sciences used a belief survey with eight open-ended questions. This study adopted this same survey, with minor text revision (e.g., changing the word 'science' to 'mathematics'). The eight questions are as follows: (1) What is mathematics? (2) What does doing mathematics mean to you? (3) What is an ideal way to teach mathematics? (4) What are some key factors for successful mathematics teaching? (5) What makes an ideal mathematics teacher? (6) What is an ideal way to learn mathematics? (7) What are some key factors for successful mathematics learning? (8) What makes an ideal mathematics learning environment? Of the items, questions 1 and 2 concern the nature of mathematics; questions 3 to 5 concern the nature of mathematics teaching; and questions 6 to 8 concern the nature of mathematics learning. Content analysis was employed (Strauss & Corbin, 1990) using a pre-determined coding scheme developed based on the above conceptualization of mathematics beliefs (Handal, 2003) (see Table 1). Wilcoxon signed rank tests were conducted to measure if there were any pre-post belief changes. Two coders independently performed the coding process. The inter-coder kappa was calculated to be 0.95.

Table 1. Coding scheme of mathematical beliefs

Category	Sub-category	Example
Absolutist-oriented beliefs: Regarding mathematics as a set of tools, consisting of formulas, theorems and theories. Students need to master the use of tools in order to achieve teaching objectives (Ernest, 1988).	**Mathematics**: is a science (or group of related sciences) dealing with number, quantity and measure (Risteski et al., 2008).	- Mathematics is geometry, algebra, statistics, probability, number, quantity, etc.—a combination of different mathematical knowledge and [tools]. (S1). - Math is a science about calculating numbers. (S04)
	Mathematics teaching: is to train students' thinking ability.	- I think Mathematics is a subject that trains and exercises our brain. (S2). - The best way to teach a math course is to lecture,

		using the simplest and most straightforward way to explain concepts in order to help students understand them, as complex mathematics builds upon simple mathematical facts and concepts. (S1).
	Mathematics learning: is to acquire basic mathematics concepts and procedures and to practice again and again.	- Practice makes perfect. (S3) - The more you think, try, and practice math quizzes/problems the better you can solve similar quizzes or problems and understand the concepts and facts that are required to solve these problems. (S5)
Constructivist-oriented beliefs: Mathematics is a course of dynamic exploration and creative invention. The course includes making mistakes and sustained revision and correction. Mathematics does not necessarily represent absolute truth or eternal knowledge, but can be validated or falsified by continual exploration and improvement (Ernest, 1988).	**Mathematics**: is a science of exploring patterns, orders, and relations (Franklin, 1994).	- Doing mathematics is to seek for patterns or principles by means of given conditions, using symbols and numbers to predict, estimate, or conjecture possible outcomes. (S9) - Math is a way to find patterns and orders in life, through the use of symbols and numbers and that of logical thinking…math provides a means to knowing the world, exploring rules in complex affairs, and reducing errors. (S4)
	Mathematics teaching: is to help students develop their own way of mathematics learning, and to guide them to explore and solve problems, through discussion and collaboration.	- It is (a) to make students like math and be interested in it; (b) to want to explore a math problem in depth and discuss with others about it; (c) to be willing to collaborate with others and try various means collectively to solve problems. (S9). - I think teaching is not to lecture myself, but is to provide opportunities for students to explore math in a natural way, to frequently interact with students and to motivate students to think about problems, to allow students to try and learn from their own mistakes, by giving them enough time to think and discuss among themselves; one-way talking will be unlikely to motivate students to learn. (S8).
	Mathematics learning: is to develop one's own way of understanding through mathematical problem-solving.	- It is to establish one's own learning style by learning how to learn math and by working and discussing with others; by accumulating such experiences, one will not be limited to one's habitual ways of thinking and will be able to think from multiple perspectives, and be able to come up with even better solutions to the same math problem. (S6). - Learning is to explore and identify a more systemic way for one's own math learning and to gradually develop more effective learning processes. (S02).

