## PRELIMINARY REPORT: INTERCULTURALLY RICH MATHEMATICS PEDAGOGICAL CONTENT KNOWELDGE FOR TEACHER LEADERS

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We report on our work to build an interculturally aware theory for pedagogical content knowledge (PCK) in the context of teacher leadership. The effort is based on existing and continuing work on developing pre- and in-service teacher classroom PCK and intercultural competence. The RUME session focused on two discussion topics. Discussion Item 1: How do we identify and capture evidence of what might be called "teacher leader pedagogical content knowledge" in interculturally aware ways? Discussion Item 2: What question formats (for written assessments, surveys, interviews) might be productive for eliciting information from teacher leaders about their awareness of and attention to the intercultural aspects of mathematics instruction? ...of mathematics itself?...of teacher leadership?

Key words: pedagogical content knowledge, teacher leader, intercultural competence

## Relation of the Work to the Research Literature

Teacher leaders are experienced teachers who take on responsibilities and risks to improve students' educational opportunities while working collaboratively with fellow teachers, administrators, and others (Yow, 2007). Many teacher leaders are mentors to colleagues such as math coaches or facilitators of teacher professional development (Borko, 2004), conduits of communication with administrators, and collaborators on educational policy, research, curriculum product development, and school law (Dozier, 2007; York-Barr & Duke, 2004). Many who identify themselves as teacher leaders report entering leadership positions without any formal training, particularly in adult teaching and learning (Lieberman & Miller, 2007; York-Barr & Duke, 2004). Much of the work of a teacher leader involves negotiating meaning across professional and personal cultural differences.

Several frameworks currently exist for professional contexts that involve understanding, interacting, and communicating with people from various "cultures." In particular, healthcare and international relations groups have generated tools for personal and professional growth based on the theory of intercultural development and communication (Bennett, 1993, 2004; Hammer, 2009). "Culture" can include professional and classroom environments as well as personal or home experience. In this sense, several cultures - sets of values and ways of communicating about them - are involved in doing the work of teacher leadership. A university partnership, the Mathematics Teacher Leadership Center (MathTLC), is investigating the potential for university-based mathematics teacher leadership development that involves a partnering of mathematics disciplinary knowledge growth and leadership learning (this appears to be a relatively unexplored area of collegiate mathematics education research). Members of the MathTLC program include teacher leaders (teachers whose current or near-future job roles include leadership responsibilities), university mathematics and mathematics education professors who are instructors in the program, and graduate student and faculty mathematics education researchers. One goal of the MathTLC project is contributing an interculturally aware theory about pedagogical content knowledge (PCK) in

the work of mathematics teacher leaders (TLs). In this work we build on existing efforts related to mathematics classroom teacher PCK (Hill, Ball, & Schilling, 2008; Jackson, Rice, & Noblet, 2011) and intercultural competence development (DeJaeghere & Cao, 2009).

## **Research Questions**

Given the ultimate goal of building a theory for mathematics teacher leader PCK, we started by identifying what might be included under the heading "teacher leader pedagogical content knowledge" (TL-PCK). We have relied on the rich practice-based literature and the available research on teacher leadership, particularly in mathematics and science. The underpinning for the definition of TL-PCK is the nested conception of content and context shown in Figure 1. Mathematics PCK is knowledge for teaching mathematics based in the content-teacher-learner triadic interaction. For mathematics teachers, this triad is represented in Region 1 (math-teacher-student). Teacher PCK about mathematics is in use in Region 1 and PCK is developed by a teacher-as-learner in Region 2 (for example, during a districtoffered professional development workshop that uses analysis of the mathematical ideas in a lesson as the base "content" for the workshop). Similarly, teacher leader PCK is knowledge about the "content" that is Region 1 and can include knowledge of separate and interlinking processes such as knowledge of mathematics, of students, of teachers, of classroom contexts, as well as integrated concepts such as teachers' PCK, student thinking about mathematics, forms of mathematical discourse, and the nature of socio-mathematical norms. TL-PCK about Region 1 is in use in Region 2 and may be further developed in Region 3. That is, a significant portion of what might be called TL-PCK is associated with knowledge of Region 1 and the implementation/adaptation of it during use in Region 2. Just as many are attending to the role of multicultural awareness and responsiveness for teachers to be effective with students within Region 1 (Gay, 2000; McNeal, 2005), a question for us is the role of intercultural awareness in the packing and unpacking of knowledge of Region 1 as it happens in-the-moment in Region 2 as teacher leaders do their work. This has lead to the driving questions for our current work: How can attention to intercultural competence play a role in the development, assessment, and refinement of TL-PCK? In what ways do self-awareness and awareness of others as cultural support mathematics teacher leadership development?



