Engaging Higher Education Faculty in K-16 Learning Communities to Improve Teaching and Learning in Science and Mathematics in the K-12 Schools

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The Partnership for Reform in Science and Mathematics (PRISM) is a comprehensive MSP project with state and regional partners. The state partners include the University System of Georgia, the public higher education state agency, and the Georgia Department of Education, the K-12 state agency. Four regional P-16 partnerships include at least one institution of higher education (IHE) and one K-12 system. The IHEs include major research universities, regional universities, state universities and two-year college partners. The K-12 systems range from large urban to small rural districts.

A major goal of PRISM is to increase the quality of science and mathematics teaching in Georgia. One strategy is to implement school, district and cross-district level Learning Communities (LCs). These PRISM LCs may focus on mathematics, science or both, but the goal is to have at least one IHE science or mathematics faculty member working with each PRISM LC.

This paper reports findings from the quantitative evaluation of PRISM. The PRISM evaluation questions and data sources are provided as an Appendix. This paper addresses the following questions:

- Does participation in a LC increase K-12 teachers' use of inquiry- and standards-based teaching practices in science and/or mathematics (SM) classes?
- Does having IHE faculty members engaged in LCs increase K-12 teachers' use of inquiry- and standards-based teaching practices in SM classes?

Theoretical Background and Research Base

The context in which teachers work has changed dramatically in the last decade. Increased testing and emerging accountability legislation (NCLB, 2001) have increased the pressure for teachers to understand and respond to data on student and school performance. Teachers are encouraged to use data for planning, conduct action research (Calhoun, 1994) and adopt programs that have strong foundations in research. The days of teachers working in isolation are over. Several programs over the years have encouraged teachers to engage in collaborative governance (Glickman, 2002). Current research on the importance of teacher knowledge and the awareness that, in many cases, teacher content knowledge is limited, as well as the importance of specific content pedagogy, has led educators to focus teacher professional development on collaboration among teachers using study groups, learning communities and other forms of collaborative inquiry. The importance of improving student learning in science and mathematics is also a priority in schools because US students are repeatedly outperformed in international rankings.

The Joint Committee on Developments in the Science of Learning's extensive review of the research on learning (Bransford, Brown & Cocking, 2000) applied cognitive research to the learning of teachers. This source concluded that teachers learn about teaching from their personal teaching practice and through their interactions with other teachers. Teachers also learn through professional development, but limitations include the uneven quality of professional learning experiences and the fact that teachers do not take disciplinary courses in their graduate programs. According to this summary of research, effective learning environments are learner-centered, knowledge-centered, assessment-centered and community-centered.

A great deal has been written on models for implementing learning communities at the college level, for preservice teachers, and more recently, professional learning communities for inservice educators and teachers. Newmann, King and Youngs (2000) argued that improvement in student learning is most affected by improvements in instructional quality, and instructional quality requires the promotion of teacher learning and the development of school organizational capacity. The authors pointed out that the aspects of school capacity that are important are the development of professional community and the teachers' knowledge, skills and abilities. Engaging teachers in professional learning communities is one way to increase organizational capacity. While a great deal is written on learning communities for teachers and other educators, research on their effectiveness for teachers is scarce.

While much is written about how to form learning communities in K-12 schools (e.g., Dufour; 2001; Dufour, 2004; Joyce & Calhoun, 1996) there is little empirical evidence of the effectiveness of LC in improving teaching and learning. However, Bransford, Brown and Cocking (1999) in the National Research Councils' report on *How People Learn*, cited research supporting the importance of "community-centered environments . . . that encourage collaboration and learning" (p.197). They cited research on the effectiveness of teachers' participation in educational research and practice, teachers sharing and discussing lessons and student work (Annenberg Critical Friends Project). They concluded that "two major themes emerge from studies of teacher collaborations: the importance of shared experiences and discourse around texts and data about student learning and a necessity for shared decisions" (p.198-199).