Results

Idea improvement

Content analysis on students' notes was performed to illustrate how the participants produce and improve ideas. The results revealed that a total of 516 ideas were contributed in the KF throughout the school year. These ideas mainly came from two sources: peer feedback and self-reflection. A non-parametric Wilcoxon signed-ranks test showed a significant difference between the two sources in terms of the percentage of idea contribution, with more ideas coming from peer feedback (M=71.7%, SD=11.4%) than self-reflection (M=28.3%, SD=11.4%; $z=-2.67$, $p<.01$). Further, in terms of areas of idea improvement, it was found that ideas mainly contributed to improving teaching practices in three areas: learning content, instructional method, and personal performance. A non-parametric Friedman test showed a significant difference among the three areas, with significantly more ideas being contributed to improve instructional method (M=24.22, SD=7.10) than in the two other areas (i.e., personal performance, M=18.67, SD=4.95; and learning content, M=14.44, SD=3.32; χ^2 =12.06, p<.01). Moreover, in terms of the course of idea improvement, using participants as units of analysis and repeated-measures ANOVA, it was found (see Figure 1) that there was a progressive decrease in terms of the percentage of the number of participants' ideas being contributed to improving more teacher-centered teaching practices. The percentage in the three improvement stages was 66.3% (SD=15.0%), 57.0% (SD=15.5%), and 46.3% (SD=15.6%) respectively (Wilks' lambda=.403, F=5.19, p<.05, $\eta 2$=.60). In contrast, there was a progressive increase in terms of the percentage of the number of participants' ideas being contributed to improving more student-centered teaching practices. The percentage in the three improvement stages was 33.7% (SD=15.0%), 43.0% (SD=15.5%), and 53.8% (SD=15.5%) respectively (Wilks' lambda=.413, F=4.98, p<.05, $\eta 2$=.59). As a case example, to illustrate how the participants progressively move away from more teacher-centered to more student-centered idea improvement, shown below is the way in which a participant (S4) collaborated with peers and worked on ideas to improve her teaching practices in the areas of learning content, instructional method, and personal performance. This case was selected as the participant's teaching is highly teacher-centric and she mainly relied on lectures in her first teaching practice, as compared with other participants.

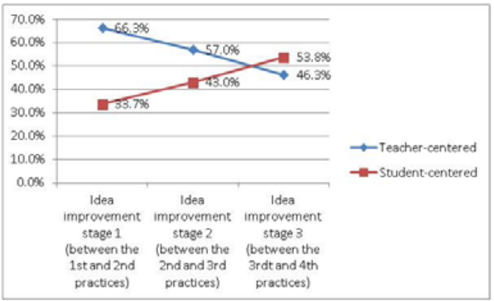

Figure 1. Two courses of idea-improvement in teaching practices (teacher-centered vs. student-centered)

First, in terms of learning content, S6 suggested to S4: "From a student point of view, I think the examples you used for teaching should be simpler because students were not familiar with this new concept [i.e., congruent triangles] that you were introducing." S6 thought S4 did not put herself in students' positions, finding that the test items S4 prepared in the worksheet were too difficult for the students; she did not take students' prior understanding into her teaching consideration. In response, S4 reflected: "The test items I used were selected from national competency tests with which I was familiar. I was not conscious that they were too difficult. I will think again what test items to include next time." So peer feedback promoted S4 to reflect on how to select test items that are more appropriate from the viewpoint of students. Second, regarding instructional method, S2 told S4 that "there was too much lecture and because you were mainly lecturing, your teaching heavily relied on the use of the textbook. You may try to integrate some visual aids or illustrations into your teaching, so as to better engage students." In this case, S2 shared her personal ideas about how to motivate students to learn. In response, S4 elaborated, "using visual aids is a good idea. When I was preparing this lesson, I thought that the textbook already has figures in it, so lecture alone is good enough. I agree that using figures can be helpful for increasing learning interest." In this case, peer feedback helped S4 to shift her teaching focus to student learning and motivation, having previously focused too much attention inward. Finally, in terms of personal performance, after observing S4's teaching practices, S6 suggested: "I think you should raise your voice and maintain comfortable eye contact and posture with the students at all times". In response, S4 wrote, "I was very nervous during my whole teaching. Maybe it was because I am not a very confident person. I guess my nervousness is also because I am afraid of dealing with unplanned events that might occur during teaching. This is definitely an area that I want to improve in my next practice." Clearly, peer feedback also prompted S4 to be aware of her highly teacher-centric teaching style.

Changes in mathematical beliefs

Content analysis was performed on the data derived from the pre-and-post belief surveys to answer the third research question of whether the instructional activities affected teacher-education students' mathematical beliefs. Overall, regarding general epistemological views in mathematics, as Table 2 shows, the non-parametric Wilcoxon signed rank tests showed that there was significant decrease in ratings from pre-survey to post-survey in terms of absolutist-oriented views (z=-2.25, p<.05); in contrast, it was found that there was significant increase in ratings from pre-survey to post-survey in terms of constructivist-oriented views (z=-2.67, p<.01).

