Design-based knowledge building practices in mathematics teaching

Huang-Yao Hong & Yu-Han Chang
National Chengchi University, Taiwan
Email: Hyhong@nccu.edu.tw, 97152010@nccu.edu.tw

Abstract: This study investigates the impact of engaging teacher-education students in sustained design and knowledge building practices in mathematics teaching on their views of mathematics and mathematics teaching. Participants were nine teacher-education students who took a university course titled "Middle School Mathematics Teaching." Data primarily came from student discourse recorded in a Knowledge Forum database, peer evaluation and video analysis on student teaching practices, and an open-ended mathematics belief survey. Preliminary results suggest that teacher-education students became progressively more adaptive in their teaching practice. More importantly, their views of mathematics became more constructivist-oriented, and in the meantime, their views of mathematics teaching also became more student-centered.

Introduction

The purpose of this study is to introduce knowledge building practices into a teacher-education course and to investigate if such practices have any impacts on teacher-education students' views of mathematics and mathematics teaching. According to Paul Ernest (1991), there are two general epistemological stances in terms of views of mathematics, one often referred to as foundationalists and absolutists, the other fallibilists, humanists, relativists and constructivists (see also Handal, 2003). The fundamental argument of the former is that mathematics knowledge is certain, cumulative and unaffected by social interests or personal value. On the other hand, the latter is inclined to believe that mathematics knowledge is through historical, social and cultural, and that there are limitations to its claims of certainty and absoluteness (Ernest, 1991). While the two views are opposing to each other, it is accepted that people's epistemological views in general tend to progress slowly from one that sees knowledge as certain and absolute, to a more relativistic stance that emphasizes knowledge as uncertain and constructed by individuals (Chai, Hong, & Teo, 2009; Magolda, 2004; King & Kitchner, 1994).

As for views of mathematics teaching, they may be broadly classified under the knowledge transmission category or the knowledge construction category (Entwistle, Skinner, Entwistle & Orr, 2000; Handal, 2003; Samuelowicz & Bain, 2001). The former category is characterized as teacher-centered, content-based didactic teaching practice that emphasizes on passive reception of knowledge by students; and the later as student-centered, learning-oriented constructivist instruction that encourages students to actively make sense of their experiences.

Previous research indicates that epistemological views are closely in relation to learning in various ways and have implications for teaching (Pajares, 1992; Richardson, Anders, Tidwell & Lloyd, 1991; Schommer, 1994; Wilson, 1990). Yet, such views are often neglected, or not properly addressed, within teacher education programs (Nespor, 1987). Despite studies in general suggest that it is possible to change pre-service teachers' epistemological views (e.g., see Brownlee, Purdie & Boulton-Lewis, 2001; Gill, Ashton & Algina, 2004; Howard, McGee, Schwartz & Puecell, 2000), there is no consensus as to what represents a most effective way.

One way to help teacher-education students develop more constructivist-oriented epistemological and pedagogical views is perhaps to directly engage them in knowledge building practices (Chai & Tan, 2009; Hargreaves, 1999; Hong, Zhang, Teo, Scardamalia, 2009). Knowledge-building is a social process focused on the production and continual improvement of ideas of value to a community (Bereiter & Scardamalia, 2003) and is supplemented by the use of a software program called Knowledge Forum. Previous research on in-service teachers who have been practicing knowledge building pedagogy for years suggests that it may stimulate epistemological growth among teachers (Chai, Wong & Bopry, 2009; Chai & Tan, 2009; Hong, Zhang, Teo, Scardamalia, 2009). Therefore, it is posited that engaging teacher-education students in collaborative knowledge building practices should also have effects on their views about the subject matter they are to teach and about their teaching methods. Yet, such assumption remains to be examined, especially for the subject of mathematics. The purpose of the present study is to investigate this claim and our main research questions focus on: How do knowledge-building practices affect students' learning processes and outcomes? Specifically, in terms of processes, we looked into participants' online contribution pattern, social interaction patterns, and patterns in their teaching practices throughout the semester; and in terms of outcomes, we looked into changes in their views of mathematics and mathematics teaching.

Method

Context and participants

The present research was conducted in a university course titled "Middle School Mathematics Teaching" in Taiwan. The course was offered by the university's Center of Teacher Education to students who plan to become a mathematics teacher at the middle school level. The university is ranked as one of the best universities in the nation and the students enrolled in the subject university are all academically high-achievers and are overall considered by the society as the best prospective teachers in the nation. Participants in this study were four female and five male teacher-education students and their age ranged from 19 to 23 years (M = 21; SD=1.59).

