

行政院國家科學委員會補助專題研究計畫 期中進度報告

**The Impact of Computer-Supported Collaborative Learning (CSCL)
on Elementary Students' Understanding of the Social Nature of
Science (1/2)**

計畫類別：個別型計畫

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計畫主持人：洪煌堯

共同主持人：

計畫參與人員：王博賢、洪明、詹雯靜、林書平

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Abstract

The purpose of this study in the first year was to explore elementary school students' views on "scientific inquiry" and "scientific collaboration." Participants were fifth-grade students from a urban elementary school located in Taipei City. Data sources mainly came from group interview, students' discourse as recorded in a Knowledge Forum (an online learning platform) database, and video-taping of classroom activities. Preliminary results based only on group interview indicate (1) that students tend to believe that scientific theories were discovered, rather than invented; and (2) that scientists' collaboration is mainly based on "division of labor", rather than based on sustained "idea improvement." The findings suggest that students' views of scientific knowledge and collaboration are naïve and immature, and that it would be helpful if science instruction can help student develop more sophisticated views on scientific knowledge and collaboration. Further data analysis will reveal that whether after being exposed to knowledge building pedagogy for a year, students' views on scientific knowledge and collaboration become more informed.

Keywords: Scientific Collaboration, Scientific Inquiry, nature of Science

摘要

本年度的主要研究目的在探究國小學生在進行電腦輔助合作學習 (CSCL) 教學前與教學後的「科學探究觀」與「科學合作觀」。教學環境主要使用「知識論壇」(Knowledge Forum) 的科技學習平台。研究對象為台北市某國小五年級的學生。資料來源主要為訪談稿。針對訪談稿前測的初步分析顯示，學生對於科學知識本質的「暫時性」與「共構性」僅有初步瞭解。其中，在科學探究的概念上多數小學生對於科學理論和定律所持的觀點則是偏向實證的發現觀(意即知識是永恆存在)，而缺少建構的發明觀。同時多數小學生認為科學家雖會合作，但卻普遍多強調傳統式以「分工」為基礎的科學合作觀，而缺乏以「創新」知識為基礎的合作觀。預計於年年底將完成所有資料分析及一篇完整文章，並投稿於期刊。

關鍵字：科學合作、科學探究、科學本質

計畫成果自評

本計畫名稱

The Impact of Computer-Supported Collaborative Learning (CSCL) on Elementary Students' Understanding of the Social Nature of Science 電腦支援合作學習(CSCL)對國小學生瞭解科學之社會本質的影響

The purpose of this study in the first year was to explore elementary school students' concept of "scientific collaboration" and "scientific inquiry." There are three main research questions that we intend to answer in the first year:

- (1) What are elementary students' views of scientific progress as a social process and how do such views developed over time?
- (2) What are elementary students' views of scientific collaboration as an idea-centered knowledge advances and how do such views developed over time?
- (3) Does an online collaborative theory-building approach help young students develop more sophisticated social views of science?

Participants recruited were fifth grade students in a local elementary school located in Taipei City. The main data sources came from (1) group interview; (2) students' discourse as recorded in a database; (3) video-taping of class activities. So far, we have collected all needed data, but have not had enough time to analyze all the data, in order to answer all the above research questions.

Preliminary results based only on group interview conducted in the beginning of this study indicate that the majority of students believe that scientists do collaborate, but the methods of how scientists collaborate were quite diversified. The majority of students believe that the key means to collaboration is "division of labor" and how scientists collaborate is usually decided by two factors: (1) personality or personal characteristics; and (2) the nature of work or projects. Moreover, students also tend to believe that scientific theories were discovered, rather than invented.

Based on our preliminary findings, a draft paper was prepared as shown in Appendix 1 (附錄一). Our immediate goal is to submit this draft paper to a local conference for presentation.

In addition, we also have a conference paper presented in the 12th (2008) Knowledge Building Summer Institute; another conference paper presented in the 8th International Conference on Computer Supported Collaborative Learning; and a SSCI paper accepted by the journal of Asia-Pacific Educational Researcher, which is expected in June. This paper is attached in Appendix 2 (附錄二).

本年度發表之論文

Chai, C. S., **Hong, H.-Y.**, Teo, T. (in press, expected in June, 2009). Singaporean and Taiwanese pre-service teachers' beliefs and their attitude towards ICT use: A comparative study. *Asia-Pacific Educational Researcher*. Expected in Jun 2009. (SSCI)

Hong, H.-Y., Chen, F. C., Chang, H. M., Liao, C. C. Y., & Chan, W. C. (2009). Exploring the effectiveness of an idea-centered design to foster a computer-supported knowledge building environment. *Proceedings of the 8th International Conference on Computer Supported Collaborative Learning (CSCL) 2009*. Rhodes, Greece.

Hong, H.-Y., & Chen, F. C. (2008). *Understanding how pre-service teachers perceive and interpret knowledge-building principles*. Paper presented at the 12th Knowledge Building Summer Institute. Toronto, Canada.

參與國際研討會

會議名稱	12 th (2008) Knowledge Building Summer Institute
會議性質	The nature of this international conference is concerned with the understanding and practices of knowledge building theory in education. Specifically in this year, the overarching question to be addressed concerns the extent to which an international team can work productively to continually extend the limits of the possible in education.
會議地點	Toronto, Canada
會議日期	97年08月05日至97年08月08日
參與者	洪煌堯
參與目的	<p>The purpose of attending this conference is twofold. One is to understand what the most current challenges and issues are being addressed in this community. The other is to build international connection with important people in this community. This second goal is especially important as this conference represents the most important yearly meeting where most scholars who are doing research in relation to “knowledge building theory and practices” will attend.</p> <p>One thing to note is that as this conference was held in August, 2008, when this NSC project just started. The paper presented in this conference was not generated from this project, but it is still deeply related to knowledge-building theory and practices in education in a broad sense.</p>
論文發表	Hong, H.-Y., & Chen, F. C. (2008). <i>Understanding how pre-service teachers perceive and interpret knowledge-building principles</i> . Paper presented at the 12th Knowledge Building Summer Institute. Toronto, Canada.