At the first MSP Evaluation Summit, preliminary research on the effectiveness of PRISM LCs in improving teaching and learning was reported (Monsaas & McGee-Brown, 2005). That paper reported results from the Spring 2005 administration of the Inventory of Teaching and Learning (ITAL), a teacher self report instrument assessing their emphasis on inquiry, standards-based and traditional teaching and learning practices as well as findings from the qualitative case studies conducted by the evaluators. The quantitative findings showed a small but statistically significant difference in reported emphasis on standards-based teaching and learning practices between mathematics teachers who reported participating in LCs and those who did not. There were no statistically significant differences on the inquiry and traditional subscales for mathematics teachers and no differences on any of the scales for science teachers. Those results were not surprising because many of the learning communities were just getting underway during the

2004-05 year. Also new, more rigorous performance standards were being rolled out in science and mathematics so teachers across the state were focusing on implementing standards-based practices in their classrooms. This paper, in addition to replicating the earlier study on the effectiveness of LCs, adds an additional variable, K-16 participation in the LC. In other words, this paper will investigate the impact of IHE engagement with K-12 teachers in LCs.

PRISM Learning Communities

While PRISM learning communities are unique in each school, district and PRISM region, there is an underlying structure on which each is designed. The PRISM Leadership Team generated a definition document for learning communities that includes the essential characteristics that provide the underpinnings of each PRISM learning community:

- Trying, testing, verifying, and replicating teaching practices deemed to have a positive impact on K-16 student learning
- Shared vision of teaching and learning among K-16 faculty participants
- Collaboration between K-12 and higher education faculty
- Shared leadership by K-16 faculty participants
- Making the work of learning community participants public
- Results oriented work
- Collaborative inquiry

The PRISM Leadership Team also developed a LC rubric that the PRISM LCs use to evaluate their progress in meeting the "definition" of a PRISM LC. During the 2005-06 year, there were over 200 PRISM4 LCs in the four regions of the state. Many, but not all, had one or more IHE faculty members working with them. Some regions had challenges getting enough IHE faculty to work with all their LCs. This allows us to analyze the difference in teaching and learning practices for teachers in LCs that do and do not have an IHE member.

PRISM LCs have focused on action research and data-based decision-making as well as SM content and pedagogy. Because the new, more rigorous Georgia Performance Standards (GPS) are being rolled out in science and mathematics (as well as English/language arts and social studies), a great deal of the focus has been on teacher collaboration to prepare for the new standards (McGee-Brown, Martin, Despriet, Monsaas & Payne, 2006).

Methods

Measures. The *Inventory of Teaching and Learning* (ITAL) is a self report survey that was developed by a team of PRISM evaluators to assess teachers' reported emphasis on reformed teaching and learning practices (Ellett, Monsaas, Payne & Pevey, 2006, April). The initial phase of the PRISM Evaluation used the Reformed Teaching Observation Protocol (RTOP) developed at Arizona State University by the Arizona Collaborative for Excellence in the Preparation of Teachers (Sawada, Pilburn, Falconer, Turley, Benford, Bloom, & Judson, 2000). The RTOP incorporates some elements of the Local Systemic Change Revised Classroom Observation Protocol developed in 1997-1998 by Horizon Research. The RTOP was designed as an observational measure of *reformed teaching* to be used in mathematics and science classrooms.

Reformed teaching can be characterized as primarily learner-centered whereas more traditional teaching can be characterized as primarily teacher-centered. Another term often used synonymously with reformed teaching is *inquiry-based* teaching.

The observation categories and assessment indicators of the RTOP were initially used to develop a set of parallel, self-report items for teachers. Building upon past studies, a pool of 56 items was developed for the Inventory of Teaching and Learning (ITAL) (Ellett, Monsaas, Pevey & Payne, 2006). These items reflected both reformed teaching *and* learning activities (e.g., *encouraging students to evaluate their own thinking throughout the lesson*) and traditional teaching practices (e.g, *evaluating learning and performance on the basis of right and wrong answers*). A six-point scale ranging from 1=No Emphasis to 6=Very Strong Emphasis was developed for teachers to rate the extent to which they emphasized each ITAL teaching and learning activity in their classrooms.

