A Case of Cultivating a Global Community of STEM Teachers

Woong Lim
Kennesaw State University

Ji-Won Son
University at Buffalo, The State University of New York

Abstract

This paper examines an international collaborative project where preservice and inservice teachers in two countries—the United States and South Korea—collaborated in curriculum planning and exchanged peer feedback through asynchronous communication tools. The participants exhibited different cultural traditions of teaching mathematics. Additionally, their cross-cultural experiential learning helped to illustrate how teachers develop global perspectives and pathway to teaching Science, Technology, Engineering, and Mathematics (STEM) according to the Kolb's learning cycle.

Introduction

The integration of multicultural approaches in mathematics instruction helps to identify appropriate attitudes about the teaching and learning of mathematics and its cultural relevancy in education (Stigler & Hiebert, 1999). During the last two decades researchers have identified cultural tradition as a factor that could considerably contribute to the ways in which individuals teach mathematics. We introduce an international collaborative project in which participants in the United States and South Korea worked together to create lesson plans and exchange peer feedback and shared findings on various approaches in curriculum planning. The project offered unique opportunities to explore STEM teaching—the ways science teachers contributed to the sections concerning application and problem solving in mathematics lessons—and allowed mathematics educators in both countries to think more deeply about their teaching of mathematics in conjunction with the teaching of science. More importantly, the participants exhibited different cultural traditions of pedagogy and had opportunities to broaden their perspective of teaching mathematics. This study did not have interventions or experiments designed to produce measurable outcomes, and the findings may not be generalized.

Theoretical Background

This study starts with the premise that different cultural traditions could remarkably impact mathematics teaching (An, Kulm, & Wu, 2004; Ma, 1999; Stigler & Hiebert, 1999). A wide range of international comparative studies on mathematics education has revealed the important role of cultural influence on differences in mathematics education, in particular between Japan and the United States (Jacobs, Makoto, Stigler, & Fernandez, 1997; Whitman & Lai, 1990), Hungary and England (Andrews, 1999; Hatch, 1999; Harries, 1997), France and Britain (Jennings & Dunne, 1996), China, Hong Kong and Britain (Leung, 1995) and elsewhere.

Other cross-cultural studies comparing U.S. and East Asian students' mathematical achievement have indicated that East Asian students consistently outperform American students in almost every area of mathematical knowledge (Geary, Fan, & Bow-Thomas, 1992; Gonzales, et al., 2004; Lemke, Sen, Pahlke, Partelow, Miller, Williams, Kastberg, & Jocelyn, 2004; Stevenson &

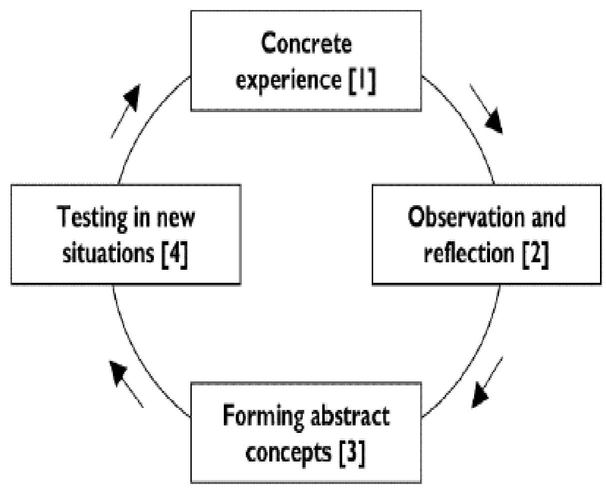
Stigler, 1992). These researchers have explored and hypothesized several factors that explain such learning gaps, including different systems of numerals (Fuson & Kwon, 1991; Miller, Smith, Zhu, & Zhang, 1995; Miller & Stigler, 1987), cultural differences (e.g., parents' expectations, students' motivation, beliefs, and effort), school organization (e.g., time spent on learning mathematics in school), classroom practice (Yang & Cobb, 1995), and the content and organization of mathematics curricula (Geary, Stigler, & Fan, 1993; Stevenson & Stigler, 1992; Sutter, 2000). The outcomes of this body of research have had a large impact on current mathematics education in the United States; however, without careful exploration of the cultural influence coming from first-hand experience in other cultural systems, it is difficult to achieve a full understanding and to promote learning from different educational systems (An, 2004; Wang & Lin, 2005).