會議名稱	8 th International Conference on Computer Supported Collaborative Learning
會議性質	此會議為「學習學」(Learning Sciences)與「網路輔助學習」(Computer Supported Collaborative Learning)兩領域菁英學者匯集之社群 (ISLS, International Society of Learning Sciences) 的最重要會議, 人數約兩百人, 多為此領域最核心與專精者。

會議地點	Rhodes, Greece
會議日期	98年06月8日至98年06月13日
參與者	洪煌堯
參與目的	<p>本次參與國際會議，除了認識在CSCL網路合作學習領域中許多重要研究團隊及知名研究者外，也進一步了解了網路合作學習領域中的重要研究趨勢。本次參加會議中所學的新知，將會(1)對未來發展第二年度的研究計畫中相關分析方法的應用，與(2)發展對測量「知識共構之合作結果」，等方面有所幫助。</p>
論文發表	<p>Hong, H.-Y., Chen, F.C., Chang, H.M., Liao, C.Y., & Chan, W.C. (2009, 6). <i>Exploring the effectiveness of an idea-centered design to foster a computer-supported knowledge building environment</i>. CSCL (Computer Supported Collaborative Learning) Conference, Rhodes, Greece.</p>

附錄一：第一年度研究目標的成果

小學生對「科學合作觀」與「科學探究觀」的理解研究

王博賢*

洪明**

洪煌堯*

國立政治大學教育系*

台北市立木柵國民小學**

Email: hyhong@nccu.edu.tw

【摘要】

本研究主要目的在探究國小學生在進行電腦輔助合作學習 (CSCL) 教學前與教學後的「科學合作觀」與「科學探究觀」。教學環境主要使用「知識論壇」(Knowledge Forum) 的科技學習平台。研究對象為台北市某國小五年級的學生。資料來源主要為訪談稿。針對訪談稿前測的初步分析顯示，學生對於科學知識本質的「暫時性」與「共構性」僅有初步瞭解。其中，在科學探究的概念上多數小學生對於科學理論和定律所持的觀點則是偏向實證的發現觀(意即知識是永恆存在)，而缺少建構的發明觀。同時多數小學生認為科學家雖會合作，但卻普遍多強調傳統式以「分工」為基礎的科學合作觀，而缺乏以「創新」知識為基礎的合作觀。

關鍵詞：科學合作、科學探究、科學本質、小學生。

壹、前言

一、動機

資訊和傳播科技的突飛猛進已使我們所處的社會從資訊社會邁進了知識社會 (Drucker, 1986; UNESCO, 2005)，同時也讓「學習是個人的知識成長」這樣的傳統觀念，逐漸轉變成「學習是集體的知識合作」。(Scardamalia, 2002; Hong & Scardamalia, & Zhang, 2007)。因應此一轉變，教學科技研究領域也開始注重到設計有效電腦支援合作學習 (Computer-Supported Collaborative Learning, CSCL) 環境的重要。CSCL 的概念主要強調利用數位平台以促進合作與共享，希望透過小組活動以促使參與者對知識的基本單位——「意義」(meaning) 間的分享與互動能有更深的了解。CSCL 的獨特設計即在於能促成觀念或想法間的互動 (Stahl, 2007)。

在這樣的趨勢影響下，台灣小學的自然科學教室也開始營造成偏重合作學習的科學教室環境 (楊榮祥、Fraser, 1998)。例如，我們可以發現學生坐位的安排從五六零年代的劇場式座位，到八零年代開始出現部分課程的小組式排列，而到今天科學教室的座位排列更是強調要以便利科學合作來進行課程。然而，在這樣的學習環境下，學生對於科學「合作」與「探究」的觀點是否也會受到影響呢？科學知識的產生是一個集體社會建構的過程，然而，過去研究卻指出多數學生並不瞭解科學本身是這樣的一個社會事業體，以及科學家之間的協同合作對科學知識創造的重要性。正如同 Driver 等人 (1996) 的研究指出，多數學生對「科學之社會本質」(Social nature of science) 的瞭解仍停留在科學家都是在封閉的研究環境中獨自進行其科學探究的觀點上。同時，我們知道，在「科學本質」(Nature of science) 中「科學知識」是經久的，但仍有暫時性的特性，(McComas、Clough and Almazroa, 1998)，因此，才能在科學社群中不斷翻新，創造新的理論以解釋更多的現象。現在的小學生對於課本中的科學知識，在九年一貫課程實施強調「科學本

質」教育後（教育部，民 90），是否仍對課本中的科學知識深信不疑，而忽略其暫時性的特性，而阻礙學生對於科學合作與探究概念的理解。

從工業革命後泰勒化的分工強調個人精熟一部份的工作，以達最高的效率、最大的產出，到合作學習中給予學生分派工作，各自精熟各自部分後在小組內合作（黃正傑、林佩璇，1996），這些以任務與產出為中心的合作觀念深植人心。然而，合作的觀念也在轉化，Karl Popper (1972)的知識論中提出的「第三世界」知識觀中，就是一個視「概念」(Conceptual objects) 為知識主體的世界，在這樣的知識論中，合作主要是以想法或概念為中心，透過人們（特別是科學家）不斷增加對概念的瞭解，與不同概念進行互動的一種合作方式。本研究的主要目的即是要了解 (1)小學五年級學生對科學「合作」此一概念的想法為何，以及(2)小學五年級對「科學探究」此一概念的想法。