A series of principal components analyses was used to iteratively extract from one to six factors. Orthogonal rotation procedures and a set of explicit decision making rules (e.g., minimum factor/item loading to retain an item on a factor was .33) were used to retain items on a factor. The results showed the reformed teaching items comprising the ITAL can be conceptualized at the highest level as operationally defining a single reformed teaching construct (51 items loaded on a single factor ranging from .39 to .80). In this analysis, only five of the 56 ITAL item/factor loadings were less than .60.

Subsequently, two- to six-factor solutions were obtained and examined in terms of the patterning of item/factor loadings, the number of items retained, the variance explained by a particular solution, and the interpretability of the factors in view of item content. A three-factor solution was accepted as best representing the data and the structure of the ITAL as well as reflecting the theoretical assumptions underlying the instrument. This solution accounted for 46.56% of the total item variance and identified three teaching and learning measurement dimensions. The measurement dimension, number of items operationalizing each dimension, range in item/dimension loadings, and variance explained by each dimensions (principal component) were as follows:

I: *Inquiry-Based Teaching and Learning* (30 items) (.48 to .75) (26.42%)

II: *Standards-Based Teaching and Learning* (10 items) (.37 to .73) (11.71%)

III: *Traditional Teaching and Learning* (12 items) (.39 to .79) (8.43%)

Across these three measurement dimensions, item loadings ranged from .37 to .75 with .50 most typical. For the most part, the patterning of the item/component loadings was consistent with the logical, content classification of the items. Alpha reliabilities for the empirically derived subscales for this large sample of teachers ranged from .93 to .85. The principal components analyses reduced the number of ITAL items from 56 to 52. Four items were excluded from the final measure because they were double loaded on two ITAL measurement dimensions and the difference between squared loadings was less than .10.

In addition to the ITAL questions about teaching and learning practices, several demographic questions (e.g., grade level and science and/or mathematics courses taught) and questions about participation in PRISM activities were asked. The questions analyzed for this paper were,

- Are you currently a member of a PRISM learning community? There were three response categories: Yes, No and I am a member of a learning community but I am not sure if it s a PRISM Learning Community. Only respondents who chose Yes or No are included in the analyses here.
- Do you regularly attend the meetings of your learning community? Yes, No
- Does your current PRISM Learning Community work with a higher education faculty member? Yes, No

Analyses were performed separately for science teachers and for mathematics teachers.

Procedures. The ITAL was administered to all K-12 teachers who teach science and mathematics in the 15 school districts participating in PRISM. Because PRISM is being phased in to the K-12 schools over five years, schools in PRISM districts that are not yet participating in PRISM serve as the comparison group. The names and email addresses of all science and mathematics teachers were requested from the four regions during winter 2006. Note that one large district sent the names of all of the certified personnel making it difficult to determine response rate for that district. That district had a response rate of 24%, though it is unclear how many non-mathematics and science teachers were included in the total number for computing response rate. The other districts response rates ranged from 53% (another large urban district) to 93% (a small rural district). The median district response rate was 72%.

Results

Table 1 shows the results of the ITAL for mathematics and science teachers who reported that they did or did not participate in a PRISM LC during the 2005-06 school year. The means for the three ITAL subscales shows that teacher in both groups (PRISM LC and Not in LC) reported greater emphasis on standards-based teaching and learning practices and least emphasis on traditional practices in both mathematics and science. Multivariate Analysis of Variance (MANOVA) tests were performed for mathematics and science teachers separately. The results showed main effects for participation in a PRISM LC for standards-based teaching and learning in both mathematics and science, $F(1, 5.64) = 14.00$, $p = .000$ and $F(1, 3.021) = 7.08$, $p = .008$, respectively. The effect sizes for these two tests are relatively small, but the effect appears to be consistent across science and mathematics and consistent with findings from the previous years study (Monsaas & McGee-Brown, 2005). There were no significant effects of LC participation for inquiry and traditional teaching and learning practices.