Further analyses were conducted to look into the three specific aspects of the epistemological views (beliefs in the nature of mathematics, beliefs in mathematics teaching, and beliefs in mathematics learning). First, regarding absolutist-oriented views, a significant pre-post change was found only in participants' beliefs in mathematics teaching (z=-2.23, p<.05). There was no significant pre-post change in participants' beliefs regarding the nature of mathematics and belief in mathematics learning. Possibly, this was due to the small sample size. Alternatively, it may be because, to a certain degree, students still believed that memorization of mathematical facts is needed as a base for higher levels of mathematics learning. On the other hand, it was found that all three aspects of the constructivist-oriented views showed significant pre-post changes (z=-2.39, p<.05, in terms of beliefs in the nature of mathematics; z=-1.98, p<.05, in terms of beliefs in mathematics teaching; and z=-2.53, p<.05, in terms of beliefs in mathematics learning).

Table 2. Participants' mathematical beliefs

Mathematical views	Pre-survey		Post-survey		*z-value*
	M	SD	M	SD	
Absolutist-oriented beliefs	9.89	4.40	4.56	2.79	-2.25*
- Mathematics: is a science (or group of related sciences) dealing with number, quantity and measure	3.67	1.87	2.11	2.37	-1.13
- Mathematics teaching: is to train students' thinking ability	4.11	2.42	1.89	1.36	-2.23*
- Mathematics learning: is to acquire basic mathematics concepts and procedures and to practice again and again.	2.11	2.2	0.56	0.73	-1.7
Constructivist-oriented beliefs	0.89	1.05	10.22	6.63	-2.67**
- Mathematics: is a science of exploring patterns, orders, and relations	0.00	0.00	2.56	2.07	-2.39*
- Mathematics teaching: is to help students develop their own way of mathematics learning, and to guide them to explore and solve problems, through discussion and collaboration	0.67	0.87	3.67	4.42	-1.98*
- Mathematics learning: is to develop one's own way of understanding through mathematical problem-solving	0.22	0.44	4.00	2.06	-2.53*

*<.05 **<.01

Conclusions and Implications

It is thought that helping pre-service teachers develop the necessary skills and attitude for lifelong learning is of great consequence to the teaching profession (Bereiter, 2002). To address this challenge, the present study focused on an instructional shift—from learning-to-teach by following a lesson 'script' (Adams & Engelmann, 1996; Engelmann, 1980; Sawyer, 2004; Slavin & Madden, 2001), to learning-to-teach by working innovatively with 'ideas' (Bereiter, 2002). While scripted teaching practices can help teacher-education students acquire greater abilities in routine teaching performance with high efficiency, such mode of teaching might also lead practitioners into a comfort zone and develop a mental habit that is inclined to seek a strong sense of security (White, 2009). Instead, guiding teacher-education students to work innovatively with ideas for teaching practice is more likely to help them move beyond thinking about routines to try out new teaching strategies and adjust what they are doing, developing progressively more effective and personalized teaching practices (Hammerness et al., 2005).

Knowledge-building theory has been developed over the past 20 years (Scardamalia & Bereiter, 2010) and has been recognized as a foundational approach to learning sciences (Sawyer, 2006). As 'deep constructivism' (Scardamalia, 2002, p. 4), knowledge-building attempts to guide classroom activities away from proceduralized tasks to innovative knowledge work (Zhang, Hong, Scardamalia, Teo, & Morley, 2011). In a special issue of the *Canadian Journal of Learning and Technology on knowledge-building* (Jacobsen, 2010), a set of studies ranging from the elementary-school classroom setting to campus classrooms provided convincing examples of what students can achieve in knowledge-building classrooms in the advancement of knowledge. In the present study, the findings further suggested that engaging teacher-education students in sustained knowledge-building in a teacher-education course could also help the teacher-education students develop beliefs that view teaching as creative and improvable practices (contrasted with beliefs that view teaching as ritualized activities). In conclusion, this study shows that the proposed idea-centered instructional design was viable for guiding teacher-education students to develop more adaptive teaching beliefs. Admittedly, there are limitations that must be recognized in this study. There is a need for greater consideration regarding generalizability from a single class of nine teacher-education students; further research is needed in more diverse class contexts.

References

Adams, G.L., & Engelmann, S. (1996). *Research on Direct Instruction: 25 years beyond DISTAR*. Seattle, WA: Educational Achievement Systems.