貳、研究方法

本研究為一初探性研究。資料來源主要為晤談學生的錄影帶。以瞭解受訪者的概念。研究對象主要為台北市某國小五年級學生 (N=77)。分別來自三個班級。每班各分為六組，三班總共十八小組，每組三到五人，然後進行小組訪談。訪談內容主要包含 12 個問題，分為四個面向：(1)「學生對知識產生的觀點」、(2)「學生對資訊共享和科學交流、互動的觀點」、(3)「學生對科學合作的觀點」與(4)「學生對科學社群的觀念」。訪談者首先針對各個問題對學生進行說明，然後請學生自由回答，並同時錄下全部訪談的內容。時間每小組約為 15-20 分鐘。資料經轉錄成文字後，研究者再針對受試者的回答進行內容分析，以學生回答中的主要概念 (key concept) 作為分析單位。分析過程所形成的主要概念編碼共有 171 個。之後，研究者再進一步歸納與分類這些概念。

參、結果與分析

研究者分析訪談資料後所得結果主要與以下四項概念有關。一是小學生對於科學本質「暫時觀」的瞭解；二是小學生對科學探究的概念；三是小學生對有關科學家是否會合作的概念；四是小學生對科學家如何合作的概念。茲分述如下：

1. 小學生對科學本質「暫時觀」的瞭解。而小學生對於知識本質所持的觀點，是權威觀（即知識是存在的真理，不會改變）、還是暫時觀（及知識可以隨著時空藉著互動而翻新）。如表 2 的分析結果指出，在知識的本質方面，小學生對「知識本質」的看法，顯示偏向「暫時觀」(24) 認為知識可以隨著時空變換藉著互動產生翻新，例如：訪談者：「……好，那下一題你們覺得課本裡面的知識一定都是正確的嗎？那他會不會改變？為什麼？有沒有人先要回答的？不然我們先這樣輪回來，換你先！都是對的嗎？還是有可能他會錯啊？」503-4：「有可能錯！」訪談者：「那為什麼錯？」503-4：「因為他可能在實驗或者是在想的時候，配合一些環境或者是不同阿，就可能做出來的東西可能就不同！」另一例，507-4：訪談者：「就這樣子來的，也不知道為什麼？對不對？那老師再問一題喔！就是阿你們覺得課本裡面的知識都是正確的嗎？那他會不會改變？為什麼？」507-4：「會！因為有很多覺得他是不對的話就會去研究。然後就弄出東西來。」訪談者：「所以有可能我們現在覺得對的東西，以後會覺得是錯的。」

而非固定不變的權威觀真理 (5) 例如：訪談者：「去查！去查出來的是不是？沒關係隨便講，老師剛剛講了沒有標準答案。好不好，沒有標準答案，所以大家都可以有想法啊！好不好，那課本的知識你們是不是都覺得寫得很正確啊？」501-1：「不一定」訪談者：「不一定喔？」501-1：「有些是老師講得比較正確，有些是書講得比較正確。」訪談者：「那你呢？」501-1：「我跟他一樣。」訪談者：「那你呢？」501-1：「既然要寫成一本書，就一定是正確的，不然要怎麼寫？」

表 2 小學生對科學本質「暫時觀」的瞭解

	編碼類別	發生頻率
知識本質	知識暫時觀	24
	知識權威觀	5

2. 小學生對科學家探究的概念. 而小學生對於科學理論和定律所持的觀點，是發現(即知識永恆存在，因此科學理論和定律是被發現的)、還是發明(即知識是演化的呢？如表 3 的分析結果指出，在科學理論方面，小學生對「科學探究」的看法，顯示偏向於「發現觀」(44)，認為理論即永恆存在的知識，因此科學理論和定律是被發現的，例如：訪談者：「通常是會變好，但是也可能會破壞東西這樣子。那你可不可以描述一下科學家阿，他怎麼樣發明或發現新知識阿？比如說像你們課本學得啊！來！」507-1：「他可能這樣看生活中的東西，然後我們試著研究來的。」老師：「好，那怎麼研究呢？」507-1：「他可能看那東西很有興趣，所以就帶回家觀察！」；訪談者：「……那我們先問下一題喔，就是有時候阿，就是我們古早以前阿，那些知識阿，那你們覺得那些知識後來是怎麼發現的？比如說像以前一定沒有眼鏡嘛！那為什麼後來會變成有眼鏡呢？或者是為什麼以前沒有電腦，那現在為什麼會有電腦？你們覺得是怎麼轉變的？好，你說反正你想到甚麼就說甚麼？」……501-5：「就是可能是因為他看到了一樣東西，他覺得很好奇想去研究，然後無一間研究得這個東西，對我們人類有極大的幫助，之後它們就慢慢的就開始研究更多的那種，比如說眼鏡和電腦，就慢慢的一步一步的去發掘，然後來帶給我們一種生活上的便利。」；訪談者：「……就是阿我們不是有發自然課本嗎？然後裡面的科學知識阿，你們覺得是從哪裡來的？舉例來說比如說是科學家自己發明的啊？還是說有誰發現的啊？還是它們做了甚麼研究，就是這些知識是從哪裡來的？好你先說！」503-4：「就是人們就是做了一件東西，像是晷一樣。究是以前人早期人就是發現把竿子插在泥土，就是可以計算時間！」訪談者：「所以說是有人發明的？」503-4：「沒有！是發現！」訪談者：「發現的！好，那有沒有誰你講看看，你覺得這些知識都是從哪裡來？」而非發明的(14)。

表 3 科學探究觀

	編碼類別	發生頻率
科學探究	發現觀	44
	發明觀	14

3. 小學生對有關科學家是否會合作的概念. 小學生對於科學家是否會合作，如表一所示，多數學生認為科學家是有合作的(N=44; N 是此概念被提及的頻率)例如：507-2：訪談者：「可以用別人的知識去用到自己的地方。好，那科學家喜歡在自己的研究室研究問題？還是她們喜歡跟別人一起合作研究？」學生：「應該是跟別人一起研究！」學生：「大概是可能兩三個科學家一起」；而認為科學家不會合作的只有少數(N=5)。例如：訪談者：「那科學家要不要合作？還是自己做實驗？」507-6：「有時候需要合作有時候不一定。」