Instructional approach

We employed an instructional approach that features design-based knowledge building practices (Hong, Zhang, Teo, & Scardamalia, 2009). The main purpose of engaging teacher-education students in such practices is threefold: (1) to help them understand the nature of teaching as creative and adaptive (Sawyer, 2004), rather than routine and script-oriented, (2) to help them avoid viewing teaching as merely pursuing best practices of certain model teachers by means of mastering pre-defined teaching skills; and (3) to enable them to go beyond "best practices" and assume the role of designer and knowledge-builder in continual improvement of their own teaching practices.

To implement, the course was divided into the following four related phases: (1) Initial Design: First, participants were guided to work on their initial design in order to implement their first teaching practice; accordingly, they prepared lesson plans, and learning materials and learning sheet, etc.; (2) First teaching practice: Then, based on their initial design, they performed their first teaching practices in class, with the other classmates serving as the audience. The whole process of each student's teaching practice was video-taped, and, at the end of each teaching practice, a peer evaluation was conducted to assess the quality of teaching for future improvement; (3) Re-design: During this phase, participants collectively worked online in Knowledge Forum to provide feedback and suggestions to the target student who already performed his (or her) teaching practice. Then he (or she) further reflected on these suggestions, analyzed the recorded video of his (or her) own teaching practice, and collaborated with other peers to improve his (or her) initial design by co-designing next lesson; and (4) Second teaching practice: Finally, based on the new instructional design, each participant performed their second teaching practice; the whole teaching process again was video-taped, and then a second peer evaluation on the quality of teaching was conducted again.

In addition, the course also employed other complementary instructional activities, mainly whole-class and small-group discussion after each teacher-education student's teaching practice, in order to engage them to frequently reflect on how to improve their own and others' teaching practices. Some questions being discussed in class were, for example: what have you learned from others' teaching practices; if you were to teach this lesson again, what would you do differently, and why? There were no fixed or pre-defined answers to most questions. The instructor served as a facilitator in guiding students to explore, discuss and reflect on all questions emerged in class in order to help them construct their own views of mathematics and mathematics teaching. Knowledge Forum were only used after class and it played an important role as an online space for students to record all key points generated from class discussion and personal reflection.

Knowledge Forum environment

The learning environments adopted in the present study is Knowledge Forum (KF). It is an online platform that runs on a multimedia database. KF allows users to simultaneously create and post their ideas in the form of note into the database, read others' postings, reply to others' notes, search and retrieve records, and organize notes into more complex knowledge representation. KF runs on both a text-based and graphics-based mode. In the graphics mode, it shows linkages of postings as a way to represent the interconnectivity and dialogical nature of knowledge. As such, it also enables the development of ideas to be traced. Figure 1 shows an example of a KF view (i.e., an open space designed for collaborative problem-solving), within which users are guided to work as a community by posting their problem of interest, producing initial ideas for problem-solving, sharing and connecting ideas, synthesizing their ideas, and deepening their collective understanding of problems at issue. Specifically for this study, the main problem of interest is concerned with understanding of the nature of mathematics and mathematics teaching, and in the beginning of the course students generated and shared their best ideas (e.g., "What is mathematics?"); then they designed and practiced their mathematics teaching according to their initial ideas and try to improve their initial ideas about mathematics teaching through frequent discussion, reflection, and co-design in Knowledge Forum.

