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Integrating Teaching Research with Teaching Practice: A Modified Chinese Model of Professional Development

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This paper proposed to adapt the Chinese teaching research model of professional development (PD) to engage university faculty in implementing existing evidence-based teaching strategies in preservice teachers' mathematics classrooms, studying developed learning theory, and developing a body of shared, high-quality resources for good teaching practice. The process of conducting the PD activities will help mathematics faculty grow professionally in teaching and research and get preservice teachers better prepared for future teaching. The significance of implementing this PD model will go beyond the immediate impact on university teacher preparation programs; the model of teaching research may shed light on advancing the integration of teaching and research for other university programs.

Key words: *Teaching research, professional development, collective lesson preparation, teaching seminar, teaching research project, worthwhile mathematics problems*

Researches have revealed consistently that many preservice elementary teachers don't understand fundamental mathematical ideas and lack the ability to make connections among those ideas (Hill & Ball, 2004; Ma, 1999). Evidences also indicated that the number of university mathematics courses taken by preservice teachers, doesn't increase their conceptual understanding of fundamental mathematics (Ball & Rowan, 2004; Zerpa, Kajander & Barneveld, 2009). Mathematics teacher educators need to design mathematics content courses that construct pre-service teachers' mathematics knowledge, deepen their conceptual learning, and prepare adequate future classroom teachers for improving students' learning performance in STEM classrooms.

According to Ponte and Chapman (2008), many studies indicated that improving teacher preparation were not simply providing more mathematics but more importantly, engaging preservice teachers doing meaningful mathematics which meant allowing them to understand and reconstruct what they knew in depth. A question comes next: how can "doing meaningful mathematics" be orchestrated in mathematics classrooms? National Council of Teachers of Mathematics (NCTM, 2000) suggested that worthwhile mathematics task can promote conceptual learning through engaging students

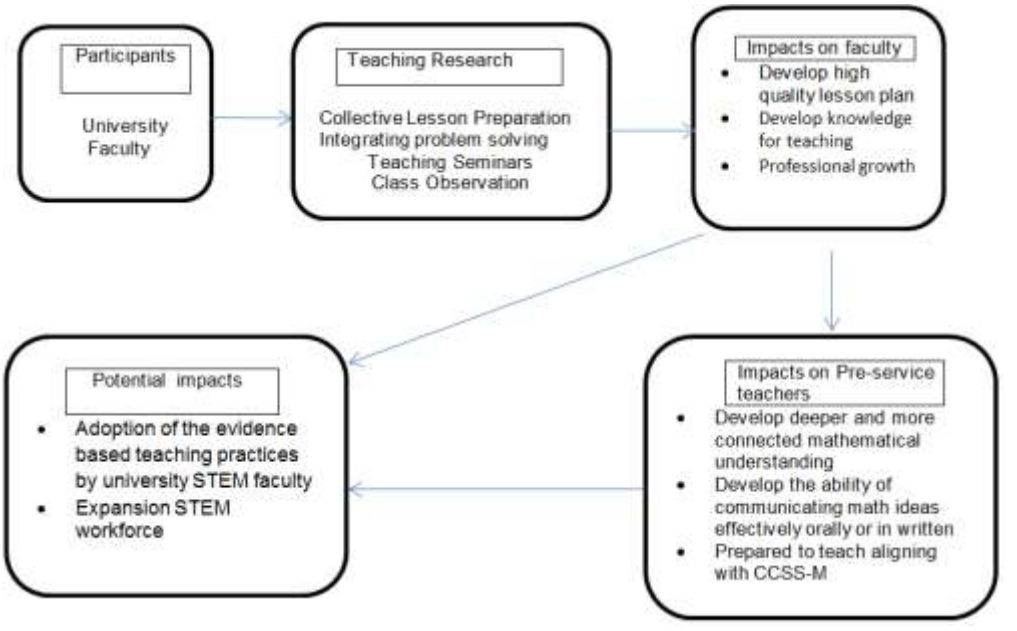
in investigating mathematically meaningful ideas and making connections among those ideas. Research also support that solving mathematically rich problems in which certain mathematics concepts or skills are embedded helps students develop a comprehensive system of knowledge, and meaningful mathematical problem solving should be integrated throughout the curriculum (Cai & Lester, 2010; Hiebert & Wearne, 1993; Lambdin, 2003; Schoroeder & Lester, 1989). Incorporating problem solving throughout mathematics curriculum is promising strategy on increasing engagement of undergraduate students in mathematics learning and developing productive habits of mind.