Figure 1. Nested model for teacher leadership: Regions 1, 2, and 3 are labeled at their respective centers.

### **Theoretical Perspective**

Our efforts rely on two theories: one for intercultural competence development for mathematics teaching and learning in post-secondary settings and one for PCK. The first is based on the *Developmental Model of Intercultural Sensitivity* (Bennett & Bennett, 2004). A developmental model of orientation towards cultural difference, it includes lower and upper anchor orientations, intermediate orientations, and descriptions of the transitions among the orientations. Associated with the *Developmental Model of Intercultural Sensitivity* in our work is an explicit attention to aspects of discourse based on effective intercultural conflict resolution (Hammer, 2005). See Figure 2 for a visualization we have found useful in describing the stepping places and transitions.



Figure 2. Intercultural competence developmental continuum

The continuum of orientations runs from a monocultural or ethnocentric "denial" of difference based in the assumption "Everybody is like me" to an intercultural and ethnorelative "adaptation" to difference. The development from denial to the "polarization" orientation comes with the recognition of difference, of light and dark in viewing a situation (e.g., Figure 2a). The polarization orientation is driven by the assimilative assumption "Everybody should be like me/my group" and is an orientation that views cultural differences in terms of "us" and "them." A developing tendency to deal with difference by minimizing it by focus on similarities, commonality, and presumed universals (e.g., biological similarities we all have to eat and sleep; and values - we all know the difference between good and evil and agree on what they are) leads to the minimization orientation. A person in minimization will, however, be blind to deeper recognition and appreciation of difference (e.g., Figure 2b, literally a "colorblind" view). Transition from a minimization orientation to the "acceptance" of difference involves attention to nuance and a growing awareness of oneself as having a culture and belonging to cultures (plural) that differ in both obvious and subtle ways. In the acceptance orientation, people are aware of difference and the importance of relative context, but how to respond and what to respond in the moment of interaction is still elusive. The transition from acceptance to "adaptation" involves developing frameworks for perception, and behavior shifting skills, that are responsive to a full spectrum of detail in an intercultural interaction (e.g., the detailed and contextualized view in Figure 2c). Adaptation is an orientation wherein one may shift cultural perspective, without loosing or violating one's authentic self, and adjust communication and behavior in culturally and contextually

appropriate ways. There are several ways that knowing one's orientation, or the normative orientation of a group, can inform teacher leader development.

Intercultural theory gives a language for thinking and talking about how we each come to communication. This includes communication across orientations and how we respond to the variety of orientations in a room. The theory also gives a language to develop awareness, to indentify and discuss perspectives about difference and similarity in educational contexts, and for calibrating self-efficacy (e.g., adjust judgments of ability to successfully complete task X to take into account how others involved in task X define "success"). In particular, at the conference we focused on:

*RUME Session Discussion Item 1:* How do we identify and capture evidence of what might be called "teacher leader pedagogical content knowledge" in interculturally aware ways?

*RUME Session Discussion Item 2*: What question formats might be productive for eliciting information from teacher leaders about their awareness of/attention to the intercultural aspects of mathematics instruction? ... of mathematics itself?...of teacher leadership? This includes questions for written instruments, interviews, and surveys.

## Methods

The work we brought to the conference session is part research and part development. Our continuing research into the nature of professional learning and experience for mathematics teacher leaders and secondary mathematics teachers has included codevelopment of measures for, and theory around, the knowledge for teaching secondary mathematics as well as the knowledge for mathematics teacher leadership. The focus at the conference was giving a situated view of the theory development for TL-PCK *and* the coevolving development of measures (written and interview) for TL-PCK.

