Session Number: **42**

Abstract Name: **Schools and Teachers as Connectors: Providing Access to Math and Science**
MSP Project: Rocky Mountain Middle School Math Science Partnership
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1. Questions(s) or issue(s) for dialogue at Learning Network Conference session:

In addition to content and pedagogical knowledge, how does a focus on "connected knowledge" enhance teachers professional learning and add to their instructional practice?

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2. Context of the work within the STEM education literature and within your MSP project:

Today, in a highly technological society, there is a greater urgency for students to heighten both their math and science content knowledge and what is being touted as 21st Century Skills such as inventive thinking, digital-age literacies, complex problem solving, and communication and collaboration (North Central Regional Educational Laboratory and the Metiri Group, 2003; Partnership for 21st Century Skills, 2006). Traditionally, we have always looked to schools and teachers to provide access to knowledge—to equalize access for future opportunity. "Virtually from the beginning of the campaign to establish a system of public education in the United States, advocates have argued that schools are meritocratic institutions that function to expend individual opportunities and further the social good (Beyer, 1996, p.1)." So the push for 21st Century knowledge and skills requires us to once again ask how teachers will acquire the knowledge and skills needed to provide this higher level of instruction in the classroom.

The Principles and Standards for School Mathematics document suggests that "teachers must know and understand deeply the mathematics they are teaching and be able to draw on that knowledge with flexibility in their teaching tasks" (NCTM, 2000, p. 17). In order to carry out the demands of 21st Century mathematics and science instruction, teachers need increased opportunities to broaden and deepen their professional knowledge. In particular, they need opportunities to gain knowledge of mathematics for teaching, including both specialized subject matter knowledge and pedagogical content knowledge (Ball, Hill, & Bass, 2005). In a similar vein, the National Science Standards state that "Science has a rapidly changing knowledge base and expanding relevance to societal issues, and teachers will need ongoing opportunities to build their understanding and ability" (p. 55). In addition, Loucks-Horsley, Hewson, Love, and Stiles (1998) call for professional development that concentrates on specific issues of science content that are derived from research and build on teachers' prior knowledge. The beginning of contemporary efforts to explore teachers' professional knowledge is typically attributed to Lee Shulman and his presidential address at the 1985 annual meeting of the American Educational Research Association, entitled "Those who understand: Knowledge growth in teaching." In the published version of that address, Shulman (1986) suggested that "we distinguish among three categories of content knowledge: (a) subject matter content knowledge, (b) pedagogical content knowledge, and (c) curricular knowledge" (p. 9). In this paper, however, we suggest that teachers also need "connected knowledge"-- knowledge of how to connect students to resources outside the classroom and the school that provides student access to components beyond what formal education or educators can supply. Knowledge that connects their pedagogical and content knowledge with others who can supplement and provide teachers with additional resources and expertise that can directly impact the classroom.

In order to take on this role, teacher professional learning must change so that teachers build connected knowledge outside school boundaries. They need to see and understand the resources and community assets available beyond the school walls in order to understand those factors that students need exposure and access to. Through this type of professional learning, teachers are able to re-think curricular and instructional innovation and become the link for students to the opportunities afforded them in a democratic society and to 21st Century learning. Schools must also begin to engage the community with the intent of creating symbiotic relationships.

In August 2008, the Rocky Mountain Middle School Mathematics and Science Partnership (RM-MSMSP) was awarded a Noyce Supplemental Award to engage Mapleton Public Schools middle and high school mathematics and science teachers in an effort to improve mathematics and science instruction across the district. The project goals and objectives are to: (a) develop a cohort of mathematics and science master teachers to improve practice in middle and high school mathematics and science classrooms across the district, (b) develop teacher leadership capacity in mathematics and science teachers serving students in urban school settings by exposing the cohorts to culturally responsive practices and/or teachers' leadership practices, such as curriculum/assessment design, reflective coaching, and data analysis and dialogue, in order to provide support and skill development in new mathematics and science teachers entering into the district, and (c) retain our most highly trained and recruited teachers in the system.