Teachers' View and International Collaboration through Experiential Learning

Over the past two decades, teachers' conceptions of mathematics and their views of mathematics teaching have continued to interest many research communities, as they "play a significant role in shaping teachers' characteristic patterns of instructional behavior" (Thompson, 1992, p. 130). Stigler and Hiebert (1999) stress that the integration of multicultural approaches in mathematics instruction helps to identify appropriate attitudes about the teaching and learning of mathematics. In addition, numerous studies confirm that cross-national studies in mathematics education provide opportunities for increasing mathematics educators' awareness of alternatives in teaching and learning and promoting their reflections on their own teaching practices (An, 2004; Lemke, Sen, Pahlke, Partelow, Miller, Williams, Kastberg, & Jocelyn, 2004; Stigler & Hiebert, 1999; Stigler & Perry, 1988). However, little research exists that shows how preservice teachers interact with peers in a different cultural setting and work on a task with an authentic international partnership to develop global perspectives of teaching.

Grounded in experiential learning by Kolb and Fry (1975), this study aimed at exploring the impact of participation of a community of science and mathematics teachers between the United States and South Korea on the development of their views and experience about teaching. Figure 1 shows Kolb and Fry's learning circle which consists of four stages: concrete experience, observation and reflection, the formation of abstract concepts, and testing in new situations.

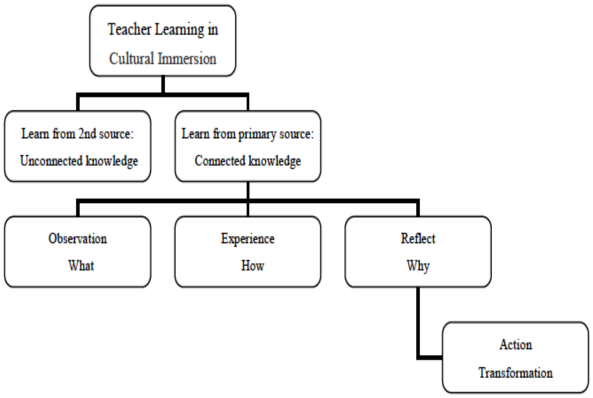
Figure 1. Kolb's learning cycle



According to them, experiential learning occurs as direct participation in which one experiences, reflects, abstracts, and tests their learning in a new situation from primary experience (Jarvis, 1995).

Figure 2 shows the three stages of the first-hand experience of teacher learning in a cultural setting: observation, experience, and reflection, which were drawn from An (2004).

Figure 2. Teacher learning in cultural immersion



Among the three stages of the first-hand experience, discussion and observation would help both U.S. and Korean teachers see "what" is happening in real classroom teaching in both countries. Experience of teaching in actual classrooms enables the U.S. teachers to understand "how" instruction works in mathematics teaching; reflection facilitates the U.S. teachers' thinking "why" it works in Korean teaching, which then advances the U.S. teachers' knowledge and encourages them to take action on applying their learning in their own classrooms in the U.S., thereby fostering the transformation into new learning.

According to Bruce et al. (2004), learning is about broadening one's ways of experiencing some aspect of the world. Prior research indicates that integrated experiential learning in teacher learning in multicultural education produced the benefits of preservice teacher learning from cultural immersion experience in cross-cultural settings (e.g., Spalding et al., 2003; Spalding et al., 2005; Stachowski & Mahan, 1998; Wiest, 1998; Willison, 1994). However, more studies are needed in this area focusing on preservice teachers' learning to accomplish a subject-specific and significant teaching task, such as lesson planning, delivery, or assessment from cross-cultural experiences.

This study involves preservice teachers in STEM areas and addresses their learning to plan mathematical lessons with international peers. We attempted to illuminate an understanding of roles of teacher learning in a different cultural setting, focusing particularly on the preservice teachers' views from their first-hand experiential learning and its impact on their teaching in developing reflective attitudes. We hypothesize that the co-investigation of teaching mathematics education from U.S. preservice teachers' and Korean teachers' perspectives may help provide insights into both U.S. and Korean mathematics education, in particular, the quality of teacher education programs. In addition, it will contribute to a better understanding of how different cultural traditions influence mathematics teaching and learning from international perspectives.

Project Description

This project originated from a friendly lunch conversation in 2008 between two mathematics teacher educators who attended the 32nd Conference of the International Group for the Psychology of Mathematics Education and agreed to implement the same course assignment as part of an international partnership at the course level. The educators worked in different teacher preparation programs but noticed positive interactions of their graduate advisees between Korea and the United States. Before this study, they revised their education courses with a focus on international mathematics curriculum and included an international project as a major assignment. This project aimed to build an international partnership in teacher education at course-level from Spring, 2009 to Summer, 2010. Teachers in two countries, the United States and South Korea, participated in a project of building a community of science and mathematics teachers.