Our exploration of the intercultural aspect of teacher leadership and the nature of pedagogical content knowledge for teacher leaders is mixed-methods. Quantitatively, we have relied on several existing measures and two project-developed instruments. Qualitatively, our work has included interviews, observations, and examination of documents. For the RUME 2012 session, to contextualize the Discussion Items, we gave an overview of results from several components of the MathTLC research program. The MathTLC program members (teachers, teacher leaders, graduate students, post-docs, and faculty), all completed a 50-item validated and reliable *Intercultural Development Inventory* (see idiinventory.com) that provided intercultural orientation profiles of stakeholder groups. To date, we have completed thematic and categorical coding of teacher leadership program application essays along with initial cognitive interviews and piloting of written assessments of teacher leader pedagogical content knowledge.

Participants in research data gathering for the MathTLC research program have included, to date, 14 teacher leadership program participants (teachers of grades 4-12), 42 master's program students (secondary mathematics teachers of grade 6-12), and 18 university faculty, graduate student mathematics education researchers, and post-doctoral researchers.

#### **Results and Development at RUME 2012 Session**

To give a sense of the teacher leader population in the project and a preliminary portrait of TL-PCK and cultural awareness, we summarize analysis of application essays for 14 teacher leaders (the first of four planned cohorts) in Figures 3 and 4. Essays prompts were about (1) ideal classroom, (2) significant experiences prompting a move to leadership, and (3) personal and professional goals.



Figure 3. Teacher leader applicant professional learning goals.



Figure 4. Significant experiences prompting a focus on leadership

Many TL participants talked about the desire to understand another persons' perceptions: "I hope the program will help me gain a deeper understanding of how other teachers view their teaching of mathematics" and a to "translate my knowledge and skills as a classroom teacher into pedagogical knowledge about adult teachers learning math and learning to teach math to diverse population." Reports on goals included "My hope would be that through my participation in this program I would gain the skills and knowledge to improve my own teaching, better meet the needs of the diverse population of County High School and to influence more classroom teachers to be involved in the school improvement process from the classroom to the national level." For context, we offer also Figure 5, showing the distributions of intercultural orientations of program members along with a reference set of additional stakeholders: secondary mathematics teachers (the "students" of the program's teacher leaders). As a group, the teachers' orientation has been normatively in polarization while the teacher leaders have been largely at the lower end of minimization and university folk largely in minimization.

As part of the research process, we have conducted group profile debriefing sessions with teachers, teacher leaders, and university staff and asked how knowledge of these orientations (for oneself and awareness that they exist for others) might play a part in their professional work. We have also created items used on a written instrument and in interviews with teacher leaders to look at the various aspects of the TL-PCK model shown in Figure 1.



Figure 5. Distribution of intercultural orientations for stakeholder groups

As discussed in the conference session, one of the challenges for the researchers is acknowledging minimization tendencies in developing measurement instruments and attending carefully to nuances in professional cultural differences. Here cognitive interviews with teachers with polarization and acceptance orientations have been most helpful. The noticing of difference by these teachers (both large scale and subtle) has helped researchers acknowledge differences in assumptions about what constitutes mathematical understanding, awareness of others, and the relative importance of these in instructional decision-making. This was foregrounded in the conversation about Example 2. Below, we give several examples along with a summary of the session discussions of the Examples 2 and 3.

## Example 1

- *Part 1.* Create a story problem whose solution would require  $8^{\text{th}}$  grade students to solve the following for *x*: 5x 3 = 12.
- *Part 2.* What challenges might you expect the students to encounter in doing your story problem?
- *Part 3.* Now think about helping teachers in a PD workshop to build skills in writing story problems. What challenges might you expect 6<sup>th</sup> to 8<sup>th</sup> grade teachers to encounter in creating such a story problem?
- *Part 4.* [Given examples of two different teachers problem posing efforts either on video or in writing] How would you respond to each of the teachers?

# Example 2

You are planning a PD workshop on responding to student thinking. The participants are ten 6<sup>th</sup> grade teachers with whom you work each month. To get an idea of where the group is in making sense of student thinking, you ask teachers to work on a question at the end of the previous workshop (see Figure 6). In looking at teacher answers, you notice that 7 of the 10 teachers answer the question like the example on the left (Figure 7a) and 3 of the 10 answers are similar to the one on the right (Figure 7b).