Future teachers require support in developing mathematical habits of mind in order to develop the standards for mathematical practice in their own students. University faculty who teach mathematics content courses for preservice teachers must make significant instructional shifts in order to meet these needs. However, there are few scalable models for sustained improvement of teaching and learning in university mathematics classrooms. Universities are challenged to improve their teacher preparation programs, especially, those providing new teachers for high-need schools. In order to address the challenges in mathematics teacher preparation, university faculty need to work together improving teacher preparation program. This paper offers a professional development model which could result in improving mathematics teacher preparation constantly.

The Proposed Model

This paper proposes to adapt the Chinese model of *Teaching Research* in university level of faculty professional development. *Teaching Research* is multi-dimensional professional development model, consisting of a variety of rigorous activities. Studying a specific lesson is only one component of *Teaching Research* (see the below section "Framework" for detail). Teaching research activity will engage the participating faculty in working to implement evidence-based teaching practices in mathematics content courses for preservice teachers. The ultimate objective is to address the urgent need to prepare new teacher candidates to teach the more rigorous mathematics enunciated in the Common Core State Standards for Mathematics (CCSS-M) in the United States.

More specifically, this modified model of professional development (PD) is to engage faculty of university teacher preparation programs in integrating teaching research into teaching practice to change pre-service teachers' mathematics learning experience and attitude toward learning mathematics through incorporating meaningful mathematics problem solving into the curriculum of mathematics content courses for preservice teachers. The immediate goal is to engage prospective teachers in doing mathematics with conceptual understanding and to help them construct mathematics knowledge for teaching. The logic model is showed as the graph below.



Expected Significance

This proposed PD model would support university instructors in implementing the evidence-based teaching methods advocated in the *Engage to Excel* report (President's Council of Advisors on Science and Technology, 2012) and contribute to our knowledge of instructional change at university level. The PD activities proposed would integrate teaching research with teaching practice, engaging university faculty in implementing existing evidence-based teaching strategies in preservice teachers' mathematics classrooms, studying developed learning theory, and developing a body of shared, high-quality resources for good teaching practice. The process of conducting the PD activities will help mathematics faculty grow professionally in teaching and research and get preservice teachers better prepared for future teaching. The significance of implementing this PD model will go beyond the immediate impact on university teacher preparation programs; the model of teaching research may shed light on advancing the integration of teaching and research for other university programs.

The participating faculty should include mathematicians and mathematics educators. Their expertise will serve implementing the modified PD model and help ultimately reach the objective – deepening prospective teachers' mathematics conceptual understanding. By conducting the PD this group of faculties would make the integration of teaching research and teaching practice take place in higher education institution.

In addition, new faculty and part-time instructors can be recruited to participate in the teaching research activities. The PD group will support new

faculty and part time faculty with resources and effective strategies to improve their classroom instructions. Engaging in the teaching research activities itself is a learning process for them to grow quickly in teaching and research.

The Research Questions

There are many potential research questions could be investigated when implementing the proposal model of faculty professional development, the following are some examples of the research questions:

1. To what extent does conducting teaching research affect the participating faculty's teaching?
2. How does faculty participation in teaching research affect preservice teachers' knowledge and beliefs about learning mathematics?
3. How does teaching research affect university faculty's professional growth?
4. To what extent does teaching research improve preservice teachers' learning outcomes?
5. How does a certain designed lesson effectively help pre-service teachers learn mathematics conceptually?
6. How has some new knowledge for teaching mathematics been developed through the PD activities?

The above research questions are only some examples. More related research questions could be added to the list.

Research Methodology

The research of this PD model could utilize both quantitative and qualitative methods to answer the research questions. For example, surveys could be designed to investigate how faculty's developing the lesson plans together affects pre-service teachers' knowledge and beliefs about learning mathematics. A pilot study can be conducted at first. The result of the pilot study could help refine the research design and the research method of the PD model. Students of participating faculty can be surveyed. The collected data can be analyzed using quantitative method.