Participants

The participants included two course instructors and their students. The students were teacher candidates and practicing teachers who enrolled in science and mathematics methods courses (see Table 1). Participants collaborated in curriculum planning (e.g., lesson plan) and exchanged peer feedback through asynchronous communication tools. The setting of the project involved two education courses in the United States and South Korea, respectively. In the United States, the course, "Middle School Curriculum Design," was offered as part of the Master of Arts in Teaching (MAT) program at a state university. The U.S. participants were teacher candidates (n = 27) in the areas of middle grades mathematics and science with no full-time teaching experience in their junior and senior years in the program. The collaborator course in South Korea was titled "Curriculum and Instruction" and was offered in their MAT program. Korean participants (n = 40) were experienced math/science middle school teachers with four to eight years of teaching experience in their first year of the Masters degree program. An English conversation course was a co-requisite in the degree plan.

Table 1. ***Number of Participants in Each Course***

Location/Number of Participants	The U.S.	South Korea
Spring Semester 2009	16	18
Summer Semester 2010	11	22

Key Features of the Project

As the project was purposeful in providing collaborative learning experiences in the international context and documenting the development of a global community of learners, the key features of the project were identified and provided to the participants.

Establishing a baseline. Due to differences in methods and perspectives of curriculum design in the two countries, the researchers in the project examined the course syllabi and identified learning goals and related tasks/assignments that were common in both courses. Students did not participate in the planning process of this project. Table 2 shows an outline of the international learning task. Instructors incorporated the outline in their course syllabi so that students could opt out at the beginning of the semester if they did not want to participate in the project of international collaboration.

Participants were asked to construct a lesson plan on the same mathematical topic that addressed learning objectives, anticipatory sets, lecture, activities, application, problem solving, closure, and assessment. The target grade levels were 6th, 7th, and 8th grades. The grouping of the participants in the study was such that the collaborator group has at least one Korean math teacher, one Korean science teacher, one American math teacher, and one American science teacher, respectively.

Table 2. ***Outline of the Project Activities***

Activity/Assignment (Duration)	Product (Responsible Party)	Communication Tools
1. Create small groups (each group can have 2-4 members; both math and science teachers should be represented) (< 30-min)	• Small group title submitted to the instructor (Students)	N/A
2. Select a mathematics topic for a lesson plan (< 30-min)	• Math topic Proposed to the instructor (Students; Instructors provide a list of topics)	N/A
3. Partner with an international collaborator group; follow-up meetings with students	• List of collaborator groups with the common math topics (Instructors)	Emails (or Dropbox)/ Video Conferencing

	to negotiate topics when there is no matching (< 3 days)		
4.	Produce welcome greetings to collaborator group (< 2 days)	• Video file or written messages (Students)	Camcorder; Emailing (or Dropbox) video files/document attachment
5.	Identify a target grade/level of middle grade students (< 2 days)	• Description of student population submitted to instructors (Students)	Email (or Dropbox)
6.	Green light to begin lesson planning	• N/A	Email
7.	Produce a lesson plan + Report progress + Videotape meetings to highlight progress for the collaborator group (optional) (< 1.5 weeks)	• Lesson plan + Discussion forum entries (Students) • Discussions include synthesizing different content standards and infusing various pedagogical strategies	Email (or Dropbox) video files and documents; Online Discussion forum
8.	Provide peer feedback on lesson plan (< 1 week)	• Feedback form + video commentary (optional) (Students; instructors provide feedback form)	Camcorder; Email (or Dropbox) video files and documents
9.	Teaching Demo of lesson plan (30 min) (< 1 week)	• Videotaped teaching demo (Students)	Camcorder; Email (or Dropbox) video files
10.	Provide peer feedback on teaching (< 1 week)	• Feedback form + video commentary (optional) (Students; instructors provide feedback form)	Camcorder; Email (or Dropbox) video files and documents
Repeat the entire process with the same collaborator group (< 3 weeks)			
11.	Reflection and Recommendations (2 hours)	• Videotaped classroom discussion; online discussion forum (Students and Instructors)	Camcorder; Online Discussion forum

Connecting to STEM. Both courses aimed to address curriculum design in middle school mathematics and science, although a majority of participants had mathematics as their primary concentration. Thanks to the interconnected nature of mathematics and science, the mathematics teacher is encouraged to integrate scientific phenomena that are practiced and experienced in the real world into his/her mathematics lessons. Although mathematical topics were assigned in planning lessons, participants with science content knowledge were asked to design the application/problem solving section of the lesson plans so that both subject areas could be represented and all participants were engaged in STEM teaching.

Communication tools. Due to time differences between the two countries, digital technologies enabling asynchronous communications were used. Emailing video files and documents was useful in prompt communication, and participants were provided appropriate support including equipment from instructional technology staff. Participants were asked to courtesy copy all emails to instructors. This procedure enabled the instructors to monitor the process and mediate any misunderstanding. In addition, participants were asked to videotape group discussions and teaching demonstrations. In order to provide opportunities to reflect with all participants in both countries, the project provided an online platform for discussion forums in which participants could read and write commentaries.