*Question 1:* What have you learned about the group of teachers from their answers? *Question 2:* How might you use their answers as you make plans for your workshop?

- 1. Ms. Sepastin reports working with her class on divisibility rules. She told her class that a number is divisible by 4 if and only if the last two digits of the number are divisible by 4; for example, 7,548 is divisible by 4 because 48 is. One of her students asked her why the rule for 4 works. She asked the other students if they could come up with a reason, and several possible reasons were proposed.
- 1.1. Which of the following statements comes closest to explaining the reason for the divisibility rule for 4?
- (A) Four is an even number, and odd numbers are not divisible by even numbers.
- (B) Once you subtract the number represented by the last two digits, the number that remains (e.g., 7,500 in the example above) is a multiple of 100, and any multiple of 100 is divisible by 4.
- (C) Alternating even numbers are divisible by 4, for example, 24 and 28 but not 26.
- (D) It only works when the sum of the last two digits is divisible by 4 (4+8=12, in this example), just like the rule for divisibility by 3.

1.2. Below, for each of the student statements, describe what you consider to be appropriate teacher responses:

Figure 6. Example 2 detail: Multi-part question answered by teachers

Since the responses offered in Example 2 were distilled from actual teacher answers on a separate assessment that included the item in Figure 6, discussion in the conference session included expressions of concern that the example teacher answer in Figure 7b is mathematically incorrect and that teacher leaders, especially early in a TL experience, might have similar challenges with mathematical content. A generally agreed upon suggestion was that those completing the instrument be asked to do the problem shown in Figure 6 on a separate page before coming to the item as a teacher leader. That is, first ask for activity in Region 1, then ask for activity in Region 2. Such a process is certainly consonant with common mathematics teacher professional development practice – first engage with "content" (do the math) then consider student thinking about the content. Second, given the complexity of attending to intercultural aspects and mathematical PCK of teachers along with

mathematics content knowledge of teachers present in Figures 7a and 7b, it was suggested that an interview might be a more productive venue for directing attention as needed than attempting to do it in a written instrument. That is, perhaps teacher leadership participants would complete items like those in Figure 6 (Region 1 engagement) on paper and then revisit the context as a leader (Region 2 engagement) during an interview (possibly revisiting their own work before and/or after engaging with analysis of Figure 7).

(A) That is true. How can you apply that to this situation? What happens when you have even numbers in this situation? None of the students (B) Good thinking. Can you show that works all the time? are right; A& C probably because they dont speak (c) That is the. How did you apply that to this situation? English, and B & D probably because they What would happen IF you just are talking math had a really by number and you were trying to test your theory? words, so I would encourage them to try (D) some examples on their That is a good observation. abut 18. Dies it works calculators to see if they can find a pattern. For 12?

Figure 7a.

Figure 7b.

## Example 3

Discussion of Example 3 (see Figure 8a, next page), though brief, allowed session attendees to review teacher leader responses to a Region 2-focused item and propose follow-ups to elicit more. Nine of the 10 teacher leaders who responded to the item gave answers like those shown in Figure 8b (next page). These responses seemed to many in the RUME session to be more characteristic of a traditional response one might expect from a teacher to a student (Region 1 activity). The exception was the teacher leaders who said: "Explain how you arrived at your answer." How teachers and teacher leaders follow-up with students, when students say or give a correct answer, is an ongoing area of research for the project. This brought up the additional question, during the session, of how teacher PCK activated in Region 2 is repackaged for use in Region 1. For example, besides modeling the behavior, what can facilitators do in Region 3 to scaffold teacher leaders to prompt with "Why" questions to build on teacher correct answers in Region 2 and to have teacher leaders scaffold teachers in asking "Why" questions in Region 1?



- Please answer the question below AND address the question that follows:
- 9.1. The figure above is a graph of a differentiable function. Which of the following could be the graph of the first derivative of the function?



9.2. You pose the question above to teachers in your professional development course. Of them, 68% chose (B), 19% chose (D), and 13% left the item blank. How would you respond to the teachers who chose option B?

#### Figure 8a. Test item.

B is correct because you at derivative graph is the I the slopes of the fargert the slope at a is lenes, a. The Alopes of the are

You are correct. Explain how you arrived at your

you are correct! The derivative represents x70when When X=a.