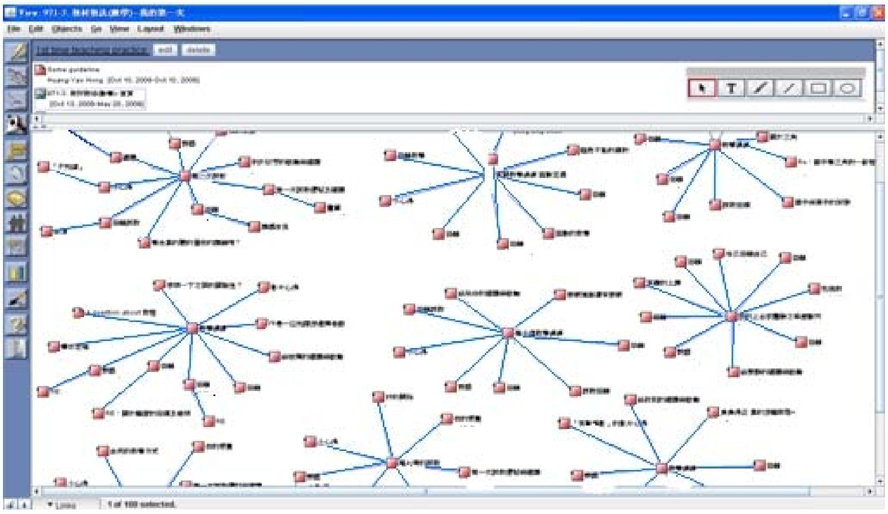


Figure 1. A Knowledge Forum view

Data Source and Analysis

Data source mainly came from student online discourse, two teaching practices, and a belief survey. First, in terms of student online discourse, it was recorded in a Knowledge Forum database and we analyzed student participation patterns (e.g., note creation and reading) and interaction patterns by employing descriptive analysis and social network analysis. In addition, we also looked into patterns of group feedback and personal reflection, in terms of each participant's own teaching practices.

The second set of data came from peer evaluation and video analysis on students' two teaching practices. In the beginning of the course, students collectively constructed an evaluation form focusing on the following five categories: objective (one item), learning materials (five items), instructional methods (six items), activities (six items), and presentation (three items). All items employed a 5-point Likert scale (5=excellent performance, 1=poor performance). In addition, both teaching practices of each participant were videotaped and then content-analyzed based on a pre-determined coding scheme highlighting the following three general types of learning activity: passive, active, and interactive (see Collins, 1996). To analyze, we examined percentage of time spent in each type of activity during each teaching practice.

The third set of data came from a belief survey, which was designed based on Handal's (2003) conceptualization of mathematics beliefs concerning the nature of mathematics and that of mathematics teaching. Accordingly, we asked the following eight open-ended questions: (1) What is mathematics? (2) What does "doing mathematics" mean? (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 does an ideal mathematics learning environment mean to you? Of all questions, questions 1 and 2 concern the nature of mathematics; and questions 3 to 8 concern the nature of mathematics instruction. To analyze, we employed an open coding procedure (Strauss & Corbin, 1990). Six codes emerged from this coding process (see table 1). Pair-sampled t-tests were conducted to examine if there were any pre-post differences.

Table 1: Coding scheme for students' views of mathematics and mathematics teaching

Categories	Code	Example of students' statements (Translated from Chinese)
Nature of mathematics	A science of quantity and calculation applied in life	Math is a science about calculating numbers. What we see, do and make in our daily life all needs math.
	A science of patterns and orders	To do mathematics is to seek for the patterns or rules by means of certain given conditions, using symbols and numbers to predict, estimate, or conjecture possible outcomes.
Nature of mathematics teaching	To let students practice again and again	Practice makes perfect.
	To let students understand basic concepts and procedures	To understand what each mathematical formulas means and to get the gist of a math problem and know how to solve it.
	To train logical thinking skills	The most important thing is to train students' problem-solving and thinking abilities.

	To help students develop and explore their own way of mathematics learning	Students have to explore and find their own way of math learning and develop their own learning styles.