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3. Claim(s) or hypothesis(es) examined in the work (anticipating that veteran projects will have claims, newer projects will have hypotheses):

The presentation of this proposal is two-fold : (a) to introduce an ecological model, centered around the learner, which moves closer to equity and access for students who need math and science knowledge to be participants in democratic decision-making and for students whose interests and possible future economic sustainability are dependent on access to math and science knowledge and skills, and (b) to report the results of a study examining a professional learning program designed to capitalize on the partnerships noted above and use this model as a basis for experiential professional learning of mathematics and science teachers. The hypothesis, therefore, is that through this model, teachers attitudes, knowledge, and practice for teaching mathematics and science will change as a result of their participation in this type of professional learning opportunity.

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4. Evaluation and/or research design, data collection and analysis:

Data Collection

As part of the project evaluation (Swackhamer & Sutton, 2009), the participants were asked to complete a teacher survey and an end-of-course evaluation. The evaluation team also conducted a focus group with the teachers and observed many of the professional development activities.

Teacher survey. The teacher survey was designed to measure changes in teacher attitudes over time by utilizing a retrospective pre-test/post-test design. The teachers were given the survey at the end of the summer institute and asked to rate each item twice. First, according to how they felt before the program began, and second, how they felt at the end of the first year. The survey consisted of items measuring levels of preparedness to teach, confidence to teach, and math and science knowledge around the core factors of the project. The items were rated on a 5-point scale from 1 = strongly disagree to 5 = strongly agree.

End-of-course evaluation. The end-of-course evaluations were also given to the teachers at the end of the summer institute. The evaluations asked the teachers to indicate the degree to which they agreed with a number of statements regarding the overall quality of the professional development content and instruction and the overall utility of the sessions. These items were rated on a 5-point scale where 1 = strongly disagree and 5 = strongly agree. Additionally, the teachers were asked to respond to open-ended questions regarding what they liked best, what they might change, how they would describe the workshop to colleagues, potential impact on students, and what additional support they might need to implement these approaches into their classrooms.

Focus group. A teacher focus group was conducted during the summer institute and consisted of questions centered on changes in participant mathematics and science content knowledge and classroom practice; leadership roles and responsibilities; and challenges, possible solutions, and levels of support regarding implementation of activities into their classrooms.

Professional development experience observations. Five professional development experiences were observed at least once per month during the initial year of the program, including one field trip each to the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration (NOAA). The observation form focused on instructor’s delivery of content, instructor’s teaching style, instructional strategies used, and trainee behavior.

The data from the teacher survey was first analyzed for reliability and validity. Using SPSS, confirmatory factor analysis consisting of principal axis analysis with varimax rotation was conducted. Cronbach’s alphas were then computed on the revealed subscales to assess the internal reliability of each subscale. Paired samples *t* tests were computed for each subscale comparing the retrospective pretest responses to the posttest responses. Assumptions for each statistical test were checked and each was met. Qualitative data was analyzed using Constant Comparative Analysis, which is an appropriate analysis when the researcher is attempting to gain an overall understanding of the data and wishes to develop a possible theme based on the data (Strauss & Corbin, 1998). The analysis began with examining the data line by line. After all coding was completed; the codes were grouped into categories that were determined from examining the data. These groupings were then broken into subgroups that allowed for the development of a possible theme from the data.

Results:

Quantitative Results

The factor analysis conducted on the teacher survey confirmed the three factors of Preparedness to Teach Mathematics and Science, Confidence to Teach Mathematics and Science, and Level of Knowledge to Teach Mathematics and Science. The Cronbach's alpha coefficients for each scale were .69, .71, and .82, respectively. Paired samples t tests comparing the retrospective pretest responses to the posttest responses revealed statistically significant differences for each of the three scales. The participating teachers rated their preparedness to teach mathematics and science significantly higher after participation, $t(17) = 7.076$, $p < .001$, $d = 2.34$. They also rated their confidence to teach mathematics and science significantly higher, $t(17) = 6.305$, $p < .001$, $d = 1.20$, and their level of knowledge for teaching mathematics and science significantly higher after participation, $t(17) = 6.901$, $p < .001$, $d = 1.68$. The effect sizes, d, are considered much larger than typical according to Cohen (1988). Table 1 displays the means and standard deviations for each of the scales.