4. 小學生對科學家如何合作的概念. 然而，進一步分析得知，小學生對科學家為何合作的原因想法則分歧很大。基本上可分為二大類：一是會因科學家本身的個性或特性而決定如何合作(N=11)例如：訪談者：「那科學家，會不會和其他科學家有一些互動，還是他們會比較喜歡自己做研究，為什麼？」507-5：「有些科學家會屬於比較自己做研究，因為他可能別人干擾到他，可是有些科學家為了要增加新的知識，或是新的發明，就會喜歡跟別的科學家探索一些事情」；二則是會以合作項目的不同而決定是否要合作(33)例如：訪談者：「你覺得阿科學家阿是不是比較喜歡自己做研究？」507-1：「他那個比

較簡單的會自己做，然後有一些困難的話會找一些人來幫忙做！」。這在此一分項上，小學生對於合作的觀念又可分為是以分工為基礎的合作（意即以工作或任務為中心，透過結構化的分配職責以完成任務。例如：工業化的要求追求最大的產出）；或是以創新為基礎的合作觀（例如以想法為中心，因此這種合作可以不限時間、地點，有機的進行）。

而如表 5 所示，分析結果顯示小學生對合作的觀念多停留在分工式的合作觀

(N=25)，例如：訪談者：「就是說科學家他們如果有分工的話，你覺得它們要怎麼分工？」503-3：「如說是挖恐龍的化石的科學家，假如他要分工合作的話，就是一個人挖化石，好幾個人來塗石膏之類的，然後幾個人叫直升機，幾個人把他搬上去。」501-5：「那他們研究的時候是研究同一類，可是他們研究同一類某些細節哪些比較懂的就分給那個人去做，這樣子才比較會才會發現更多。」

只有少部分學生有提到以創新為基礎的合作觀 (N=5)，例如：訪談者：「所有問題都很簡單。自然課本裡面的知識是從哪裡來的？」503-2：「生活上！」訪談者：「生活上！」503-2：「是其他人研究過，然後在然後在科學一步一步的進步，然後把那些東西」訪談者：「寫在課本上？」503-2：「對！就打課本裡面！」

表 5 科學家合作與否與合作觀

	編碼類別	發生頻率
科學家會合作	因項目特性不同而合作	11
	因科學家特性不同而合作	33
科學家不會合作	不一定要合作	5
合作觀	idea center 的合作觀	5
	分工合作的合作觀	25

肆、討論與建議

合作的能力在現代的社會中愈發重要，特別是在這個網路普及的資訊社會時代 (Crook,1998)。作為一個先探性研究，本研究的初步結果顯示學生對於科學家是否需要合作普遍抱持同意的態度。然而，學生對於科學家如何合作的相關概念仍偏向傳統以「分工合作」為基礎的觀點。甚少有學生對於科學家如何進行「科學合作」的創造本質有較深的瞭解。

未來學校自然科教學將如何幫助學生發展更以「探究」、「建構」與「創作」為中心的合作觀呢？根據 Carey 與 Smith(1993)多年來對科學本質的研究，他們認為提昇學生科學本質瞭解的最有效方法應是讓學生直接從事集體「理論建構」(theory-building)。而研究顯示，目前發展較成熟的「理論建構」教學法應該是「知識翻新教學」(knowledge building) (Scardamalia & Bereiter, 2006)。「知識翻新教學」係一利用「知識論壇」(Knowledge Forum)——一個以電腦支援合作學習(Computer-Supported Collaborative Learning)的學習平台——的創新教學。此一學育理論強調鼓勵學生透過集體反思方式以對科學問題提出一些可能解決的想法(如科學假設或理論)並藉由協同合作以不斷驗證並改進這些想法，以促進個人知識增長以及整體學習社群(learning community)在科學理論上的不斷革進的過程。進一步研究將針對此一「知識創新教學」進行實驗，探討其是否可以幫助學生達到一個更成熟的科學「探究」與「合作」觀。

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附錄二：第一年度其他研究成果

Chai, C. S., **Hong, H.-Y.**, Teo, T. (in press, expected in June, 2009). Singaporean and Taiwanese pre-service teachers' beliefs and their attitude towards ICT use: A comparative study. *Asia-Pacific Educational Researcher*. Expected in Jun 2009. (SSCI)

Singaporean and Taiwanese pre-service teachers' beliefs and their attitude towards ICT use: A comparative study

Ching Sing Chai^a, Huang-Yao Hong^b, Timothy Teo^{c*}

^{a,c}National Institute of Education, Nanyang Technological University, Singapore

^bDepartment of Education, National Chengchi University, Taiwan

Abstract: Teachers' epistemological and pedagogical beliefs and their attitude towards ICT use are identified as the second-order barrier for the integration of ICT in the classrooms. In this paper, we report the findings obtained from a recent survey and conducted among Singaporean and Taiwanese pre-service teachers (N=108). The results indicate that pre-service teachers' epistemological beliefs were generally relativistic. They were inclined to believe in the constructivist notion of teaching. The results also suggested that pre-service teachers from Singapore and Taiwan hold beliefs that are congruent to the educational reform effort from their respective countries. However, the pre-service teachers' attitude towards ICT use does not seem to be associated with their epistemological and pedagogical beliefs. The findings suggest that further efforts are required to foster more productive use of ICT to support constructivist teaching.