Table 1

Mean Scores on ITAL subscales for **mathematics** and **science** teachers who did and did not participate in a PRISM learning community (LC). Scale ranges from 1 = No Emphasis to 6 = Very Strong Emphasis.

	Inquiry-based Teaching & Learning		Standards-based Teaching & Learning		Traditional Teaching & Learning	
	PRISM LC	not in LC	PRISM LC	not in LC	PRISM LC	not in LC
Mathematics						
M	4.67	4.62	5.37	5.27[1]	3.86	3.82
SD	.76	.82	.58	.67	.76	.80
n	1035	1163	1035	1163	1035	1163
Science						
M	4.67	4.65	5.34	5.26[2]	3.81	3.84
SD	.79	.84	.61	.69	.77	.81
n	894	1004	894	1004	894	1004

[1] mean difference for standards-based teaching and learning, mathematics, $p<.001$; $\eta^2_p = .006$
[2] mean difference for standards-based teaching and learning, science, $p<.01$; $\eta^2_p = .004$

Table 2 shows the descriptive statistics for IHE participation with K-12 teachers in a PRISM LC. The only respondents selected for these analyses were those who selected “yes” to the question “Are you currently a member of a PRISM learning community?” Respondents who selected “no” and “I am a member of a learning community but I am not sure if it is a PRISM learning community” were excluded from these analyses. Further, only respondents who selected “yes” to the question “Do you regularly attend the meetings of your learning community?” were included. The evaluation question addressed is whether or not having an IHE faculty member participating in a PRISM LC affects K-12 teachers’ practices. MANOVA was performed with IHE participation as the independent variable and ITAL subscales as the dependent variables. Statistically significant differences were found in reported emphasis on inquiry-based teaching and learning for both mathematics and science when an IHE faculty member was worked with the LC, $F(1, 9.77) = 17.37$, $p = .000$ and $F(1, 6.27) = 10.14$, $p = .002$, respectively. This finding suggests that having an IHE faculty member working with K-12 teachers may lead to increased emphasis on use of inquiry in the K-12 science and mathematics classrooms. Again, these effect sizes are relatively small, but somewhat larger than the effects in the analyses reported in Table 1.

An additional statistically significant effect was found for IHE participation in reported emphasis on standards-based teaching and learning in mathematics only, $F(1, 1.72) = 4.97$, $p = .026$. This table also shows that K-12 teachers reported greatest emphasis on standards-based practices and least on traditional practices.

Table 2

Mean Scores on ITAL subscales for **mathematics** and **science** K-12 teachers who participated in a PRISM leaning community (LC) with or without a higher education faculty member. Only PRISM LC participants who regularly attended LC meetings are included in this analysis. Scale ranges from 1 = No Emphasis to 6 = Very Strong Emphasis.

Grade	Inquiry-based Teaching & Learning		Standards-based Teaching & Learning		Traditional Teaching & Learning	
	IHE	no IHE	IHE	no IHE	IHE	no IHE
Mathematics						
M	4.76	4.51[1]	5.40	5.30[3]	3.82	3.85
SD	.73	.78	.56	.66	.75	.76
n	507	227	507	227	507	227
Science						
M	4.74	4.52[2]	5.36	5.26	3.80	3.77
SD	.79	.78	.56	.70	.78	.78
n	454	182	454	182	454	182

[1] mean difference for inquiry-based teaching and learning, mathematics, $p<.001$; $\eta^2_p = .023$
[2] mean difference for inquiry-based teaching and learning, science, $p<.01$; $\eta^2_p = .016$
[3] mean difference for standards-based teaching and learning, mathematics, $p<.05$; $\eta^2_p = .007$