Results and discussion

Online contribution patterns

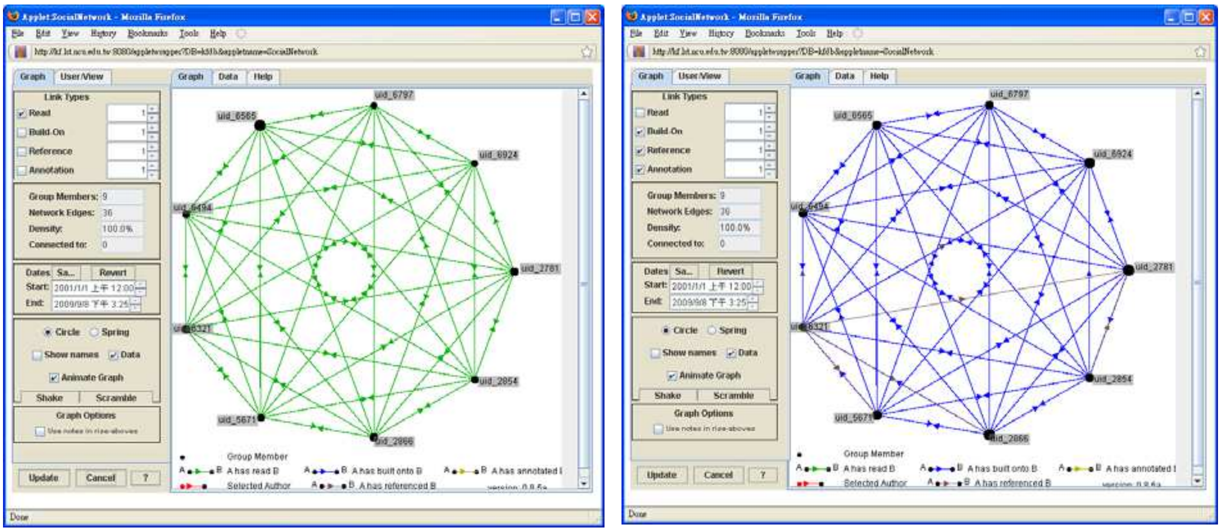
The overall online activity and performance in this community is shown in Table 2. Throughout the whole semester, participants contributed a total number of 171 notes with a mean number of 17.8 (SD=4.29) notes per person. In addition, other complementary online knowledge-building measures recorded in this community include number of note read, percentage of note read, number of annotation, number of note revisions, number of build-on notes, and percentage of notes linked. Overall, the online activities were substantive as compared with previous research using subjects with similar background (Hong & Lin, accepted). Nevertheless, while these behavioral measures gave a general picture of how participants worked online in this database, they do not tell much about how participants actually interacted with one another. To better understand the social dynamics in the community, a social network analysis (SNA) focusing on network density was conducted.

Table 2. Descriptive analysis on individual online knowledge-building activities

	Mean	SD
No. of notes created	17.8	4.29
No. of notes read	140.2	32.94
Percentage of notes read	82%	19.26%
No. of annotations	21.2	12.26
No. of note revisions	8.2	3.29
No. of build-on notes created	11.3	2.49
Percentage of notes linked	64.3%	6.17%

SNA was conducted using the automatic assessment tools embedded in the Knowledge Forum. Figure 2 shows the overall interactive and collaborative patterns in the community throughout the whole semester, using two indicators that are available in the Knowledge Forum: "note reading" (which indicates community awareness of contributions made by other peers) and "note building-on" (which indicates complementary contributions by the effort to build on to others' work and ideas). Table 3 shows detailed results of participants' interactions in two knowledge-building stages (using mid-term exam as a point of separation). In this particular analysis, we used an indicator, called "network density", which is defined as the proportion of connections in a network relative to the total number possible. The higher the number of the density is, the stronger the social dynamics a community is implied. An intention of adopting knowledge-building practices in this course is to transform the traditional way of knowledge-transmission mode of learning into a knowledge-construction mode that engages these students in collective problem-solving and knowledge work. Therefore, it was expected that students should progressively work more collaboratively in Knowledge Forum. As expected, there was an increasing trend of social interactions as reflected by the measures of density recorded online for this community from the early to the later knowledge building stages. Lipponen Rahikainen, Lallimo, and Hakkarainen (2003) regarded a social network density of .39 for students building-on each other online messages as adequate. In the present study, the density level is at .94, which indicates a highly satisfactory social dynamics of this community. The SNA findings alone, however, did not tell us much about the quality of interaction in the community. So, we further content-analyzed students' notes to illustrate what they actually did to help each other improve their teaching practices.

Table 4 shows the total numbers of group feedback and personal reflection made after the first and before the second teaching practice in terms of three dimensions: instructional design, learning materials, and presentation skills. There were in total 106 suggestions/comments and 43 times of personal reflections being made. On average each student received 13.25 suggestions from others and made 4.78 times of personal reflection between the first and the second teaching practices. This suggests that participants' online interaction were both quite purposeful and practical. The next question to ask is how online interaction, group feedback, and personal reflection contribute to the improvement of student actual teaching practices.



a. Note reading   b. Note linking

Figure 2. Interaction patterns in the community throughout the whole semester

Table 3. Social network analysis (SNA) of interactivity in the community

Network density	Early KB stage	Later KB stage	Whole semester
Note reading	100%	100%	100%
Note building-on	72.22%	94.44%	100%

Table 4. Group feedback and personal reflection made between the first and the second teaching practices