Figure 8b. Responses

#### Conclusion

Intercultural orientation is embedded in each Region in Figure 1 (a content-teacherlearner interaction, including the interaction arrows of the model in Figure 1). That is a great deal of intercultural interaction. How and what a teacher leader notices, how and what a teacher notices, and what a teacher leader does with the noticed things in working with teachers are all connected to self-awareness and other-awareness; linked to the intercultural orientations of all in the professional development classroom. Though beyond the scope of this report, we are also attending to Region 3, the experiences of university teacher leader educators, whose students are teacher leaders and for whom the "content" is the entirety of Region 2 (including Region 1 as a sub-area).

In thinking about TL-PCK we have relied on the layered model shown in Figure 1, where Region 1 is the "content" in TL-pedagogical "content" knowledge. In our session we talked with the audience about how intercultural aspects of TL-PCK and PCK live in the model. Emergent from the conversation at the conference was the importance, in teacher leadership, of developing the wide area of socio-cultural knowledge needed for teacher leaders to work

with administrators, policy makers, and others whose primary work is not itself in Region 1. As we move forward with cognitive interviews we plan to fold in questions about this aspect, which may prove to be orthogonal to the plane in which Figure 1 resides.

## References

- Aud, S., Fox, M., & KewalRamani, A. (2010). Status and Trends in the Education of Racial and Ethnic Groups (Tech. Report; NCES 2010-015). U.S. Department of Education, National Center for Education Statistics. Washington, DC: U.S. Government Printing Office.
- Bennett, M. J. (2004). Becoming interculturally competent. In J. Wurzel (Ed.), *Towards multiculturalism: A reader in multicultural education* (2nd ed., pp. 62–77). Newton, MA: Intercultural Resource Corporation.
- Bennett, M. J. (1993). Towards ethnorelativism: A developmental model of intercultural sensitivity. In R. M. Paige (Ed.), *Education for the intercultural experience* (2<sup>nd</sup> ed., pp. 21-71) Yarmouth ME: Intercultural Press.
- Bennett, J. M. & Bennett, M. J. (2004). Developing intercultural sensitivity: An integrative approach to global and domestic diversity. In D. Landis, J. M. Bennett, & M. J. Bennett (Eds.), *Handbook of intercultural training* (pp. 147–165). Thousand Oaks, CA: Sage.
- Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher*, 33(8).
- DeJaeghere, J. G., & Cao, Y. (2009). Developing U.S. teachers' intercultural competence: Does professional development matter? *International Journal of Intercultural Relations*, *33*, 437-337.
- Dozier, T. K. (2007). Turning good teachers into great leaders. *Educational Leadership*, 65(1), 54-58.
- Hammer, M. R. (2009). Solving problems and resolving conflict using the intercultural conflict style model and inventory. In M. A. Moodian (Ed.), *Contemporary leadership* and intercultural competence: Exploring the cross-cultural dynamics within organizations (pp. 219-232). Thousand Oaks, CA: Sage.
- Hill, H.C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal* for Research in Mathematics Education, 39(4), 372-400.
- Jackson, B., Rice, L., Noblet., K. (2011). What do we see? Real time assessment of middle and secondary teachers' pedagogical content knowledge. In S. Brown (Ed.) *Proceedings* of the 14<sup>th</sup> annual conference on Research in Undergraduate Mathematics Education.
- Lieberman, A., & Miller, L. (2007). What research says about teacher leadership. In R. H. Ackerman, & S. V. Mackenzie (Eds.), *Uncovering teacher leadership: Essays and voices from the field* (pp. 37-50). Thousand Oaks, CA: Corwin Press.
- McNeal, K. (2005). The influence of a multicultural teacher education program on teachers' multicultural practices. *Intercultural Education*, *16*(4), 405-419.
- York-Barr, J., & Duke, K. (2004). What do we know about teacher leadership? Findings from two decades of scholarship. *Review of Educational Research*, 74(3), 255-316.
- Yow, J. (2007). A mathematics teacher leader profile: Attributes and actions to improve mathematics teaching & learning. *Journal of Mathematics Education Leadership*, 9(2), 45-53.