In addition to quantitative study, qualitative research can be employed to produce a rich description of findings that quantitative data may miss. Sampling semi-structured interviews, field notes, selected teaching materials, completed lesson plans; instructors' reflections, shared assessment tests, student artifacts, and document review can be collected as qualitative data being analyzed by qualitative theme-generating techniques (Corbin & Strauss, 2008; Mertler, 2009; Miles, 1994; Patton, 2002).

Frameworks

The PD model follows two frameworks – framework of the Chinese Model of Teaching research and framework of the criteria for worthwhile mathematics problem. Because existing research has agreed that providing students with worthwhile mathematic problems improves students' learning outcomes (eg. Henningsen & Stern, 1997; Kramarski, Mevarech, & Arami, 2002; Schoenfeld, 2014), a very important activity of this PD model is selecting worthwhile mathematics problems when conducting collective lesson preparation. During this process, the criteria for worthwhile mathematics problem proposed by Cai and Lest (2010) can be adopted. The two frameworks are described as follows.

The Chinese Model of Teaching Research

Teaching Research, a professional development model for K-12 teachers, has been widely applied at schools in China for many years. It integrates teaching research and teaching practice, conducted by a group of teachers who teach the same subject through activities that include collective lesson preparation, teaching seminars, and teaching-research projects in order to help teachers learn and grow professionally. Constantly participating in teaching research helps K-12 teachers develop their expertise in effective mathematics teaching in China (Liang, 2012; Ma, 1999).

Collective lesson preparation. This is a very popular form of teacher professional development in K-12 schools in China, because it engages teachers constantly in learning from sharing and collaborating and helps accumulate knowledge for teaching through utilizing collective intelligence. Usually teachers who teach the same subject of the same grade level from a teaching research group. The groups of teachers meet once a week to prepare next week's lesson plans such as discussing teaching approaches, the important mathematical idea(s) needed to address, and the potential questions or misconceptions students may have.

Different from the Japanese lesson study, collective lesson preparation engages teachers in designing all lesson plans throughout the curriculum taught. Studying a specific lesson is only a part of collective lesson preparation. In China, teachers are encouraged to provide open lesson for other teachers and educators to observe. Usually an open lesson has been gone through a process of repeated revising and trial teaching by a teaching research group before it is finally presented in public. Developing an open lesson is not the whole but an integral part of collective lesson preparation. The purpose of collective lesson preparation is to provide opportunities for teachers to learn from the collaborating process. Not only young teachers learn from experienced teachers and develop teaching expertise over the years of participating in collective lesson preparation but also experienced teachers

learn some fresh ideas from young teacher and improve their teaching for the better. Young teachers in China learn dramatically from collective lesson preparation and gaining expertise of teaching in relative shorter time (Liang, 2012).

Teaching research project. K-12 Schools in China encourage teachers to

conduct teaching research projects in China. Some schools even require teachers to do teaching research project. Such teaching research could be research and implementation of high school mathematics discovery learning, could involve students in constructing mathematics knowledge in multiple formats, could be students' cooperative learning, or could be students' self-assessment, etc. Depending on the focus of teaching approach, a teaching research group design lessons together in the sessions of collective lesson preparation, implement the chosen strategies in classroom teaching, and document the process of their teaching research for both disseminating good teaching practice at other school and publishing the result in research journals. Collective lesson planning helps teaching research take place but teaching research in turn provides informative guide for effective collective lesson planning. Conducting teaching research allows teachers to learn from the process of integrating teaching and research and helps them become not only effective teacher but also scholar which advances their professional career. Many high school teachers in China published a numerous of papers in research journals after conducting teaching research projects; in the meantime, they are also recognized as highly effective teachers (Liang, 2012; 2013).

Teaching seminars. Chinese schools organize seminars regularly. Teaching experts or educational researchers are invited to give a talk in seminars for teachers to learn effective teaching strategies and keep up newly developed ideas of teaching and learning. Seminar topics are usually closely connected to teaching practice in order to provide opportunities for teachers to reflect on their own teaching practice while speakers share their teaching wisdom and experience. For example, an expert teacher could share a specific lesson she or he taught in which how an unexpected question from students could become a good opportunity leading to a teachable moment. Seminar talks and discussions help broaden teachers' knowledge for teaching and learning. What is learned in teaching seminars will be discussed and incorporated into lesson designing and classroom teaching. Seminars could be on-site presentations or online videos of experts' teaching or talks.