Data Collection and Analysis

Students' responses to surveys, reflective writings, and comments in focus group discussions were collected for the project investigation. Additionally, video clips and archived emails were used for analysis. The data analysis started first with explorative manners with survey responses and reflective comments in writing assignments in order to capture primary patterns and then with confirmatory manners with two focus group discussions in order to establish findings. Two research assistants who had completed two graduate courses on qualitative research methodology independently coded the data. The aides were informed about the areas of particular interest in this project, including the ways in which participants process cross-cultural interactions and develop STEM-related instructional strategies through collaboration. Then the primary patterns were triangulated and decided to be valid and meaningful only when at least two data sources supported the finding. Initially, in order to evaluate student performance, instructors asked individual students to provide a narrative of his/her contributions to the lesson planning and peer feedback, while linking the evidence with examples and actual products.

The quality of peer feedback and professionalism (e.g., meeting the deadlines, appropriate etiquette in communication with international partners) was considered part of course grades. Two U.S. participants were dissatisfied with the level of contributions they made in the collaboration so they opted out of the second lesson planning assignment. They were asked to submit individual work by completing the same assignments as other courses that didn't have the international collaborative project. Next, in order to investigate the students' growth in global perspectives of teaching and learning and curriculum design with a focus on STEM, surveys were administered three times. The first was at the beginning, the second survey at the mid-point before the second lesson plan assignment, and the third survey at the last meeting of the course. The surveys solicited critical perspective of program outcomes by addressing areas such as strengths, weaknesses, improvement, and individual reflections on change and growth.

This study provided no intervention and did not document changes in thinking or behavior; we were interested in how participants process multiple perspectives in content and pedagogy existing between the two countries and the ways in which a collaborative project between mathematics and science teachers inform the participants' view of teaching mathematics or science. To elicit responses related to such interest, the following items were also asked in the survey and writing assignments:

- Describe in detail how Korean/American partners were similar/dissimilar in constructing a lesson plan. In your discussion, please address each part of the lesson plan (Learning objectives, Anticipatory sets, Lecture/activities, Application/problem solving, Closure, and Assessment)
- How would you describe the following topics based on your experience of working with international partners?
    - Teaching mathematics in Korea vs. America
    - Mathematical knowledge for Korean vs. American teachers
- How was the experience working with science (or math) teachers? How did it affect your teaching knowledge and skills? How did the group work help you shape your view toward STEM education?

Focus group discussions were purposeful in that the researchers used the opportunity to confirm the proposed findings and allowed the participants (students and instructors) to confirm, clarify or further elaborate.

International Learning Project Outcomes

From the analysis of data, including

students' responses to surveys and students' comments in reflection assignments and focus group discussions, the following four themes emerged: (1) Growth in global perspectives, (2) Pathway to teaching STEM, (3) Community of collaborative teachers, and (4) High level of cross-cultural engagement.

Growth in global perspectives. The majority of the participants (82% U.S. participants and 74% Korean participants) declared that the project helped them develop global perspectives of teaching and learning, and that it facilitated effective exchanges of teaching strategies. The three most popular words in their commentary to describe effectiveness include exciting, productive, and rigorous. A popular observation (n = 48) was that the international project provided the participants opportunities to experience different teaching, and they began to realize that culture (i.e., the United States or South Korea) plays a significant role in shaping curriculum design and the content delivery. For example, one Korean participant said:

> "I never heard of equity in a classroom. It [international learning] has made me think a lot about how I treat my students fairly whether they are from a rich family or not. I guess American teachers think about ensuring equal access to education regardless of students' race or nationality. But Koreans won't worry too much about cultural diversity because it is a very homogenous society. I began to think about how our culture and society influence lots of what we do as teachers."

As participants develop a new perspective through cross-cultural experience, the Kolb's learning cycle was confirmed as an appropriate model to illustrate the change in attitude and thinking. Through the concrete experience of constructing mathematics lesson plans in collaboration with science teachers and by the observation and reflection of the global communication and feedback process, the participants were found to have formed abstract concepts, such as exploring methods unique to the teaching of STEM and conceptualizing ways to contribute to the global community of STEM educators. The last part of the cycle is testing in new situations. Sixteen American preservice teachers and 22 Korean teachers demonstrated the Kolb's cycle in their international learning experience. The following table describes each state of the cycle, the common words coded to identify the characteristics of the stage, and a representative participatory comment.