Table 1

Means and Standard Deviations for Teacher Survey Scales (N = 18)

	Pretest		Posttest	
Topic	M	SD	M	SD
Preparedness to Teach Mathematics and Science	3.36	0.38	4.11	0.26
Confidence to Teach Mathematics and Science	3.62	0.31	3.98	0.30
Knowledge for Teaching Mathematics and Science	3.41	0.45	4.09	0.36

The participants were also asked to complete an end-of-course evaluation form consisting of quantitative and qualitative questions. The results of the quantitative analysis revealed the participants rated the content and utility of the sessions very highly. As shown in Table 2 the participants had the highest level of agreement with the field trips provided useful insights, the course was a good learning experience, they learned from their peers, and they were encouraged to see connections.

Table 2

End-of-Course Evaluation Ratings of Session Content and Instruction (N = 18)

Statement	Rating
Field trips provided useful insights into STEM resource.	4.94
This course, as a whole, was a good learning experience.	4.78
I learned from my peers.	4.78
I was encouraged to see connections between course experiences and educational practice.	4.72
Information was presented clearly.	4.67
The course was well-organized.	4.65
I gained worthwhile knowledge in this course.	4.61
The teacher observations were a valuable learning experience.	4.33
Expectations were clear.	4.28
I learned from course assignments.	4.28
I learned from the readings.	3.89

The participants also agreed the utility of the sessions was very good. Table 3 reveals the participants indicated agreement with their intention to use most or all of what they learned and the fact their school or district will support their implementation of what they learned.

Table 3

End-of-Course Evaluation Ratings of Session Utility (N = 18)

Statement	Rating
I intend to implement most or all of what I learned.	4.28
My school or district will be supportive of me as I implement what I learned from this course.	4.22
I learned new strategies for teaching mathematics and science.	3.94

Qualitative Results

The qualitative responses from the end-of-course evaluation and the focus group transcript were analyzed and the following categories were revealed: strengths and weaknesses of the program, the field trips, teacher observation opportunities, curriculum mapping, and the development of relationships. Observation protocols for each of the observed professional development sessions were also analyzed for overall trends. Each of the themes developed from these categories, as contained in the project evaluation report (Swackhamer & Sutton, 2009), is discussed in the following sections.

Strengths and Weaknesses of the Program. Overall, the participants appreciated the ongoing support and layered nature of the program. They were very pleased with how respectful and open-minded the instructor was and appreciated her willingness to listen to any concerns or questions. They were very excited about implementing many of the activities and ideas from the program, but were concerned about the lack of technology and resources in the district. Suggestions for improvement included establishing clearer goals before each session, eliminating or reducing the reading requirements, and e-mailing the entire group with decisions or next steps. Specific aspects of the program that were discussed by the participants included the field trips, the quality teacher observations, the curriculum mapping, and the relationships that were built.

Field Trips. The participants were very pleased with the opportunity to visit the many different sites and discover all of the available resources that many did not even know existed. They appreciated the opportunity to see places in the community that supported mathematics and science and were amazed at all of the educational resources that each institution provided. They were looking forward to having time to deeply examine all of these resources.

Teacher Observations. The participants believed the observations were valuable and would like to have the opportunity to observe teachers for longer periods of time. They appreciated having the time to focus on what a quality teacher does and being able to observe the use of technology in the classroom. The main issue with the observations was a lack of quality teacher substitutes to take over the participants' classroom. They also suggested spending more time debriefing each individual observation instead of discussing four or five at a time.

