PROFESSIONAL DEVELOPMENT OF MATHEMATICS AND SCIENCE TEACHERS IN COMMUNITIES OF PRACTICE: PERCEPTIONS OF "WHO IS MY COMMUNITY"

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This paper investigates views of mathematics/science teachers and higher education faculty interacting in professional development projects adding a community of practice component. Knowledge acquisition in a community of practice relates to ongoing interactions among members as they perform their roles and responsibilities. In particular, the paper reports each group's perceptions of community and discusses implications for state-level programs funding professional development projects.

Introduction

As paradigms for teacher professional development shift from a "training-and-coaching model" whereby university-generated research is disseminated to teachers through workshops and university courses (Corcoran, 1995) to a learning community model that promotes educators learning together about professional matters (Darling-Hammond, 1996), professional development endeavours must reflect a community orientation. Projects to "promote improved instruction in mathematics and science for Texas school children by providing professional development for their teachers" (http://www.thecb.state.tx.us/os/TQ/), such as those funded by the *Texas Teacher Quality Grants Program* (TQGP), rely on the experiences and expertise of higher education faculty. However, higher education content faculty in the United States seldom interact with education faculty and classroom teachers outside these programs; therefore, including a community of practice component may produce challenges for state-level programs.

Guiding framework

The National Council of Teachers of Mathematics (NCTM) describes professional development for mathematics teachers in terms of community by describing roles for various stakeholders in mathematics education, including higher education (NCTM, 2000). More specifically, the National Staff Development Council (NSDC) proposes a community model stating that educators should organize "into learning communities whose goals are aligned with those of the school and district" (http://www.nsdc.org/standards/index.cfm). Descriptions of effective professional

development of teachers also suggest a community design in which teachers learn in teams, reflect together on their learning, and connect their learning to the classroom (Lee, 2001; Little, 2003). Learning in a community is a theme that is interwoven throughout Timperley's (2008) ten general principles for effective teacher professional development, in terms of student outcomes, that are based on her synthesis of ninety-seven studies from around the world. Knowledge of content and instructional practices are hallmarks of most effective professional development programs, but this knowledge does not solve the problem of enactment (Darling-Hammond, Bransford, LePage, Hammerness, & Duffy, 2007). Teachers must also adapt their practice based on this knowledge. Providing opportunities for teachers to practice and reflect on instructional approaches is crucial to them moving from knowledge to action, and communities of practice provide a forum for this sustained, long-term professional learning.

As state-level programs transition to funding community-oriented professional development projects, many adopt the paradigm of a community of practice, that is, a "group[s] of people who share a concern, a set of problems, or a passion about a topic, and deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger, McDermott, & Snyder, 2002, p. 4). A basic model for a community of practice entails three components: domain, community, and practice. Community involves the social feature of the group that develops trust and contributes to learning in a safe environment as well as the roles and responsibilities of members (Wenger, et al., 2002). However, models for the design of communities are difficult to describe (Barab, Barnett, & Squire, 2002; Barab, MaKinster, & Scheckler, 2003; Barab, Schatz, & Scheckler, 2004; Hung, Chee & Hedberg, 2005; and McConnell, 2005). In addition, aspects of communities of practice relate to members interacting in group settings (Glazer & Hannafin, 2006), and group interaction among teachers offers strong affective and supporting components to acquisition of knowledge (Rovai, 2002). As Little (2006) summarizes in speaking about the potential of professional communities, "For more than two decades, research has shown that teachers who experience frequent, rich learning opportunities have in turn been helped to teach in more ambitious and effective ways. Yet few teachers gain access to such intensive professional learning opportunities" (p. 1).

Geography also poses challenges for educational endeavors. For example, the state of Texas is the second largest in land area in the United States and is slightly larger than France (https://www.cia.gov/library/publications/the-world-factbook/index.html). The state's population is over 24 million people compared to Australia with slightly over 21 million (http://www.census.gov/). Texas educators teach a common set of standards to about five million students from diverse ethnic and economic backgrounds (African American 14%, Hispanic 48%, White 34% Others 4%, Economically Disadvantaged 56.7%) (http://ritter.tea.state.tx.us/perfreport/snapshot/2009/state.html). Since research indicates that geography affects human activities such as art and culture (Hassani, 2009), economic status (Gittell, 2009), health care (Arcury, Gesler, Preisser, Sherman, Spencer, & Perin, 2005), entrepreneurship (Gupta & York, 2008), per capita income as well as university education (Basher & Lagerlof, 2006), it seems reasonable that geography could also affect educators' concept of community.