Summary and Conclusions

The results reported here show a small, but consistent effect of participation in a PRISM LC and having an IHE faculty member working with the LC on K-12 teaching. Participation in a PRISM LC is associated with greater emphasis on standards-based teaching and learning practices in both mathematics and science K-12 classrooms. This finding is not surprising given the context in Georgia. New, more rigorous, performance standards in science and mathematics are being implemented on a phased rollout schedule. The state of Georgia has been using a train-the-trainer model and large workshops to deliver training to teachers. This is reflected in the relatively high means on reported emphasis on standards-based teaching and learning for both PRISM LC participants and non-participants. PRISM LCs have potential to have a greater impact on teaching practices because they are community-based, ongoing and focus on data use and action research to improve practice. In future studies, we will be able to classify the focus of the LC (e.g., data utilization, inquiry, content) and see if that affects teaching practice, and ultimately, student achievement.

The finding that teachers report greater emphasis on inquiry-based teaching and learning practices when there is a IHE faculty member working with the LC is an important finding. NSF is interested in promoting the involvement of science and mathematics faculty members with preservice and inservice teacher education. Many of the faculty members in PRISM are science and mathematics faculty though some are mathematics or science education or education (e.g., educational psychology) members. As with all large scale projects, implementation is somewhat uneven and while the goal is to have IHE faculty working with each LC, the fact is that there are far more schools and districts that have LCs than there are faculty to work with the LCs. This provided the evaluators with LCs that have and do not have IHE faculty members. We cannot rule out selection bias in this study since IHE faculty members may choose to work with schools and districts that they are familiar with or that are nearby. Nonetheless the results suggest that IHE faculty participation with K-12 teachers can improve K-12 teachers' teaching practices. Future studies will explore this relationship further, including investigating whether or not the role of the IHE faculty member (e.g., participant, facilitator, resource) is related to teachers' performance. Studies will also investigate the effectiveness of working with P-16 LCs on IHE teaching and learning practices.

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Appendix: Evaluation Design for PRISM Learning Communities

Data sources that will be used in the MSP Evaluation Summit II paper are in bold.

Evaluation Question	Data Collection Method
Who participated in LCs? To what extent?	**Rosters of participants** **Attendance rosters** **Participant logs** **IHE participation**
What was the nature of the LC?	Document collection, e.g., **Agendas** Reading lists Participant logs
	Observations of LCs
	Interviews
Did the participants acquire the intended knowledge and skills?	**Inventory of Teaching and Learning (ITAL) Practices**
	Open-ended questionnaire
	Interviews
Did the participants use the acquired knowledge and skills in the classroom?	Observation (Reformed Teacher Observation Protocol)
	Inventory of Teaching and Learning (ITAL) Practices
	Open-ended questionnaire
Did student achievement improve?	State tests (Georgia Criterion-Referenced Competency Tests (grades 1-8), End-of-Course Tests, Georgia High School Graduation Tests)
	Course taking patterns and pass rates in challenging SM courses