Table 3. ***Kolb's Cycle and Participants' Supporting Commentary***

Kolb's Cycle	Descriptive Words and Phrases Identified in Coding Process	Representative Comment
1. Concrete experience	Real experience; face to face meetings; learning by doing projects	"I like to read about how mathematics is taught in other countries but never imagined I'd be talking with them on Skype, sending emails, and hearing how much they liked my ideas. I think I had a real valuable experience."
2. Observation and reflection	Peer review; watch how they teach; analyze teaching; think deeply about; honestly, I think	"I am not certain how great teachers they (American preservice teachers) will become. But the way they are willing to listen to children's comments and rephrase their thinking made me reflect on how I had interacted with my Korean students. I think I was too authoritarian and

			controlling instead of focusing on how much my children learn from working with me."
3.	Forming abstract concepts	Feel strongly; believe; argue; makes more sense if; idea and concept	"STEM teaching was a buzz word I struggled with all the time until I worked together with some classmates who were science teachers. The idea about teaching STEM can't materialize until people understand how math or science is taught and how much they need the other content to develop complete thinking."
4.	Testing in new situations	My own teaching; in the future; the way it applies to my teaching	"My learning experience with Korea teachers was definitely empowering. We teach different [students], though I think all students are the same and different at the same time. When my way of doing math is not helping my students, I think I will try different methods I heard from the Koreans. One thing I realized in this course is your teaching never goes as you planned and your students are never the same type of students. The more you know, the more you remain flexible, the better teaching you can make."

Additionally, the project examined how the participants perceived the different approaches between the two countries. The lesson plan assignment required the participants to address learning objectives appropriate for middle grades (i.e., 6^{th}-8^{th} grades), anticipatory sets, lecture/activities, application/problem solving, closure, and assessment in their lesson plans. The mathematical topics selected by the participants include arithmetic sequences, the fundamental counting principle, the distance formula, exponential functions, fitting a line to data, function notation, graphing a line function, irrational numbers and radicals, the measures of central tendency, linear inequalities, quadratic equations, rational expressions, solving a system of equations, surface area and volume, transformations, and the x-y coordinates, ordered pairs and slopes. Since the two countries have different national and state content standards and various pedagogical strategies, the differences in levels were identified and presented to the participants as part of the course curriculum about the international curricular issues in mathematics. Extending the learning of international curriculum, the participants were encouraged to synthesize, negotiate and infuse differences in content standards and pedagogical approaches to address the common mathematical topic. Table 4 indicates strengths demonstrated in the different parts of the lesson plans identified by the collaborator groups relating to content and pedagogy. The number in parenthesis indicates how many times the same description was mentioned by different participants. For American preservice teachers' comments, those mentioned more than six times were included. For Korean teachers' comments, those mentioned more than nine times were included. We note that the findings in the table should not be taken as general characteristics of teaching mathematics in each country primarily because there might exist other factors contributing to the perceived differences, such as teaching experience or content knowledge; instead, the findings demonstrate the multiple layers of perceived differences and rising learning opportunities through cross-cultural interactions.

Table 4. ***Perceived Strength and Weakness in Lesson Plans***

Stages in a Lesson Plan	Korean participants said American teachers were effective concerning:	American participants said Korean teachers were effective concerning:
• Learning objectives	▪ Writing explicit objectives (n=12) ▪ Aligning well with state standards (n=14)	▪ Using objectives to establish high expectations (n=8) ▪ Presenting mathematically powerful ideas (n=7) ▪ Not afraid to ask abstract thinking (n=12)
• Anticipatory sets	▪ Allowing students to do mathematics (n=21) ▪ Short and easy to increase motivation (n=18) ▪ Involving student-teacher conversations (n=29)	▪ Clearly addressing the prerequisite skills necessary for the pertaining lesson (n=8)
• Lecture/activities	▪ Providing details about procedures (n=10) ▪ Actively using PowerPoint slides (n=33) ▪ Using visualizations to represent mathematics (n=13)	▪ Not afraid to present difficult problems (n=18) ▪ Pervasive use of decimals and fractions (n=11) ▪ Emphasizing writing math solutions as a cohesive body of procedures and concepts (n=9)
• Application/problem solving	▪ Creative presentations, such as use of interviews with scientists, computer games, science fictions and movies (n=28) ▪ Connecting to real life situations (n=31) ▪ Willing to take risks by trying teachers' own ideas; not relying on prescribed curricular materials (n=20) ▪ Emphasizing modeling situations (n=11) ▪ Using manipulatives, objectives, and visuals (n=34) ▪ Flexible and selective use of existing curricular materials (n=9)	▪ Using textbook examples effectively (n=11) ▪ Asking students to research; not afraid to challenge students (n=18) ▪ Science teachers' high content knowledge (n=20)
• Closure	▪ Asking for student feedback (e.g., the muddiest point) (n=18) ▪ Interesting strategies such as exit slip, 3-2-1, 3W's (n=19) ▪ Encouraging student-student interactions (i.e., think/write/pair/share) (n=8)	▪ Willing to omit closure if the lecture/activities extend (n=14)
• Assessment	▪ Using performance-based assessment (n=11) ▪ Applying multiple ways to assess (n=10) ▪ Enforcing test accommodations (n=10)	▪ Using standardized testing (n=7) ▪ Sharing the same assessment in the department (n=8) ▪ Objective grading using scoring rubrics (n=9)