Thus, an issue for state-level programs is the structure of professional development in a community of practice designed by higher education faculty. If teachers are to gain

knowledge and to change their classroom practices based on that knowledge by interacting with and developing trust among community members, then the question arises "who is my community?" In particular, how do higher education faculty and teachers who comprise a community of practice perceive community in terms of membership? How do they perceive the roles and responsibilities of members?

Method

Exploration of the concept of community as perceived by directors and participating mathematics and science teachers occurred through a case-study design. Qualitative research through structured interviews, observations, field notes, and other "rich" data sources offers researchers avenues to answer questions such as "What is going on here? What does this mean? Why do the participants behave this way?" Nine projects funded by the *Texas Teacher Quality Grants Program* comprised a case for this study that served as a pilot for the program's state-wide evaluation. To account for Texas' geographical influences, the projects, chosen by TQGP staff, represented six geographical regions of Texas. Interviews with nine project directors and eight sets of teachers took place face-to-face on the campuses of the higher education institutions that received the funding. One set of teachers answered questions during one of their project's online sessions. Table 1 depicts a summary of the projects.

Table 1. Participating Teacher Quality Grant Program *projects.*

Geographical Region	*Number of Teachers*
East Texas	3
Coastal Region	3
South Texas	4
Central Texas	2
North Texas	5
West Texas	3

Digital voice recordings and field notes recorded the data collected during each site visit. As part of the interview process, the researcher stated that TQGP views their projects to be communities of practice and gave each interviewee a sheet of paper with Wenger et al.'s (2002) definition of a community of practice recorded on it. Then the researcher read the definition out loud to the interviewees. Following this reading, project directors and teachers answered questions that asked them to state who were the members of their community and to describe the role and responsibilities of the members. Next observations of professional development activities by the researcher occurred and recordings of interactions between teachers and projects directors took place. Analysis of the data transpired through a triangulation process that compared project directors' responses, teacher-participants' responses, and observations during project activities as directors and teachers interacted.

Findings

A disconnect existed between project directors' and teachers' perceptions as to the members of a TQGP community of practice (see Table 2). Seventy percent (70%) of

project directors stated that both teachers and project staff are part of the community; however, only 32% of teachers reflected this same view. Some teachers (37%) described their community as one that excludes higher education faculty and consists only of participating teachers in the project. Other teachers (32%) ignored the TQGP project and described their community as teachers, administrators, and students in their schools. Other perceptions of community held by teachers extended the concept of community to include the school and the community at large; whereas another limited community to TQGP participants who were going through a Master's degree program together.

Table 2: Members of community.

Perception of community membership	*Percent of project directors*	*Percent of teachers*
Teachers, principal, administrations, students, parents, business leaders, university staff & faculty	10%	16%
Teachers in TQGP projects pursuing Masters degree	0%	5%
Teachers only in TQGP project	0%	37%
Teachers in TQGP project & project staff	70%	32%
1) Teachers & staff in current TQGP project 2) Teachers in past/current TQGP projects pursing Masters degree	10%	0%
Teachers, students, & administrators at school	10%	10%

Both project directors and teachers described community membership in visual terms (see Figure 1). One project director described her TQGP community of practice in terms of two TQGP communities with overlapping members, but possessing different goals.