Keywords: Epistemological beliefs, pedagogical beliefs, attitudes toward ICT use

Introduction

In recent years, the formation of the knowledge-based economy has prompted numerous educational reforms in many countries. These countries recognize the fact that, in order to stay ahead and remain competitive, they need to shift the emphasis in education towards cultivating knowledge workers and promoting more knowledge innovation oriented pedagogy (Hong, Scardamalia, Messina, & Teo, 2008; Hong & Sullivan, accepted). To this end, using information and communication technologies (ICT) to support constructivist-oriented pedagogies are generally reported to be an important strategy (Jimoyiannis, & Komis, 2007). Many educational technologists have argued that ICT has substantial potentials in facilitating the shift of traditional pedagogical practices to constructivist-oriented learner-centered teaching practice. For example, Jonassen, Howland, Marra and Crismond (2008) explain how ICT can support active and collaborative learning among students by providing students with access to information resources through the Internet and the knowledge construction medium such as hypermedia authoring tools and concept mapping tools. They also argue that learners can form intellectual partnership with ICT and exploit the affordances of the computers to perform higher order cognitive tasks such as hypothesizing and meaning making. Scardamalia and Bereiter (2006), on the other hand, report how the use of computer-supported collaborative learning environment such as the Knowledge Forum encourages students to

work creatively and constructively with their ideas as a knowledge-building community. Both Janoassen et al. (2008) and Scardamalia and Bereiter (2006) have documented how some constructivist-oriented use of ICT promote higher-order learning among students.

While the general provision of ICT resources are improving in most countries, changes in teaching practices are less forthcoming. Recent research indicates that teachers' use of ICT is largely confined to productivity tasks such as preparing lessons with word processors (Lawless & Pellegrino, 2007; Paraskeva, Bouta, & Papagianni, 2008). From the literature, many factors have been found to inhibit teachers from utilizing ICT to engage students for meaningful learning. These include the lack of ICT leadership (Ng, 2008); traditional assessment practices (Fox & Henri, 2005); teachers' characteristics such as self-efficacy (Paraskeva et al., 2008) and low perceived control over the computers (Teo, 2008); and environmental conditions such as the lack of facilitating conditions (Teo, in press). Hu and colleagues (2004) survey of more than 3000 beginning Singaporean teachers revealed that while teachers were already using ICT for routine work, they did not engage learners to co-construct knowledge constructively with ICT. Ertmer (2005) reported a similar phenomenon in America and attributed this to teachers' epistemological and pedagogical beliefs as a deeply rooted barrier. For example, a teacher who views knowledge as facts and knowing as a process of facts acquisition is less likely to engage students in constructing personal representations of understanding using ICT. On the other hand, a teacher who views knowledge as evolving conceptions and knowing as a process of meaning construction is likely to see the processes of constructing mental representations about a phenomenon by a group of students as a meaningful learning activity. Many computer programs can be utilized as knowledge construction platforms. Becker's (2000) study indicates that teachers who encourage student to use computers to investigate and research about phenomenon are also more oriented towards constructivist beliefs. Researchers in Asia have started to investigate how teachers' views affect educational reforms that are directed towards the constructivist teaching (Leung, 2008; Lim & Chai, 2008).

The aim of this study is to examine pre-service teachers' epistemological beliefs and pedagogical beliefs, and how these beliefs are related to their attitude towards ICT use. We also aim to establish a baseline description of the pre-service teachers' beliefs. This study has the potential to inform teacher professional development in Singapore and Taiwan. Such cultural comparison could balance the view that all Eastern cultures are similar (Nisbett, 2003; Tweed & Lehman, 2002). While Singaporean and Taiwanese cultures may generally be attributed to the same origin, there are subtle differences that influence teachers' beliefs. For example, the education system in Singapore is an extension of the British education system while the system in Taiwan is modeled after the American system. In terms of their ties towards traditional culture, Singapore may not be as strong compared to Taiwan as the former is a multiethnic society with English as the working language for education and commerce. Politically, while both Singapore and Taiwan are democratic societies, the latter has a more active political environment. These differences should be adequate to warrant a comparative study to be conducted.

Literature Review

In this study, we examine teachers' epistemological beliefs and pedagogical beliefs in relation to their attitude towards the ICT use. We define epistemological beliefs to be one's views about knowledge and about knowing. Other constructs such as belief about learning effort and innate ability, which are usually reported as part of epistemological studies, are not treated as core epistemological beliefs (Hofer & Pintrich, 1997). They are not included in this study. We define pedagogical beliefs as one's views about teaching, which are broadly classify as constructivist oriented or transmissive oriented (Chan & Elliot, 2004; Teo & Chai, 2008) These constructs are reviewed sequentially in the following paragraphs with an emphasis on

studies involving pre-service teachers.

Research on beliefs about knowledge and about knowing or personal epistemology by educational researchers began in the late 60s. Perry (1970) was among the first researchers who had established a pattern of epistemological development among college students. Generally, college students progressed from a naïve epistemological belief that views knowledge as certain and is passed down from authority, to a more sophisticated and relativistic stance that emphasized knowledge as uncertain and constructed by individuals based on warrants. This general pattern of development was also observed by later researchers who also relied on interview as the method for data collection (Hofer & Pintrich, 1997). Building on these earlier works, Sutton, Cafarelli, Lund, Schurdell, and Bichsel (1996) reported the epistemological development of 32 student teachers near the end of their teacher education. More than half of them were assessed to be at the higher end of epistemological development. White (2000) and Brownlee's (2001) study on student teachers further strengthened Sutton et al.'s (1996) findings. In summary, these studies indicate that student teachers' epistemological beliefs are distributed across the developmental stages with more of them holding relativistic beliefs. These studies also found very few pre-service teachers had held absolutists/dualistic epistemological beliefs.