Category	Dimension	Frequency
Group feedback	1. Instructional design	44
	2. Learning materials	28
	3. Presentation skills	34
Personal Reflection	1. Instructional design	16
	2. Learning materials	14
	3. Presentation skills	13

Patterns in teaching practices

Table 5 shows students' peer evaluation results. It was found that the ratings in the second teaching practice were significant higher than the first teaching practice in 20 (out of the total 24) aspects of teaching practice. This suggests that there were significant improvement in students' second teaching practice. While the findings showed no significant improvement in four aspects—"Clarity of instructional goal" (M=4.49), "Appropriateness of learning materials" (M=3.98), "knowledge of the learning content" (M=4.38), and "Time management" (M=4.19)—this could be due to ceiling effects as their initial ratings were already very high (i.e., closer to or beyond point 4, out of the maximum points of five in a Likert scale). One thing worth noting is that the biggest improvement mainly came from the "Instructional methods" category which in particular highlights adaptive teaching (e.g., Uses innovative instructional approaches) and student-centered learning (e.g., Promots creative, critical and higher-level thinking), rather than conventional step-by-step and scripted teaching methods. These changes are important indicators of adaptive teaching as a central goal of employing design-based knowledge building practices in the present study was to help participants achieve a more flexible and innovative teaching approaches.

Table 5. Peer evaluation on one another's teaching practices

Category	Aspect	1st practice		2nd practice		t-value
		M	SD	M	SD	
Objective	Establishes clear purpose or objective of lesson	4.49	0.13	4.58	0.15	-1.31
Materials	Materials are purposeful and interesting	3.72	0.32	3.88	0.29	-3.04*
	Materials are age-appropriate	3.98	0.32	4.22	0.16	-2.29
	Materials are integrally designed and developed	4.09	0.26	4.25	0.15	-2.60*

	Materials are ready and available	4.31	0.35	4.52	0.18	-2.64*
	Materials are rich	4.09	0.23	4.33	0.21	-3.26*
	Knows the content of the subject very well	4.38	0.26	4.52	0.18	-2.05
	Uses visual aids (handouts, manipulatives, pictures, etc.)	3.57	0.15	4.01	0.31	-6.41***
Methods	Uses innovative instructional approaches	3.56	0.47	3.88	0.42	-4.56***
	Maintains academic focus	3.67	0.43	4.04	0.32	-4.47***
	Begins lesson with attention getter	3.64	0.51	4.11	0.39	-6.19***
	Maintains high percentage of student involvement	3.81	0.46	4.42	0.26	-5.44***
	Promotes creative, critical and higher-level thinking	3.59	0.40	3.96	0.38	-7.07***
	Instruction is adaptively designed	3.48	0.47	3.65	0.45	-3.28*
Activities	Manages time well	4.12	0.17	4.22	0.12	-2.16
	Applies established rules for behavior consistently	4.19	0.22	4.32	0.15	-2.53*
	Maintains instructional momentum	4.32	0.17	4.38	0.16	-2.35*
	Maintains an enjoyable learning environment	3.67	0.14	3.83	0.16	-3.16*
	Utilizes appropriate assessment techniques and practices	3.72	0.44	3.87	0.47	-4.26**
	Presents activities appropriate for all students	4.12	0.17	4.22	0.12	-3.42**
Presentation	Exhibits positive body language related to content	4.32	0.46	4.47	0.35	-3.02*
	Appropriately varies volume and inflection	4.10	0.39	4.36	0.28	-4.67**
	Uses clear, unscrambled discourse	3.86	0.52	4.15	0.25	-2.55*
	Maintains eye contact with everyone	4.04	0.36	4.28	0.19	-3.59**

* p<.05 ** p<.01 *** p<.001

Video analysis was further conducted as a form of data triangulation. Table 6 shows analysis results in terms of percentage of time spent in three different instructional activities during the two teaching practices. It was found that there was a significant decrease in the percentage of time spent in passive learning activities, from the first practice (72.1%) to the second practice (46.9%) (t=5.04, df=8, p<.01). In contrast, there was a significant increase in the percentage of time spent in active learning activities, from the first practice (17.9%) to the second practice (36.4%) (t=-3.79, df=8, p<.01), and a slight increase in the percentage of time spent in interactive learning activities (t=-2.15, df=8, p=.064). Overall, our video analysis confirmed that participants' teaching practice was shifting from a more teacher-centered approach to a more student-centered approach.