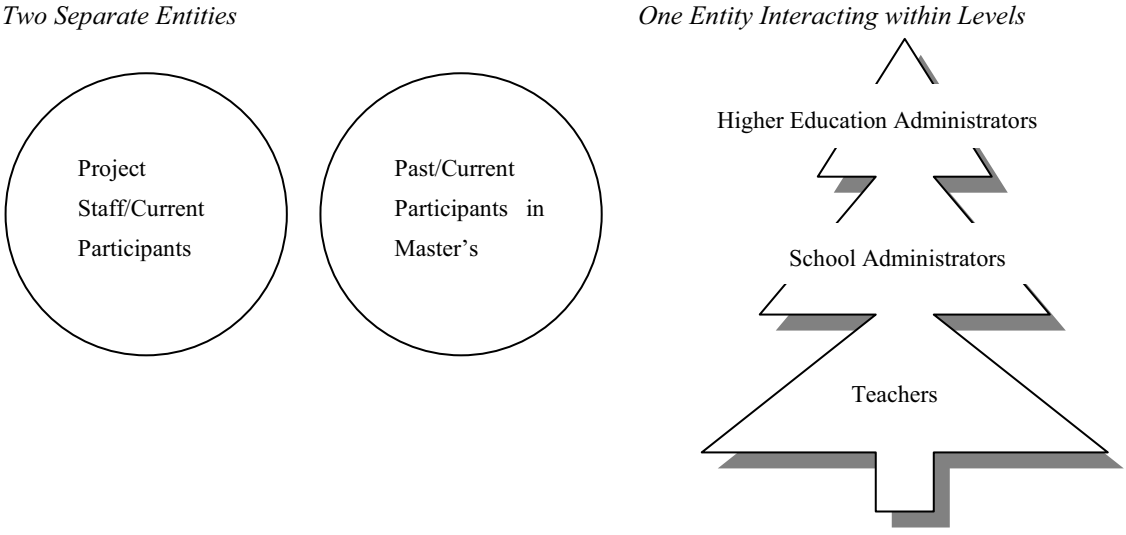
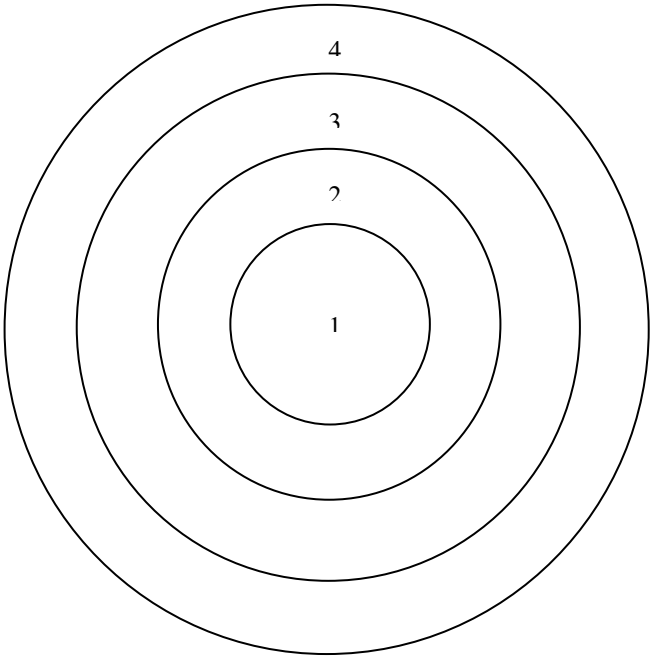


Figure 1: Visualisation of community by two project directors

Interestingly, the interviewed teacher from that project who enrolled in the Master's program expressed only one view—those past/current participants in the master's degree program—and completely discounted other teachers who did not pursue the

degree. Another project director described the TQGP community as a tree whereby members at a particular level of branches communicate with each other but have limited communication with other branches. This description resembled, to some degree, NCTM's community as teachers can undergo professional development with various stakeholders in mathematics education but not in one activity.

In contrast, a teacher from a different project that was conducting lesson study, a site-based professional development model originating in Japan (Fernandez, 2003; Fernandez & Yoshida, 2004; Isoda, Stephens, Ohara, & Miyakawa, 2007; Lewis, 2002; Takahashi, 2000) described her TQGP community in terms of concentric circles, as shown in Figure 2. She referred first to a very small nucleus of teachers in her immediate lesson study group and expanded outward to include all teachers and staff in the project. She then extended community membership to others outside the project who provided expertise and support to those in the TQGP project. Similarly, another teacher in a project located in a different geographical region of the state that was beginning to implement lesson study expressed her TQGP community completely in terms of their lesson study effort, identifying teachers in the project, project staff, and consultants who assisted them with the lesson study process. These descriptions reflected more of NSDC's learning community concept.