Schommer (1990) proposed a model of five more or less independent dimensions of epistemological beliefs. The dimensions include the structure, certainty, source of knowledge, and the control and speed of knowledge acquisition, with the last two dimensions pertaining to learning. Hofer and Pintrich (1997) contested that the last two beliefs should not be included in the study of epistemological beliefs as philosophically, the latter are not core matter of epistemology. However, it is not uncommon to see control and speed of knowledge acquisition being included in the literature as beliefs about learning. To measure the five dimensions of beliefs, Schommer (1990) developed the Epistemological Beliefs Questionnaire (EBQ) and it has enabled many researchers to study the relationships among epistemological beliefs and their related constructs. On the issue of students' learning, myriad of studies have documented that epistemological beliefs are associated with learning strategies, academic achievements, interpretation of text and conceptual change (for example, see Braten & Stromoso, 2005; Chan, 2007; Manson & Boscolo, 2004). In general, sophisticated epistemological beliefs are positively associated with learning and higher order thinking. However, studies that explored the relationships between teachers' epistemological beliefs, pedagogical beliefs and teaching practice are generally lacking (Chan & Elliot, 2004), especially in the Asian context (Chan, 2007). Obviously, this area warrants further research since epistemological beliefs are closely linked to teaching and learning.

The relationship between teachers' epistemological beliefs and their beliefs about teaching and learning is complex. First, beliefs about what teaching and learning can be broadly classified under the knowledge transmission category or the knowledge construction category (Entwistle, Skinner, Entwistle, & Orr, 2000; Samuelowicz & Bain, 2001). The former is characterized as teacher-centered, content-oriented didactic teaching practice that emphasizes on passive reception of knowledge by students. As for the later, it is usually characterized as student-centered, learning-oriented constructivist teaching that encourages students to actively make sense of their experiences situated within the social cultural contexts. Second, teachers with more sophisticated epistemological beliefs seem to be more engaged than their peers, with regards to personal learning. For example, Ravindran, Greene and Debacker (2005) reported that pre-service teachers' epistemological beliefs and their goals of learning were related to their level of cognitive engagement during teacher preparation. Third, the relationship between pre-service teachers' epistemological beliefs and their pedagogical beliefs seems to be incongruent at times. A review of studies focusing on pre-service teachers' beliefs indicates that they are likely to perceive teaching as an unproblematic process of knowledge transmission (Richardson, 2003). The predominance of

teacher-centered didactic views of teaching among pre-service teachers seems to contradict the above-mentioned studies that suggest pre-service teachers tend to hold relativistic epistemological outlooks. For example, Chan and Elliot (2004) surveyed 385 Hong Kong pre-service teachers and reported that most of the teachers were relativistic in their epistemological outlooks. However, they were not inclined towards constructivist teaching. Chan and Elliot's (2004) research indicate that beliefs towards authority as source of knowledge and the view of knowledge as certain are both significantly and positively correlated to traditional teaching. The belief towards authority is also significantly correlated to the conception of constructivist learning. This seems to point to a possibility that the pre-service teachers may hold inconsistent views about epistemological beliefs and their pedagogical beliefs. Sinatra and Kardesh's (2004) study of American student teachers, however, indicates that teachers who see knowledge as evolving and learning as a process of constructing understanding are also more receptive towards the idea of teaching as facilitating knowledge and beliefs revision among students. Given that studies in different contexts may indicate different relationship between epistemological beliefs and beliefs about teaching and learning, it seems clear that more cross-cultural studies are required (Hofer, 2008).

Research that studied the relationships between teachers' epistemological beliefs and their perception of ICT use generally suggests that teachers who hold constructivist belief are more likely to engage their students to use computers and the Internet (Becker & Ravitz, 1999). However, epistemological belief is just one factor among many others that influence teachers' attitude towards ICT use. Wozney, Venkatesh, and Abrami (2006) employed the expectancy-value theory to study relationship between teachers' use of ICT and their perceived value of ICT. The results indicate a positive relationship between the two constructs. Zhao, Pugh, Sheldon, and Byers (2002) investigated the complexities involved in integrating ICT into classrooms. Their analyses indicate that a successful integration of ICT depends on the interrelationships among the school contexts, the key drivers (teachers) of the integration project, and the information technology involved. Specifically, when the technology chosen for implementation is compatible with the teachers' pedagogical beliefs, there is a higher chance for integration to occur. Fox and Henri (2005) investigation of Hong Kong teachers' perspective on the use of ICT reveals that a perception towards the goal of education as producing good examination results will inhibit teachers' use of ICT. In addition, Teo, Chai, Hung, and Lee (2008) found that teachers' beliefs in teaching and learning played a significant role in teachers' ICT usage, whether it was used in a traditional or constructivist way.

The above literature review has mapped out the complex relationships among teachers' epistemological beliefs, pedagogical beliefs, and their perception of ICT use. The study attempts to investigate the beliefs of pre-service teachers from two cultures. The research questions are as follow:

1. What is the profile of the pre-service teachers from Singapore and Taiwan in terms of their epistemological beliefs and pedagogical beliefs?
2. Are there significant differences between Singaporean and Taiwanese pre-service teachers in terms of their epistemological and pedagogical beliefs?
3. To what extent are pre-service teachers' epistemological and pedagogical beliefs related to their attitude towards ICT use?

As discussed above, more comparative studies are required in order to better understand the different relationships between epistemological beliefs and beliefs about teaching and learning across different cultural context (Hofer, 2008). The present study represents such research initiative, and we selected Singapore and Taiwan due to their similar reform emphasis on constructivist education and their cultural and contextual difference gradually developed in history.

Methods

Participants and data collection

The participants for this study were pre-service teachers who volunteered for this study. They were selected from the teacher preparation classes that were taught by the authors.