Appendix: PRISM Learning Community Rubric

Indicators	Beginning	Emerging	Developing	Accomplished
Community and diversity	Learning communities regularly engage all participants in discussions about teaching and learning.	Learning communities regularly engage all participants in discussions about teaching and learning. School participants engage in some peer observation and mentoring.	All participants have an opportunity to share ideas and experiences within the learning community. Participants give and receive feedback within the learning community setting.	All participants share ideas and experiences within the regional learning community network. Participants engage in peer observation both to give and receive feedback.
Trying, testing, verifying, and replicating of effective teaching practices	P-16 educators share classroom practices and teaching materials. Some follow up on effectiveness of classroom experimentations is done.	Research based practices are shared, studied and discussed within the learning community setting. Educators engage in professional development which is research based.	P-16 educators within and across regional learning communities share research based practices that they've tried and verified in their own classrooms. Educators at all levels collaborate, replicate these practices, and verify positive student impact.	P-16 educators within and across regional learning communities implement research based practices and verify positive student impact. Effective practices are made an integral part of teaching introductory level college courses
Shared vision	Educators discuss appropriate levels of student achievement relative to specific courses. Learning community dialogue focuses on successful implementations of effective practices, particularly participant experiences	Educators discuss the vertical alignment of student achievement, expectations and standards. Methods of integrating effective practices such as guided inquiry and collaborative leaning throughout the P-16 curriculum are explored.	Educators explore which teaching practices work best with various disciplinary topics. Some consensus is reached as to acceptable levels of student achievement and classroom expectations.	Agreement is reached across regional learning communities as to effective practices to be employed when teaching particular topics to specific populations.
P-16 faculty collaboration	Higher education faculty offer professional development opportunities in-line with professional knowledge and self-assessed P-12 teacher needs. P-12 teachers help inform the pedagogical methods used higher education classrooms.	P-16 faculty engage openly in LC discussions about teaching and learning of SM. Through LC participation, P-16 educators offer and engage in needed professional development.	Higher education and P-12 faculty collaboratively develop and offer professional development for educators across learning communities. Higher education and P-12 faculty within disciplines collaborate on classroom instructional practices.	Higher education and P-12 faculty fully engage in action research collaborations. Results are determined and shared across the region. P-16 teaching and learning conferences/symposia become a part of the culture at regional institutions.

PRISM Learning Community Rubric

Indicators	Beginning	Emerging	Developing	Accomplished
Shared Leadership	Learning communities are guided mainly by teacher leaders and P-12 administration or higher education faculty. Higher education faculty participation varies according to professional development needs.	Most learning communities are co-facilitated by higher education and P-12 faculty. Principals may regularly instigate and manipulate the agenda according to existing school programs.	All learning communities are co-facilitated by higher education and P-12 faculty. The needs and strengths of all P-16 SM educators guide the learning community. Goals are established and facilitated collaboratively by LC participants and administration. LC activities are supported by higher education and P-12 administration.	All learning communities are co-facilitated by higher education and P-12 faculty. The learning community agendas are dependent upon the needs of all P-16 educators and institutions in the region. Learning community results affect regional administrative decisions.
Making the results public	Educators present results within school and district learning community settings.	P-16 educators communicate results throughout the region through school, district, and regional learning communities, making it open for discussion, verification, refutation and modification.	P-16 educators make presentations of results in regional and statewide venues. Regional work is published on the PRISM web-site and in PRISM sponsored publications.	P-16 educators make presentations of results in state and national venues. Regional work is published in peer reviewed journals.
Results oriented work	The purpose of dialogue and inquiry is solely the sharing of ideas and materials to improve individual teacher's practice.	The purpose of collaborative dialogue is primarily the sharing of ideas and materials to improve the individual teacher's practice. Methods for evaluating improved student achievement are emerging	The purpose of collaborative dialogue is to improve learning for students in selected areas of the curriculum. Improved student achievement is evaluated.	The purpose of dialogue and inquiry is to result in practices that lead to improved learning for students and teachers at all levels of SM.
Collabora-tive Inquiry	Some educators have professional development opportunities to engage in inquiry around classroom practice	Educators have professional development opportunities to engage in inquiry around classroom practice. Some teachers engage in action research cycles, beginning to make changes in their classrooms.	Groups of educators examine practice and engage in inquiry about areas of mutual interest. Educators at various career levels are contributing to the design and implementation of collaborative inquiry cycles. Educators are making some changes in classroom and school-wide practices as a result of collective inquiry.	All educators have ongoing opportunities to engage in collaborative cycles of inquiry, reflection, analysis and action. Those who develop, present and facilitate PD experiences are integrated within the learning community and participate in cycles of inquiry related to the work they do. Data, evidence and reflection are systematically used to promote changes at the classroom and institutional levels.