1 Teachers in immediate lesson study group.
2 Higher education and other teachers who are knowledgeable about lesson study.
3 Teachers in TQ Project in other lesson study groups.
4 Others who help and support teachers.

Figure 2: Visualisation of TQGP community by participant.

Perceptions about the roles and responsibilities of members in the majority of TQGP projects held higher education faculty as dispensers of knowledge and providers of classroom activities. Members who are teachers were recipients of knowledge who discussed the activities in the TQGP community setting, took them back to their schools, and worked them with their own students or with other teachers. One project director added that he believes these roles and responsibilities result from teachers' perceptions of what constitutes professional development and not from the design intended by the project director who wanted teachers to take a more active role.

Members in another TQGP project perceived roles and responsibilities changing as project activities continued throughout the year. In this project, teachers and project directors were researchers in an outdoor learning environment during the summer. However, in the fall roles and responsibilities changed to participants being students in a class taught by project staff. These types of roles and responsibilities for community members followed more of a "training-coaching" model for professional development.

In projects that included an outreach component requiring site-based interactions, both teachers and project directors tended to view roles and responsibilities of members in terms of each one possessing some type of expertise that is of value to the community. In projects implementing Lesson Study, both groups cited learning together with each member being a different resource for the group, providing knowledge of content, pedagogy, curriculum, and student misconceptions. Their perceptions of the roles and responsibilities in their community is a feature of the Lesson Study model, a model that moves teachers from recipients of knowledge disseminated by others to practitioner-researchers of student learning (Takahashi & Yoshida, 2004). This view of roles and responsibilities as group learners with access to resources aligned to professional development described by Lee (2001) and Timperley (2008).

Discussion and conclusion

Since TQGP project directors' and teachers' perceptions of community do not align, these projects offering professional development using a paradigm of a community of practice are not well defined. Project directors consider themselves part of the community; however, the majority of teachers do not. Teachers generally perceive their communities in terms of other teachers. Those teachers who do include project staff view them as outside resources and supporters. This latter view is prevalent among members in projects with site-based components that require directors to interact with teachers in their classrooms. Although most projects do reflect community in terms of higher education as a stakeholder in mathematics and science education, teachers do not work side by side with higher education faculty to plan and contribute to their own professional development. Since a community of practice is about people learning together, this factor may contribute to teachers' exclusion of project staff from their concepts of community.

In most projects, roles and responsibilities of members follow traditional forms of professional development with higher education faculty being givers of knowledge, designers of activities, and modellers of pedagogy and teachers being recipients of knowledge, takers of activities, and implementers in their classrooms. However, in projects where interaction among members occur in the schools, especially in those implementing lesson study, descriptions of the roles and responsibilities view each member as an expert. For example, higher education faculty offer support and provide knowledge of content and pedagogy; whereas, teachers provide experiences about students thinking, curriculum, etc. Connecting learning in a community to student learning is a feature of effective professional development of teachers.

This analysis of TQGP projects as communities of practice reveals that more thought needs to be put into the design of professional development by higher education faculty. Since most project directors who structure these projects, especially those in content departments, have little experience with learning communities, state-level programs

need to consider how to provide this experience for them. In addition, these experiences need to include working in schools with teachers, especially in their classrooms, in outreach efforts to shift project directors' thinking from teachers as students to teachers who have students. Ultimately, the perceptions of project directors and teachers about members in their professional communities will play a major role if site-based professional development, which is indicative of improved teaching in mathematics and science for school children, materializes.

References

Arcury, T. A., Gesler, W. M., Preisser, J. S., Sherman, J., Spencer, J., & Perin, J. (2005). The effects of geography and spatial behavior on health care utilization among the residents of a rural region. *Health Services Research, 40*(1), 135–156.

Barab, S. A., Barnett, M. G., & Squire, K. (2002). Developing an empirical account of a community of practice: Characterizing the essential tensions. *Journal of the Learning Sciences, 11*, 489–543.

Barab, S. A., MaKinster, J., & Scheckler, R. (2003). Designing system dualities: Characterizing a web-supported professional development community. *Information Society, 19*, 237–256.

Barab, S. A., Schatz, S., & Scheckler, R. (2004). Using activity theory to conceptualize online community and using online community to conceptualize activity theory. *Mind, Culture & Activity*, *11*(1), 25–47.