Table 6. Percentage of time spent in different instructional activities in two teaching practices

Activity	First practice	Second practice
Passive learning	72.1%	46.9%
Active learning	17.9%	36.4%
Interactive learning	10.0%	16.7%
Total	100.0%	100.0%

Views of mathematics and mathematics teaching

Finally, we looked into whether engaging students in design-based knowledge building practices also have effects on their views of mathematics and mathematics teaching. As shown in Table 7, in terms of views of mathematics, there was a significant drop in scores in the view that emphasizes mathematics as a science of quantity and calculation (M = 3.67 in the pre-survey and M = 1.67 in the post- survey). In contrast, there is a significant increase in scores in the view that highlights mathematics as a science of patterns and orders between the two measurements (M = 0 in the pre-measurement and M = 2.33 in the post- measurement). In sum, the findings suggest that in the beginning of the semester, teacher-education students tended to think that mathematics was all about number calculation or was something that is useful and can be applied to our daily life. Accordingly, it was assumed that a teacher should focus his or her instructional goal on helping students do appropriate mathematics calculation or develop related math abilities. However, such routine mathematics practices and training may only help students be familiar with and able to acquire some conceptual and procedural mathematics knowledge efficiently. It may not necessarily help students to use mathematics in a more creative way. But, after a semester, it was found that the teacher-education students were able to gradually view mathematics from a more constructive and creative manner. They began to appreciate mathematics as a science of finding patterns and orders, or as a tool for more constructive learning and problem-solving.

Accordingly, they also changed their views of mathematics teaching. As shown in the bottom part of

Table 7, there was a desirable (although insignificant) drop in scores in terms of the first three views of mathematics teaching, which regard mathematics teaching as a way "to let students practice again and again" (M = 2.11 in the pre-test and M = 0.44 in the post-test), or a way "to let students understand basic concepts and procedures" (M = 2.56 for the pre-test and M = 1.33 for the post-test), or a way "to train students' logical thinking ability" (M = 4 for the pre-test and M = 3.11 for the post-test). In contrast, there is a significant increase in scores between the pre-measurement (M = 0.22) and the post-measurement (M = 3.56) in terms of the last view of mathematics teaching, which highlights mathematics teaching as a way "to help students develop and explore their own way of math learning". Overall, it was found that in the beginning of the semester, teacher-education students' views of mathematics teaching is more teacher-led, whereas after engaging in design-based knowledge building practices for a semester, their views of mathematics became more student-centered.

Table 7: Students' views on the nature of mathematics and that of math teaching

Views of mathematics and mathematics teaching	Pre-survey		Post-survey		*t-value*
	M	SD	M	SD	
Nature of Mathematics					
A science of quantity and calculation applied in life	3.67	1.87	1.67	1.41	4.00**
A science of patterns and orders	0	0	2.33	1.80	-3.88**
Nature of mathematics teaching					
To let students practice again and again	2.11	2.21	0.44	0.73	2.041
To let students understand basic concepts and procedures	2.56	3.05	1.33	1.80	0.854
To train students' logical thinking ability	4.00	2.50	3.11	3.52	0.567
To help students develop/explore their own way of learning	0.22	0.44	3.56	2.19	-4.588**

**p<.01

Summary and implication

In this study, we reported an instructional approach of design-based knowledge building practices among a group of teacher-education students and investigated the effects of such instructional approach on their views of mathematics and mathematics teaching. The instructional approach was design-based as participants were engaged in sustained design, re-design, and co-design activities when planning and practicing their mathematics teaching. The instructional approach was knowledge building oriented as it highlighted continual production and improvement of ideas in pursuit of deeper understanding of the nature of mathematics and mathematics teaching. In summary, it was found that design-based knowledge building practices as an instructional approach was helpful to promote more interactive and reflective online activities. Moreover, it was found that at the end of the course, teacher-education students changed their views of mathematics to become more relativist-oriented and they also changed their views of mathematics teaching to become more student-centered. Arguably, while cultivating teachers' pedagogical content knowledge is important and should always be included as part of overall teaching training in a teacher-education program, our study suggests that it is equally important to help teacher-education students develop more informed and sophisticated mathematical beliefs. And to enable such belief change, it will be crucial for teacher education programs to avoid traditional didactic ways of teacher training, and adopt more constructivist-oriented instructional approaches in order to cultivate more future teachers who view mathematics teaching as creative and adaptive, rather than routine and ritualistic, practices.