Pathway to teaching STEM. The project offered unique opportunities to explore STEM teaching – the ways science teachers contributed to the sections concerning application and problem solving for lesson plans. This allowed mathematics teachers in both countries to think deeply about their teaching of mathematics in conjunction with the teaching of science. For example, American participants recognized that Korean teachers were more challenging in encouraging students to make use of basic math skills and mathematical reasoning in application and problem solving in physics, chemistry, and biology. On the other hand, Korean participants recognized that American teachers were committed to making learning of mathematics relevant and engaging. One Korean participant wrote:

> "American math teachers seem to really try hard to show how math is useful outside the class when all Korean teachers were trying to show that math exists in classrooms and science exists in the lab. When I see most American teachers were excited for using computer games or magazine articles in the application section, I knew that their attitude and intention was to make students think and learn rather than to make students work, work, and work. I thought I will start reading some science magazines just to get some ideas on the use of math in science so that I can share with my students."

The participants were math/science teachers and 75% of American preservice teachers (n=20) and 82% of Korean teachers (n=32) provided evidence to demonstrate their change in attitudes and their knowledge of content and pedagogy. The evidence included their comments on attitudes and descriptions on content and pedagogy added to their current knowledge. Additionally, the focus group discussion informed the study that quite often, the mathematics teachers were willing to revise the content by emphasizing particular concepts or adding more opportunities to practice certain math skills when the science teachers share their experience of using the mathematics in their teaching. At the same time, the science teachers consulted with the mathematics teachers in designing application and problem sections in their lesson plans so that the context drawn from science can include rich mathematical thinking and reasoning. In particular, 38 % of the participants (n=25) mentioned that they recognized problem solving as a primary vehicle in achieving STEM outcomes and renewed their commitment implement more problem solving in their lessons.

Community of collaborative learners. The project offered opportunities to collaborate in curriculum planning but included few social activities to directly promote global community of learners and educators. However, over time, the participants began to build relationships by increasing opportunities to work online (video-conferencing) as well as offline (email) in addition to the project requirement. Their interactions included exchanging solutions to problem solving, sharing teaching resources, and even learning to speak each other's language. These activities did not count for a grade, but the participants continued to seek opportunities to network and deepen human relationships. This outcome supports the view that students respond positively to an autonomous learning environment in which they can develop as collaborative learners. In the survey, the majority of the participants (93% of the U.S. participants and 91% of the Korean participants) expressed that the participants were comfortable in saying that they had a successful global community of educators and would seek similar international learning opportunities in the future. One American participant wrote:

> "The Korean teachers knew so much math and science. I felt I was contributing a lot in a very serious professional organization of inter-

> national teachers. I thought a lot about my own skills as science teacher. Yes, I do speak English and helped the Korean teachers with their writing. But I wish I had more experience and content knowledge to discuss real teaching. I got a lot work to do!"

High level of cross-cultural engagement. Both instructors reported that there was a substantial increase in student participation and performance. In the U.S. program, the average grade for a lesson plan project over three school years before the project was 78% or the letter grade C. This international project produced an average grade of 85% with a significantly low number of dropped students. In the Korean program, the course traditionally produces 10% A's and 25% B's; with about 15% of dropped students. This project allowed about 15% A's and 45% B's with only one dropped student. The Korean instructor commented:

> "Students attended to the tasks, were committed to the tasks when there were no extrinsic rewards, persisted in completing the task even when the work became difficult; most students said that they didn't want to quit and in fact, worked harder to impress American peers."

Indeed, a meaningful opportunity to experience a community of collaborative learners can help address the critical aspect of becoming a reflective educator. Other evidence, especially about developing reflective thinking by learning in the community of learners included the analysis of commentary provided in the online discussion forum. About 67% of the participants (n=45) produced written comments that address how their learning with peers had a positive impact on broadening their perspectives and critically examining their current teaching knowledge and practice. In particular, more than two thirds of participants from each country mentioned at least twice in commentary that their learning was engaging in a way that they are intrinsically motivated to participate and perform at a high level. When participants were asked to list factors that motivated to be an active participant in the project, the most popular factors were international learning opportunity (mentioned by 52 participants out of 67), grades (n=48), relationship (n=34), and usefulness of the assignments (n=27), and others. Also, about 50% of the participants (n=35) described how their international partners were instrumental in understanding diversity and how it enriched their content and pedagogy. One American participant wrote:

> "It was clear to me the Koreans have superior content knowledge. However, do they use the knowledge and work hard [to learn] great teaching strategies [and] make the materials easy for the students? Some Korean teachers mentioned they had not ever thought about increasing student motivation in the ways I explained to them. It felt great to know that teachers need to know both content and pedagogy regardless of nationality, and different cultures help us understand we need to collaborate in unison in educating our children."