This PD model adapt this Chinese model of professional development to engage the participating faculties including new faculties and part-time faculties in the teaching research which would help prospective teachers' learning with conceptual understanding by integrating meaningful mathematical problem solving into the entire curriculum. The teaching research conducted would also help the participating faculties learn from the process and grow professionally; specifically, provide opportunities for new

faculties and part-time faculties to learn in a supportive professional learning community and fit in their new role of teaching without feeling isolated and struggling alone.

The criteria for worthwhile mathematics problem. This mode of PD will also have a group of faculty working collaboratively to integrate meaningful mathematical problem solving throughout the mathematics curriculum for future teachers. Incorporating worthwhile mathematics problems with teaching takes a process of selecting, modifying, and carefully designing. The participating faculty will follow the criteria for a good mathematics task proposed by Lappan and Phillips in1998 and modified by Cai and Lester later (2010):

- The problem has important, useful mathematics embedded in it.
- The problem requires higher-level thinking and problem solving.
- The problem contributes to the conceptual development of students.
- The problem creates an opportunity for the teacher to assess what his or her students are learning and where they are experiencing difficulty.
- The problem can be approached by students in multiple ways using different solution strategies.
- The problem has various solutions or allows different decisions or positions to be taken and defended.
- The problem encourages students' engagement and classroom discourse.
- The problem connects to other important mathematical ideas.
- The problem promotes the skillful use of mathematics.

Implementation

The participating faculty will work collaboratively to conduct the teaching research. Adapting the Chinese model of professional development, the teaching research activities will includes collective lesson preparation, teaching seminar, and classroom observation.

Collective lesson preparation. The participating faculties will meet regularly to design lesson plan together. In the lesson preparation sessions, they will

- studying lesson content and determine what materials to be used to facilitate students' learning
- discussing important knowledge points and concepts included in a lesson
- designing class activities connecting current knowledge to knowledge learned in the past and new knowledge in the future.
- identifying potential questions or difficulties students may have
- selecting mathematically worthwhile tasks
- deciding teaching strategies
- determining and organizing classroom activities

- sharing ideas and resources
- sharing class experience of effective teaching
- Reflecting on classroom discourse
- other related activities

Implementation of collective lesson preparation should be fully documented, including on-site discussion notes, selected teaching materials, student artifacts, shared assessment, etc. Collected data would be good resource to be analyzed qualitatively for providing supporting evidence for effectiveness or ineffectiveness of the teaching strategies applied in university mathematics teaching. The documentation will help accumulate knowledge for teaching mathematics and provide a useful guide for future lesson designing and preparation.

Teaching seminar. Seminar will be run monthly. Experts from local or other states will be invited to give talks related to content being taught in the mathematic curriculum for preservice teachers. Topics could include

- Problem-based learning
- Evidence-based effective teaching strategies
- mathematics education research
- connecting teaching practice to the current research
- video of live teaching

Teaching seminars are conducted to provide opportunities for the faculty to learn the most recent innovative teaching ideas and promote exchanging and sharing teaching wisdoms within the university and among institutions. After each teaching seminars, the faculties will reflect upon what learned and discuss how to utilize the proposed ideas to the classroom instructions in order to accomplish the goal of this project. Data will be collected, including video tapes of seminars, field notes, after-seminar discussions, evidence of implementation of seminar content in classroom teaching, etc. Analyzing the data will help understand what kind of teaching seminars is valuable to university faculty professional development for future improvement.

Classroom observation. Class observation is conducted to collect on-site teaching data to refine lesson designs for improvement. The observers could be other instructors teaching the same course or faculty involving designing the lesson. In order to constantly improve a lesson design, the group of faculty will observe each other's classes. Experienced teachers' classes are open for new faculty and part-time faculty to observe in order to provide opportunities for novice instructors to learn how to teach pre-service mathematics courses and gain knowledge for teaching these courses. Classroom observation will be followed by the following listed (but not exclusive) activities:

- reflecting on what happened in classroom teaching and why
- discussing if the selected task brings out the expected result

- discussing if the questions designed are effective
- discussing if classroom activities are organized in appropriate order
- revising a lesson design for improvement

New instructors could also observe classes to learn how implement the designed lesson in classroom teaching. The purpose of class observation is not to evaluate instructors' teaching but to analyze on-going teaching discourse for improving lesson design. Field notes, teachers' reflection, teaching materials, students' work, post-lesson discussions, and other related documentation will be collected and analyzed inductively to provide a rich description of the teaching research process and results which may reveal valuable findings for improvement of mathematics teaching and learning. A virtual communication (eg. google doc) could be added as a supplemental way for the learning community to share ideas and resources.