Participants completed a questionnaire containing items that were adapted from various sources (Table 2). The Singapore sample completed the questionnaire in English as shown in Table 2 while those from Taiwan responded to a translated version of the questionnaire in Chinese. The translation was done by a Chinese language expert from Taiwan and to ensure the validity of the Chinese version of the questionnaire, it underwent reversed translation (from Chinese to English) in Singapore by an academic with a high level of proficiency in both the English and Chinese languages. Each participant spent approximately 15 minutes to complete the questionnaire. No course credits or any form of reward was offered to participants in this study. Table 1 shows the profile of the participants in this study.

--- Insert Table 1 here ---

Measures

The questionnaire contained three parts. The first part of the questionnaire solicits demographic data such as age, gender, and qualification. The second part of the questionnaire was an abridged version of the instrument that was used in Chan and Elliott (2004). This modified version covers four dimensions: (1) Certainty of Knowledge (CK) and (2) the Authority/Expert knowledge (AEK) as the two dimensions of epistemological beliefs (and sophisticated epistemological beliefs means less inclined to believe in both dimensions); (3) Traditional Teaching (TT) and (4) Constructivist Teaching (CT) as the two dimensions of pedagogical beliefs. The third part of the survey measure teachers' attitude towards computer use (ATCU). These items were adopted from a recent survey by Teo, Lee and Chai (2008). All items employed a 5-point Likert scale (5 = strongly agree, 1 = strongly disagree). A high score indicates a favorable response towards the measured construct. Table 2 shows the beliefs and constructs that were measured in this study.

--- Insert Table 2 here ---

Results

The mean and standard deviation for each construct are shown in table 3. Both the means for CK and AEK are below the mid-point of 3.0 in the scale. In terms of the standard deviation, there is a narrow spread (< 1.0). The overall reliability of all constructs is satisfactory as compared to those reported in recent literature (Chai, Khine, & Teo, 2006; Chan & Elliot, 2004; Ravindran et al., 2005). For the t-test, the Levene's test of equality of variances suggests that equal variance can be assumed.

--- Insert Table 3 here ---

To understand the relationship between the two belief constructs, a correlation test was performed. First, "expert knowledge" and "certainty of knowledge" are found to be significantly correlated ($r=.031$, $p<.01$). Second, it was found that participants' constructivist teaching beliefs was not significantly correlated with their traditional teaching beliefs ($r=.03$, $p>.05$). Further, to understand the relationships between the attitude towards computer use

(ATCU) construct and the measured belief constructs, we ran another inter-construct correlation test. The results are shown in table 4. A correlation matrix revealed no significant correlations between ATCU and other belief constructs for all participants. But when looking into each specific country, it was found that there are two significant correlations (both at the .016 level). There was a significant negative correlation between ATCU and Authority/Expert Knowledge (AEK) for the Singaporean sample ($r=-.31$, $p=.016$). In addition, there was another significant positive correlation between ATCU and Traditional Teaching (TT) for the Taiwanese sample ($r=.34$, $p=.016$). In contrast, no significant correlation was found for both the Singaporean and Taiwanese samples between ATCU and Certainty of Knowledge (CK), and between ATCU and Constructive Teaching (CT).

--- Insert Table 4 here ---

Discussion

The results of this study indicate that both Singaporean and Taiwanese pre-service teachers do not believe strongly in authorities and experts as sources of knowledge. They are also not inclined towards seeing knowledge as certain and unchanging. In other words, the epistemological beliefs that these teachers hold are generally consistent with what is reported in literature that we have reviewed earlier. For example, surveys of Hong Kong and Singapore pre-service teachers' epistemological beliefs using similar items from Chan and Elliot (2004) had documented comparable epistemological profile (see also Chai & Khine, 2008). In these studies, 85 of the surveyed teachers had obtained their first degree and the remaining 23 undergraduates were in their fourth years. Their epistemological profiles were consistent with most literature for students near graduation from college (Perry, 1970; Chai & Khine, 2008). These teachers have the basic epistemological outlooks that are consistent with constructivist teaching. These profiles should also support the efforts of reform geared towards constructivist teaching.

In terms of the differences of their epistemological beliefs, the Taiwanese and the Singaporean teachers' profile seems to be similar. There is no statistical difference in the dimensions measured. Both Singapore and Taiwan pre-service teachers are strongly inclined towards constructivist teaching and less inclined towards traditional teaching. This should be a logical stance given their relativistic epistemological profile. However, this may not always be the case as Chan and Elliot's (2004) study had testified. The authors surveyed 385 Hong Kong pre-service teachers and reported that most of the teachers were relativistic in their epistemological outlooks, but they were not inclined towards constructivist teaching. Based on the reported mean score, it seemed that the Hong Kong pre-service teachers are neither inclined towards constructivist ($M=1.86$) nor traditional teaching ($M=2.63$). It seems that the Singaporean and Taiwanese pre-service teachers are holding more compatible epistemological and pedagogical beliefs.

Statistical differences were detected between the Taiwanese and Singaporean teachers' pedagogical beliefs. While the Taiwanese teachers had expressed a stronger inclination towards constructivist teaching, they also expressed an inclination towards traditional teaching. Usually, constructivist teaching and transmissive teaching are treated as forming the two opposing ends of a continuum as reported by western literature (Entwistle, Skinner, Entwistle, & Orr, 2000; Samuelowicz & Bain, 2001). However, this is not the case for the Taiwanese pre-service teachers. Further analysis of correlation was conducted for the Taiwanese teachers and it shows that the two conceptions of teaching were not correlated ($-.083$). Paradoxically, Taiwan as a society is generally more open than Singapore but it is also more traditional. Historically, Taiwan has deeper ties with Confucianism than Singapore. If we assume mother tongue languages as the main media for the transmission of cultural value, this may be due to the differences in the language policies between the two countries.