Implications

Through the project we observed that the integration of cross-cultural experience in mathematics planning and instruction helped our participants identify appropriate attitudes about the teaching and learning of mathematics and its cultural relevancy in education. In particular, our project of international collaborative learning illustrated how teachers in two countries—the United States and Korea—developed new perspectives and pathway to teaching STEM according to the Kolb's learning cycle.

The growth in the participants' reflective nature, especially by the U.S. participants who did not have full time teaching experience, indicated that preservice teachers had the potential to excel in their future teaching in which they collaborate with every stakeholders in the field of education and work with students with various cultural backgrounds. For example, one U.S. participant wrote:

> "My experience with Korean teachers allowed me to think a lot about my own teaching in the classroom where I might end up having students and parents from different countries with different expectations of learning math. And I want to be the teacher who can appreciate the differences and embrace their math knowledge and cultural backgrounds as part of what makes [students] excited for learning algebra with me… [The] more mathematics you get to learn with people from different countries, the more open-minded you become."

Although this comment may not show how the international experience would transform his/her teaching, it certainly indicates how the international learning impacted the participant especially about the ways he or she relates to their students' cultural background. We also observed that the international projects like the one illustrated in this study facilitated by teacher educators in international partnership and enabled by low-budget technology shed some light on transforming the attitude of someone who has probably never traveled outside the United States. For example, one American participant wrote,

> "The students in my [field experience] have never been the same to me when the collaborative project with Korean teachers changed my attitude towards immigrant students. One of my Indian students is extremely inquisitive, that is to say, he asks questions as often as he takes a breath. But all of my students, of all backgrounds, whether it be Chinese, Korean, Cuban are teaching me so much about dealing with 6th graders, and people in general. I want to learn more about people and their cultures and how they teach mathematics."

In response to the needs of preservice teachers who have potential to grow as classroom teachers with rich international perspectives, the kinds of learning opportunities through which participants can interact with international peers and reflect on practice can empower our preservice teachers.

Teacher educators become excited when (preservice) teachers demonstrate reflective thinking and attribute their change to the learning experiences provided in their teacher preparation program(s). The international learning is perhaps a small piece of the puzzle for becoming a reflective teacher. However, providing preservice teachers with opportunities to learn with teachers from different countries and reflect on their own practice is worthwhile. Broadening global perspectives and deepening mathematics instruction in light of STEM teaching were the significant outcomes of the project. We hope that similar international projects or transformative collaborative projects continue to inform global learning for teachers and become a regular part of the teacher preparation programs in the United States.

References

An, S. (2004). *The middle path in math instruction: Solutions for improving math education*. Lanham, MD: Scarecrow Education.

An, S., Kulm, G., & Wu, Z. (2004). The pedagogical content knowledge of middle school mathematics teachers in China and the U.S. *Journal of Mathematics Teacher Education, 7*, pp. 145-172.

Andrews, P. (1999). Looking behind the rhetoric: Some new insights from Hungary. *Mathematics Teaching, 167*, pp. 6-10.

Bruce, C., Buckingham, L., Hynd, J., McMahon, C., Roggenkamp, M., & Stoodley, I. (2004). Ways of experiencing the act of learning to program: A phenomenographic study of introductory programming students at university. *Journal of IT Education, 3*, pp. 143-160.

Fuson,. K. C., & Kwon, Y. (1991). Chinese-based regular and European irregular systems of number words: The disadvantage for English-speaking children. In K. Durkin & B. Shire (Eds.), *Language in mathematics education: Research and practice* (pp. 211-226). Buckingham, England: Open University Press.

Geary, D. C., Siegler, R., & Fan, L. (1993). Even before formal instruction, Chinese children outperform American children in mental addition. *Cognitive Development, 8*, pp. 517-529.

Harries, T. (1997). Reflections on a lesson in Kaposvar. *Mathematics Teaching, 161*, pp. 11-13.

Hatch, G. (1999). It wouldn't be like that here. *Mathematics Teaching, 168*, pp. 26-31.

Jacobs, J. K., Makoto, Y, Stigler, J. W., & Fernandez, C. (1997). Japanese and American teachers' evaluations of mathematics lessons: A new technique for exploring beliefs. *Journal of Mathematical Behavior, 16*(1), pp. 7-24.

Jarvis, P. (1995) *Adult and continuing education: Theory and practice* (2nd Ed.), London: Routledge.