References

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.

Chai, C. S., Hong, H.-Y., Teo, T. (2009). Singaporean and Taiwanese pre-service teachers' beliefs and their attitude towards ICT use: A comparative study. *Asia-Pacific Educational Researcher, 18*(1), 117-128.

Clark, C. M., & Peterson, P. L. (1986). Teachers' thought processes. In M. Wittrock (Ed.),*Handbook of research in teaching* (pp. 255-296). New York: MacMillan.

Collins, A. (1996). Design issues for learning environments. In Vosniadou, S., Corte, E. E., Glaser, R. & Mandl, H. (Eds.). *International perspectives on the design of technology-supported learning environments.* (pp. 347-361). Hisdale, NJ: Lawrence Erlbaum Associates, Inc.

Drucker, P. F. (1986),*Innovation and entrepreneurship: Practice and principles.* NY: Harper Business

Entwistle, N., Skinner, D., Entwistle, D., & Orr, S. (2000). Conceptions and beliefs about "good teaching": An integration of contrasting research areas. *Higher Education Research & Development*, *19* (1), 5-26.

Ernest, P. (1991). *The philosophy of mathematics education*. London: The Falmer Press.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research, 38*(1), 47-65.

Handal, B. (2003). Teachers' mathematical beliefs: A review. *The Mathematics Educator, 13*(2), 47-57.

Hong, H.-Y. & Lin, S. P. (2010). Teacher-education students' epistemological belief change through collaborative knowledge building. *The Asia-Pacific Educational Researcher, (19)1, 99-110*.

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., Messina, R., & Teo, C. L. (2008). Principle-based design to foster adaptive use of technology for building community knowledge. In G. Kanselaar, V. Jonker, P.A. Kirschner, & F.J. Prins (Eds.), *International Perspectives in the Learning Sciences: Cre8ing a learning world. Proceedings of the Eighth International Conference for the Learning Sciences–ICLS 2008, Vol. 1* (pp. 374-381). Utrecht, the Netherlands: International Society of the Learning Sciences, Inc.

Hong, H.-Y., Zhang, J., Teo, C. L. & Scardamalia, M. (2009). Towards design-based knowledge-building practices in teaching. In C. O'Malley, D. Suthers, P. Reimann, A. Dimitracopoulou (Eds.), *Computer Supported Collaborative Learning Practices: CSCL2009 Conference Proceedings* (pp. 257-261). Rhodes, Greece: International Society of the Learning Sciences, Inc.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27,* 65-90.

King, P. M., & Kitchener, K. S. (1994). Developing reflective judgment: *Understanding and promoting intellectual growth and critical thinking in adolescents and adults*. San Francisco: Jossey-Bass.

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction, 13*, 487-509.

Magolda, M. B. (2004). Evolution of a constructivist conceptualization of epistemological reflection. *Educational Psychologist, 39*(1). 31-43.

Nespor, J. K. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317-328.

Pajares, M. F. (1992). Teacher's beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

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.

Sawyer, R. K. (2004). Creative teaching: collaborative discussion as disciplined improvisation. *Educational Researcher, 33*(2), 12-20.

Samuelowicz, K. & Bain, J. D. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education*, 41, 299-325.

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. (2004). CSILE/Knowledge Forum®. In *Education and technology: An encyclopedia* (pp. 183-192). Santa Barbara: ABC-CLIO.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In *Encyclopedia of Education* (2nd ed., pp. 1370-1373). New York: Macmillan Reference, USA.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative conclusions. *Educational Psychology Review*, 6, 293 -319

Strauss, A. L., & Corbin, J. (1990). *Basics of qualitative research: grounded theory procedures and techniques* Newbury Park, CA: Sage Publications.

Van De Walle. A. J. (2001). *Elementary & Middle School Mathematics*: Teaching developmentally, NY: Longman.

Wilson, S. M. (1990). The secret garden of teacher education. *Phi Delta Kappan, 72*, 204-209.

Zhang, J., Hong, H.-Y., Teo, C. L., Scardamalia, M., & Morley, E. (2008). *"Constantly Going Deeper": Knowledge Building Innovation in an Elementary Professional Community.* Paper presented at the annual conference of American Educational Research Association (AERA), New York.

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