Bereiter, C. (1994). Constructivism, Socioculturalism, and Popper's World 3. *Educational Researcher, 23*(7), 21-23.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bereiter, C., & Scardamalia, M. (1993). *Surpassing ourselves: An inquiry into the nature and implications of expertise*. Chicago, Illinois: Open Court.

Bereiter, C., & Scardamalia, M. (2006). Education for the Knowledge Age: Design-Centered Models of Teaching and Instruction. In P. A. Alexander, and P. H. Winne (Eds.), *Handbook of Educational Psychology* (2nd ed.). (pp. 695-713). Mahwah, NJ : Lawrence Erlbaum.

Chai, C, S., Wong, B., & Bopry, J. (2009). A Case Study of Teachers' Perceptions of the Knowledge-building Community. *Asian Journal of Educational Research and Synergy, 1*(1), 69-81.

Chai, C. S., & Tan S. C. (2009). Professional development of teachers for computer-supported collaborative learning (CSCL) through knowledge building. *Teacher College Records, 111*(5), 1296-1327.

Chubin, D. E. (1976). The conceptualization of scientific specialties. *The Sociological Quarterly, 17*, 448-476.

Cooney, T.J., Shealy. B.E. & Arvold, B. (1998). Conceptualizing belief structures of pre-service secondary teachers.

Journal for Research in Mathematics Education, 29(3), 307–333.
Engelmann, S. (1980). *Direct instruction*. Englewood Cliffs, NJ: Educational Technology Publications.
Ernest, P. (1989). The knowledge, beliefs and attitudes of the mathematics teacher: A model. *Journal of Education for Teaching, 15*, 13–34.
Franklin, J. (1994). The Formal Sciences Discover the Philosophers' Stone. *Studies in History and Philosophy of Science, 25*, 513–533.
Granovetter, M. (1983). The strength of weak ties: A network theory revisited. *Sociological theory, 1*, 201-233.
Green, T. (1971). *The activities of teaching*. New York: McGraw-Hill.
Hammerness, Darling-Hammond, Bransford, Berliner, Cochran-Smith, McDonald, et al. (2005). How teachers learn and develop. In Darling-Hammond, L. (Ed.). *Preparing teachers for a changing world: What teachers should learn and be able to do.* (pp. 358–389). San Francisco: John Wiley & Sons.
Handal, B. (2003). Teachers' mathematical beliefs: A review. *The Mathematics Educator,13*(2), 47-57.
Hong, H.-Y. (2011). Beyond group collaboration: Facilitating an idea-centered view of collaboration through knowledge building in a science class of fifth-graders. *The Asia-Pacific Education Researcher, 20*(2), 248-262.
Hong, H.-Y., & Sullivan, F. R. (2009). Towards an idea-centered, principle-based design approach to support learning as knowledge creation. *Educational Technology Research & Development, 57*(5), 613-627.
Howard, B. C., McGee, S., Schwartz, N., & Puecell, S. (2000). The experience of constructivism: Transforming teacher epistemology. *Journal of Research on Computing Education,32* (4), 455-465.
Jacobsen., M. (2010). A Special Issue of the Canadian Journal of Learning and Technology on Knowledge Building. *Canadian Journal of Learning And Technology, 36*(1). Retrieved December 24, 2010, from http://www.cjlt.ca/index.php/cjlt/article/view/579.
Kling, S., & Rosenberg, N. (1986). An overview of innovation. In R. Landau & N. Rosenberg (Eds.), *The positive sum strategy: Harnessing technology for economic growth* (pp. 275-305). Washington, DC: National Academy Press.
Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*(4), 557-576.
Pajares, M. F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.
Popper, K. R. (1972). *Objective knowledge: An evolutionary approach*. London: Oxford University Press.
Prehofer, C., & Bettstetter, C. (2005). Self-organization in communicatioon network: Principles and design paradigmss. *IEEE Communications magazine, 43*(7), 78-85.
Richardson, V., Anders, P., Tidwell, D., & Lloyd, C. (1991). The relationship between teachers' beliefs and practices in reading comprehension instruction. *American Educational Research Journal, 28* (3), 559-586.
Risteski, I. B., Carlos, E., & Garcia, D. (2008). On what there is in philosophy of mathematics. *Discusiones Filosoficas, 9*(12), pp.151-171.
Sawyer, R. K. (2004). Creative teaching: collaborative discussion as disciplined improvisation. *Educational Researcher, 33*(2), 12-20.
Sawyer, R. K. (Ed.). (2006). *Cambridge handbook of the learning sciences*. Cambridge: Cambridge University Press.
Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago: Open Court.
Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 97-118). New York: Cambridge University Press.
Scardamalia, M., & Bereiter, C. (2010). A brief history of Knowledge Building. *Canadian Journal of Learning and Technology, 36*(1). Retrieved December 24, 2010, from http://www.cjlt.ca/index.php/cjlt/article/view/579.
Schoenfeld, A. (1989). Explorations of students' mathematical beliefs and behavior. *Journal for Research in Mathematics Education, 20*(4), 338–355.
Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative conclusions. *Educational Psychology Review, 6*, 293 -319.
Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4-13.
Slavin, R. E., & Madden, N. A. (Eds.). (2001). *Success for all: Research and reform in elementary education*. Mahwah, NJ: Erlbaum.
Szydlik, J. E., Szydlik, S. D., & Benson, S. R. (2003). Exploring changes in pre-service elementary teachers' mathematical beliefs. *Journal of Mathematics Teacher Education, 6*, 253-279.
Tsai, C.-C. (1998). An analysis of scientific epistemological beliefs and learning orientations of Taiwanese eighth graders. *Science Education, 82*(4), 473–489.
White, A. K. (2009). *From comfort zone to performance management*. Brusel: White & MacLean Publishing.
Wilson, S. M. (1990). The secret garden of teacher education. *Phi Delta Kappan, 72*, 204-209.
Zhang, J., Hong, H.-Y., Scardamalia, M., Teo, C. L. & Morley, E. A. (2011). Sustaining knowledge building as a principle-based innovation at an elementary school. *Journal of the Learning Sciences, 20*(2), 262-307.
Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *Journal of the Learning Sciences, 18*(1), 7–44.