Basher, S. A. & Lagerlof, N. (2006). *Geography, population density, and per-capita income gaps across US states and Canadian provinces*. University Library of Munich, Germany: MPRA Paper no. 369. Retrieved January 31, 2011, from http://ideas.repec.org/p/pra/mprapa/369.html

Corcoran, T. C. (1995). *Transforming professional development for teachers: A guide for state policymakers.* Washington, DC: National Governors' Association. Retrieved January 31, 2011, from http://www.aecf.org/upload/PublicationFiles/ED3622H115.pdf

Darling-Hammond, L. (1996, March). The quiet revolution: Rethinking teacher development. *Educational Leadership, 53*(6), 4–10.

Darling-Hammond, L., Bransford, J., LePage, P., Hammerness, K., & Duffy, H. (Eds.) (2007) *Preparing teachers for a changing world: What teachers shou*ld *learn and be able to do*. Jossey-Bass.

Fernandez, C. (2003). Learning from Japanese approaches to professional development: The case of lesson study. *Journal of Teacher Education*, *53*(5), 393–405.

Fernandez, C., & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning*. London, UK: Erlbaum.

Gittell, M. (2009). The effect of geography, education and labor market segregation on women's economic status in New York state. *American Behavioral Scientist*, *53*(2), 193–222.

Glazer, E. M, & Hannafin, M. J. (2006). The collaborative apprenticeship model: Situated professional development within school settings. *Teaching and Teacher Education*, *22*, 179–193.

Gupta, V. K. & York, A. S. (2008). The effects of geography and age on women's attitudes towards entrepreneurship: Evidence from the state of Nebraska. *The International Journal of Entrepreneurship and Innovation, 9*(4), 251–262.

Hassani, G. (2009). The effect of geography on art and culture. *International Journal of the Arts in Society*, 4(1), 267–272.

Hung, D., Chee, T. S., & Hedberg, J. G. (2005). A framework for fostering a community of practice: Scaffolding learners through an evolving continuum. *British Journal of Educational Technology. 36* (2), 159–176.

Isoda, M., Stephens, M., Ohara, Y., & Miyakawa, T. (Eds.). (2007). *Japanese lesson study in mathematics: Its impact, diversity and potential for educational improvement* (M. Stephens & M. Isoda, Trans.). Hackensack, NJ: World Scientific. (Original work published in 2005).

Lee, H. (2001). *Enriching the professional development of mathematics teachers*. ERIC Digest. ERIC Clearinghouse for Science Mathematics and Environmental Education. Columbus, OH. Retrieved January 31, 2011, from http://www.ericdigests.org/2003-1/teachers.htm

Lewis, C. (2002). *Lesson study: A handbook of teacher-led instructional change*. Philadelphia, PA: Research for Better Schools.

Little, J. W. (2003). Inside teacher community: Representations of classroom practice. *Teachers College Record, 105*(6), 913–945.

Little, J. W. (2006). *Professional community and professional development in the learning-centered school*. NEA Research. Washington, DC: National Education Association.

McConnell, D. (2005). Examining the dynamics of networked e-learning groups and communities. *Studies in Higher Education*, *30*, 25–42.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Staff Development Council. (2001). *Standards for staff development: Revised*. Oxford, OH: National Staff Development Council. Retrieved January 26, 2011, from http://www.nsdc.org/standards/index.cfm.

Rovai, A. P. (2002). Building sense of community at a distance. *International Review of Research in Open and Distance Learning, 3*(1), 1–16.

Takahashi, A. & Yoshida, M. (2004). Ideas for establishing lesson study communities. *Teaching Children Mathematics, 10*, 436–443.

Takahashi, A. (2000). Current trends and issues in lesson study in Japan and the United States. *Journal of Japan Society of Mathematical Education, 82*(12), 15–21.

Timperley, H. (2008). Teacher professional learning and development. *Educational Practices Series. International Academy of Education (IAE) and International Bureau of Education (IBE)*. Retrieved January 26, 2011, from http://unesdoc.unesco.org/images/0017/001791/179161e.pdf

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice*. Boston: Harvard Business School Press.