This model of PD aligns with the Common Core Standards for Mathematical Practices. The participating faculty will constantly learn how to

- effectively engage students' doing mathematics
- support students to make sense of mathematics
- help students develop the habits of mind outlined in the Common Core Standard
- deepen students' understanding of mathematical concepts
- support students to become independent problem solver

Discussion and Conclusion

This proposed PD model adapts the Chinese K-12 PD model of Teaching Research which has been established and applied all over in China. Each component of Teaching Research has played an active role in helping Chinese Teachers develop their teaching expertise (Liang, 2013). Collective Lesson Preparation conducted by a group of teacher provides an opportunity for teachers to collaborate and learn from each other as well as sharing teaching wisdoms. As one Chinese master teacher stated, "It is teamwork. The outcome comes from collective intelligence. If you do it yourself, you would not improve as fast, especially for young teachers". Another Chinese expert teacher reflected her growing path, saying that "When I was young, I benefited from collective lesson preparation. When you just start teaching, if you depend only on your own ability and but not learn from other teachers, you would not improve very fast" (Liang et al., 2012, p 155). Teaching seminar was recognized by Chinese teachers in terms of helping them reflect on their own teaching, learn innovative teaching ideas, and keep their knowledge of teaching and learning updated (Liang et al., 2012). Class observation was regarded as a powerful tool of improving teaching by teachers in China. In the same research mentioned above, all the interviewed

teachers had agreed that class observation was a learning process that benefited teaching significantly (Liang et al., 2012).

The PD model of teaching research has been helping Chinese teachers constantly improving teaching and as a result improving students' learning outcome. This paper attempts to have this model adapted and applied in the US university teacher preparation program aiming to improve faculty's teaching and pre-service teachers' learning outcome. The proposed model will utilize collective teaching wisdom including existing evidence-based teaching strategies, developed learning theory, experts' suggestions, faculty's collective intelligence, and online resources of good teaching practice. Adapting the Chinese model of *Teaching Research*, a group of faculty will work collaboratively to integrate research into teaching practice in preservice teachers' mathematics courses. The process of *Teaching Research* will provide rich opportunities for faculty to learn from each other and grow professional as a team. What being learned from integrating meaningful mathematical problem solving throughout the preservice teachers' mathematics curriculum will help improve the teacher preparation programs in the implemented institutions. The process of implementing the PD model would also make contribution to develop and refine the knowledge for teaching mathematics; specifically, advance the knowledge of future teachers' preparation. It will add some evidence-based effective mathematical teaching practice to the literature of mathematics education field. In addition, it will illustrate how some mathematical teaching approaches work effectively and why some others don't work as expected. Knowledge for preparing mathematics teachers will be accumulated through the process of this project to improve the existing research in STEM teaching.

Even though the Chinese model of teaching research is a novel approach in the US universities, the impact of implementation could be very promising. Engaging in the activities of teaching research, the participating faculties utilize the collective teaching wisdoms and implement effective teaching approaches in their mathematical instruction in the college classrooms. This PD model can support faculties to learn and practice evidence-based effective teaching and sustain the good teaching practice to constantly improve students' learning outcomes. On the one hand, this PD model will bring the faculty together pursuing professional growth that will positively impact the STEM teaching; on the other hand, incorporating meaningful mathematics problem solving into the curriculum for preservice teachers will change the prospective teachers' mathematics learning experience and the impact will go beyond extending to their own classroom teaching. In addition, this project will help future teachers be prepared to teach under the Common Core State Standards. The result of implementing the PD model can be disseminated in professional conferences and what is learned from the process can be shared with the mathematics education community in the US and all over the world through peer-reviewed research journals. Finally,

the documentation of implementing the proposed PD model could make significant contribution to enrich knowledge for teaching mathematics through faculty's diligent collaboration.

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