Curriculum Mapping. The participants appreciated being given the time and space to work on the curriculum mapping. They felt they learned a lot about middle school and high school curriculum and were excited about the next steps in the process. Some of the teachers were concerned about the buy-in of the nonparticipating teachers and felt the selection of teachers needed to be a little more balanced to represent the entire district. Additional funding will support more teachers in other schools and will provide opportunities for these teachers to lead small professional learning groups and expand the work across the district.

Relationships. The participants greatly valued the opportunity for collaboration with fellow teachers and district personnel. They believed this collaboration helped shift their thinking about what students could learn and how to incorporate STEM-related topics into mathematics. They appreciated learning more about networking and how to collaborate with other teachers outside of their school.

Professional Development Observations. All professional development experiences were collaborative learning opportunities that provided participants with information and resources that support STEM education. The teaching models included whole group instruction, guest speakers, lectures, and lectures with PowerPoint, as well as hands-on activities and numerous opportunities to reflect on teaching and learning. At all observed activities, participants were actively engaged in the learning process, operating in an open and supportive learning environment that promoted collaboration, sharing, and open dialogue among participants and project leadership for common outcomes. The participants demonstrated increased levels of comfort over time, contributing to and benefiting from the group learning, and treated each other, the instructor, and other presenters in a professional, respectful manner.

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5. Key insights (retrospective for veteran projects, prospective for newer projects) that have value for the Learning Network:

The exploration of these topics with teachers is creating a distinct awareness of curricular and instructional issues that need to be addressed. Teachers continue to expand their own thinking about what students need to know and be able to do as they are exposed to new ideas and new perspectives. While we recognize that this work is still in a formative stage, it is providing teachers with an ecological model instead of one that is contained in an isolated classroom. Through field experiences and networking with people from different sectors, teachers are realizing that they cannot and should not do it alone and that the access factors serve to open up possibilities that teachers did not know about. The results of this study reveal that professional development training using the ecological model as a guide significantly increased the participating teachers' levels of preparedness to teach, confidence to teach, and levels of knowledge for teaching. The teachers valued the experiences provided by the professional development program and recognize the impact their training can have on students. The teachers also recognized the need to work outside the school setting to create learning opportunities for their students.

There are clear implications for teacher education across the professional continuum (i.e. preservice to inservice) with this model. Teachers need experiences that broaden their scope of thinking and change their world view. They need to broaden their social networks to reach out beyond the classroom, school, and school district to understand what is happening in business and industry in their area or region, they need to understand workforce issues and opportunities for the future, and connect with informal education that often has internship, field trip, and professional learning opportunities available. As grade school content and skills standards change to reflect 21st Century learning, teacher educators need to think about how to prepare teachers to teach higher levels of standards and expectations, content integration, and application. There is also needed change in teacher education accreditation programs that include new definitions of access and equity.

Hopefully, these sentiments convey that if we want students to excel and be prepared for tomorrow's workforce, students need access to multiple constituents and institutional structures. This type of teacher connectivity needs to be supported by district professional developers, principals, and other administrators that understand that the best teaching and learning doesn't happen in an isolated classroom. Textbook publishers and curriculum developers should also think creatively about what are "real world" examples, even redefining what real world is today. Of course they should be relevant to students but they should also bring new contexts and ideas to students. Pacing guides and scope and sequence documents need to allow teachers that time to make the connections and introduce students to resources outside the school.

Most importantly, teachers need professional learning opportunities that provide content and pedagogical knowledge and skills, but they must also engage in learning in context. Teachers need to be exposed to places where math and science are used as critical components of the work so they can bring examples back to the classroom and teach from a position of contextual understanding. Teachers and administrators need to understand that the ultimate goal of students is to be sustainable citizens in their communities, graduating from high school or college is not the end at all. In order to do that, students need connectors that introduce them to the myriad of opportunities that lie ahead. Just as formal education can do everything and teachers cannot know everything, there are those in informal education circles and other service providers that can help bridge those gaps. There can be a synergistic effect ot providing access to these elements if the ecosystem is in balance and the connections are communicated well. This will take a change in professional learning that gets teachers out of the classroom and the school environment and exposes them to the 21st Century world.