Jennings, S., & Dunne, R. (1996). A critical appraisal of the National Curriculum by comparison with the French experience. *Teaching Mathematics and its Applications, 15*(2), pp. 49-55.

Kolb. D. A., & Fry, R. (1975). Toward an applied theory of experiential learning. In. Cooper (Ed.), *Theories of group process*. London: John Wiley.

Lemke, M., Sen, A., Pahlke, E., Partelow, L., Miller, D., Williams, T., Kastberg, D., Jocelyn, L. (2004). *International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results From the US Perspective*. (NCES 2005–003). Washington, DC: US Department of Education, National Center for Education Statistics.

Leung, F.K. (1995). The mathematics classroom in Beijing, Honk Kong and London. *Educational Studies in Mathematics, 29,* pp. 297-325.

Ma, L. (1999. *Knowing and teaching elementary mathematics*. Mahwah, NJ: Erlbaum.

Miller, K. F., & Stigler, J. (1987). Counting in Chinese: Cultural variation in a basic cognitive skill. *Cognitive Development, 2,* pp. 279-305.

Miller, K. F., Smith, C. M., Zhu, J., & Zhang, H. (1995). Preschool origins of cross-national differences in mathematical competence: The role of number-naming systems. *Psychological Science, 6*, pp. 56-60.

Spalding, E., Wang, J., Lin, E., & Butcher, J. (2005). Working globally: Preparing American teachers and teacher educators in Guangzhou, China. Paper presented at the annual meeting of the American Association of Colleges for Teacher Education. Retrieved December 12, 2008, from http://www.allacademic.com/meta/p36182_index.html

Stachowski, L. L., & Mahan, J. M. (1998). Cross-cultural field placements: Student teachers learning from schools and communities. *Theory Into Practice, 37*, pp. 155-162.

Stein, M. K., Smith, M. K., Henningsen, M. & Silver, E. (2000). *Implementing standards-based mathematics instruct-ion: A case book for professional development*. New York: Teachers College Press.

Stevenson, H. W., & Stigler, J. W. (1992). *The learning gap*. New York: Summit Books.

Stigler, J. W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom*. New York: The Free Press.

Stigler, J. W., & Perry, M. (1988). Cross-cultural studies of mathematics teaching and learning: Recent finding and new directions. In D. Grouws, & T. Cooney (Eds.), *Effective mathematics teaching directions*. Reston, VA: National Council of Teachers of Mathematics, pp. 194-223.

Stigler, J. W., Gonzales, P., Kawanaka, T., Knoll, S., & Serrano, A. (1999). *The TIMSS videotape classroom study: Methods and findings from an exploratory research project on eighth-grade mathematics instruction in Germany, Japan, and the United States*. Washington, DC: National Center for Education Statistics.

Sutter, L. E. (2000). Is student achievement immutable? Evidence from international studies on schooling and student achievement. *Review of Educational Research, 70,* pp. 529-545.

Thompson, A.G. (1992). Teachers' beliefs and conceptions: a synthesis of the research. In D. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning*. New York: Macmillan.

Wang, J. (2002). Beginning teaching mathematics in middle schools: Forms and substance of Chinese teachers' instructional discourses. Paper presented at the annual conference of the Comparative and International Education Society, Orlando, FL.

Wang, J., & Lin, E. (2005). Comparative studies on U.S. and Chinese Mathematics learning and the implications for standards-based mathematics teaching reform. *Educational Researcher, 34*(5), pp. 3-13.

Whitman, N.C., & Lai, M. K. (1990). Similarities and differences in teachers' beliefs about effective teaching of mathematics: Japan and Hawaii. *Educational Studies in Mathematics, 21*(1), pp. 71-81.

Wiest, L. R. (1998). Using immersion experiences to shake up preservice teachers' views about cultural differences. *Journal of Teacher Education, 49*, pp. 358-365.

Willison, S. (1994). Community field experiences in the American Indian Project. In K. Zeichner, & S. Melnick (Eds.), *The role of community field experiences in preparing teachers for cultural diversity*. East Lansing, MI:

National Center for Research on Teacher Learning.

Wu, Z. (2006). Learning mathematics with understand: Discussion of mathematics proficiency. *Journal of Mathematics Education*. *15*(2), pp. 41-45.

Wu, Z., An, S., & Wang, L. (2005, July). Comparison study of integrating technology in mathematics teachers' knowledge and confidence between U.S. and Chinese teachers. Paper presented at the EARCOME3 Conference, Nanjing, China.

Yang, M. T. L., & Cobb, P. (1995). A cross-cultural investigation into the development of place-value concepts of children in Taiwan and the United States. *Educational Studies in Mathematics, 28*(1), pp. 1-33.