In Singapore, secondary school students study 5-6 periods of Chinese language per week. All the rest of the lessons are taught in English. In Taiwan, the situation reverses. English is just one of the subjects and all other subjects are taught in Chinese. In addition, the reform effort in Taiwan education has also been more thorough for the past decades, resulting in a general de-emphasis of academic results since most Taiwanese high school graduates are likely to gain entrance to a university if they desire. Academic results still matters a lot for gaining university entrance in Singapore, which is restricted to about 30% of each cohort of high school graduates. This may also explain the differences in the pre-service teachers' pedagogical beliefs from the two countries. In terms of their attitude towards computer use, both Singaporean and Taiwanese pre-service teachers expressed moderately positive attitude. In addition, the results for the Singaporean teachers are comparable to a recent research by Teo, Lee and Chai (2008).

As expressed in our research question, a major interest in the present study is to look at ways in which pre-service teachers' epistemological and pedagogical beliefs are related to their attitude towards ICT use. As baseline information, the two major dimensions "expert knowledge" and "certainty of knowledge" in epistemological beliefs are found to be correlated ($r=.31$, $p<.01$), suggesting that the de-emphasis on expert knowledge (for the most part) goes hand-in-hand with relativism. Further results showed that there is a significant negative correlation between ATCU and Authority/Expert Knowledge (AEK) for the Singaporean sample ($r=-.31$, $p=.016$). In contrast, it was found that there was a significant correlation between ATCU and Traditional Teaching (TT) for the Taiwanese sample ($r=.34$, $p=.016$). This seems to suggest that additional effort to help Taiwanese teachers avoid using ICT to support more traditional teaching may be necessary. Although the cultural context in both countries is generally considered as similar, there still exists some subtle cultural difference in beliefs that influences how teachers use ICT to support teaching. On the other hand, in terms of relationships between ATCU and Constructive Teaching (CT), no significant correlation was found for both the Singaporean and Taiwanese samples. It is possible that despite showing support for constructivist teaching, the pre-service teachers from both countries were not yet ready to adopt ICT into actual constructivist teaching practice. Arguably, there may be a misalignment between the teachers' teaching beliefs and actual practice, indicative of the tension between what should be done and what is being done. This may have to do with cultural or contextual factors. For example, high-stake testing culture (see Hong & Chen, 2008; Lim & Chai, 2008) can force teachers with constructivist belief to compromise with less constructivism oriented teaching in order to help students pass tests. As mentioned in the literature review, how epistemological beliefs and pedagogical beliefs are related to the teachers' attitude towards computer use is not a well-researched area; therefore, these results need to be verified with further studies. In future studies, items measuring the teachers' attitude towards computer should be replaced with items measuring teacher's attitude on the use of computer in education in general and in constructivist education in particular. We note the unbalanced distribution in the Taiwan and Singapore samples and in terms of undergraduate and postgraduate qualifications. We plan to address these issues in further studies. We also suggest that future research should employ multiple regression to investigate the relationships of the constructs with larger sample size.

Conclusion

The extent of technology integration in classroom is influenced by, among other factors, teachers' epistemological and pedagogical beliefs and their attitude toward computers. Our survey seems to indicate that the pre-service teachers both from Singapore and Taiwan were at least reportedly expressing beliefs that may be congruent for reform initiatives targeted towards constructivist teaching. However, reports from field studies conducted in Singapore classrooms are pointing out that the use of ICT has not really transformed traditional

classroom practices (Hu et al., 2004). While some researchers suggest that one of the remaining barrier is teachers' beliefs, this research suggest that it may not be the case. For example, culture may play an important mediating factor that influences how teachers relate their beliefs to ICT use. Further studies that investigate relationships between practicing teachers' beliefs and their teaching practices, and their use of ICT in schools are needed for educators to better understand the dynamics at play.

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Table 1: Background information of the participants

Country	Age		Qualification		Gender	
	Mean	SD	Undergraduate	Postgraduate	Male	Female
Singapore (N=59)	26.8	2.99	0	59	28	31
Taiwan (N=49)	24.0	2.47	23	26	24	25
Overall (N=108)	25.5	3.08	23	85	52	56

Table 2: Dimensions and sample items

Belief	Construct	Number of items	Sample Item
Epistemological	Authority/ Expert Knowledge	6	a. Even advice from experts should often be questioned. b. I often wonder how much experts really know.
	Certainty of Knowledge	4	If scientists work hard enough, they can find the truth to almost anything
Pedagogical	Traditional teaching	6	a. The major role of a teacher is to transmit knowledge to students. b. Learning occurs primarily through drill and practice.
	Constructivist teaching	8	a. The ideas of students are important and should be carefully considered. b. Good teachers always make their students feel important.
Attitude towards computers use	Attitude towards computer use	4	a. I like using the computer. b. Working with the computer is fun.

Table 3: Mean, SD and t-test values for the measured constructs

Construct	Alpha	Country	N	Mean	SD	t-test
CK	.68	SG	59	2.36	.77	-.356
		TW	49	2.51	.71	
AEK	.67	SG	59	2.70	.60	-1.501
		TW	49	2.75	.48	
CT	.78	SG	59	4.15	.48	3.913*
		TW	49	4.50	.38	
TT	.90	SG	59	2.55	.55	6.473*
		TW	49	3.26	.58	
ATCU	.77	SG	59	3.54	.70	-.721
		TW	49	3.64	.73	

Notes: * p < .001

Table 4. Correlations between pre-service teachers' attitude towards computer use and their epistemological and pedagogical beliefs

Correlations	Epistemological Beliefs		Pedagogical Beliefs	
	Authority/ Expert	Certainty of	Constructivist teaching	Traditional teaching

	Knowledge	Knowledge		
towards computer use				
cts together	-0.071	0.023	0.096	0.064
cts only	-.313*	-0.101	0.2	-0.065
acts only	0.15	0.163	0.021	.343*

* p<.05