國科會補助計畫衍生研發成果推廣資料表

日期:2013/10/28

國科會補助計畫	計畫名稱: 「知識翻新」理論與科技應用於師資培育之教學設計與實施策略
	計畫主持人: 洪煌堯
	計畫編號: 99-2511-S-004-002-MY3　　學門領域: 資訊教育一電腦輔助教學

無研發成果推廣資料

99 年度專題研究計畫研究成果彙整表

計畫主持人：洪煌堯 **計畫編號：**99-2511-S-004-002-MY3

計畫名稱：「知識翻新」理論與科技應用於師資培育之教學設計與實施策略

成果項目			量化：實際已達成數（被接受或已發表）	量化：預期總達成數(含實際已達成數)	量化：本計畫實際貢獻百分比	單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	4	4	100%	篇	目前已發表或接受的 4 篇文章皆為 SSCI 期刊。
		研究報告/技術報告	3	3	100%		三年期計畫中每年的期中或期末報告。
		研討會論文	21	9	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	8	8	100%	人次	
		博士生	1	1	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	獲得政治大學校內的學術研究優良獎。

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	1	建立初步的「知識創新」教學設計模式。
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

   ■達成目標

   □未達成目標（請說明，以 100 字為限）

   □實驗失敗

   □因故實驗中斷

   □其他原因

   說明：

2. 研究成果在學術期刊發表或申請專利等情形：

   論文：■已發表 □未發表之文稿 □撰寫中 □無

   專利：□已獲得 □申請中 ■無

   技轉：□已技轉 □洽談中 ■無

   其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

   在知識社會中，「知識創造」逐漸受到重視。然而，教學方法應如何設計才可以有效支持以創新為中心的教學，則仍待進一步探討。本研究發現「知識翻新」理論與科技是一可行方案。本研究將知識翻新理論與科技逐漸地引入大學師資培育課程之中。研究方法主要採用個案研究法或設計本位研究法，針對三種相互關聯的教學設計(包括「以想法為中心」、「以社群為基礎」、和「以原則作導引」)進行實驗。研究中收集了兩大類資料：包括歷程與結果資料。主要資料包括：(1) 師培生在知識論壇(知識論壇係一以知識翻新理念所設計的多媒體網路平台)上的線上討論內容；(2) 教室活動；以及 (3)教室觀察。透過質化與量化並呈的混合分析（如內容分析法、對話分析和語料分析等），本研究逐步找出了一些知識翻新理論與科技可以應用在師資培育課程中的教學設計與實施策略，其結果亦對未來培育具創造力與適應性的 21 世紀優質教師有些許啟示。