Abstract Title: Teachers' Professionalism, Students' Achievement, and Systemic Change

MSP Project Name: The Rice University Mathematics Leadership Institute (MLI)

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120 word summary:

Implementation and evaluation of the Rice University Mathematics Leadership Institute (MLI) resulted in lessons learned regarding leadership factors at both micro- and macro-levels of educational systems which impacted how institutional change manifested at targeted schools and districts. Speakers will present evidence of growth in teachers' professionalism (including teacher knowledge, instructional practices, and professional collaboration), comparative student achievement results, micro- and macro-level change factors, and related systemic impediments. Data will be presented to explore the process of change as experienced by MLI lead teachers and directors. Speakers will discuss MLI lead teachers' and directors' impressions as change agents in classrooms, mathematics departments, on campuses, and within districts. Lessons learned through MLI about student success will be shared.

- Section 1: **Questions for dialogue at the MSP LNC**

1) What were lead teachers' outcomes as a result of their participation in MLI?
2) What results indicate lead teachers' student success?
3) What systemic change factors were identified?
4) How do the lessons learned regarding lead teachers' professionalism, their students' success, and systemic change factors inform the MSP work of MLI and the greater MSP community?

- Section 2: **Conceptual framework**

Rice University Mathematics Leadership Institute (MLI) united a variety of mathematics professionals – research and teaching faculty, post-docs, and graduate students from the Rice University departments of Computational and Applied Mathematics (CAAM), Mathematics (MATH), and Statistics (STAT); mathematics educators; high school faculty, administrators, and students from the Houston (HISD) and Aldine (AISD) Independent School Districts with a common purpose: enriched student mathematics appreciation and increased student achievement.

Research indicates K–12 school-based leadership provided by effective lead teachers can be one of the most successful forms of support to develop and sustain highly-qualified teachers in the profession (National Comprehensive Center for Teacher Quality, 2010) and to positively impact students' achievement (Darling-Hammond, 1998). Additionally, credentials of teachers (Clotfelter, Ladd, & Vigdor, 2007) and teachers' content knowledge for teaching (e.g., Hill, 2007) are known to have positive effects on student achievement in mathematics. Furthermore, the National Institute for Urban School Improvement (NIUSI, 2006) asserts that robust, synergistic efforts of students, educational professionals, school organizations, and districts create the contexts necessary for systemic change to improve teaching and learning.

MLI defines student success in mathematics as the ability of learners to develop conceptual understanding, problem-solving skills, and confidence for success on state-mandated high-stakes assessments, in addition to developing their desire to enroll and succeed in higher-level mathematics courses. Active student engagement in rigorous, student-centered mathematical experiences is understood by MLI lead teachers to be an important precursor to and aspect of "student success." MLI's definition of student success is multifaceted and grounded in theories of learning as a social, student-centered experience (Bandura, 1977, 1997; Vygotsky, 1978) that engages students in strong mathematics explorations that are aligned with students' learning styles (Piaget, 1972, 1990). Effective teaching practices of lead teachers were expected to encompass classroom activities consistent with the constructs of student success, as operationalized within MLI content tests, surveys, and classroom observation protocols.

To improve student success, MLI developed 80 lead teachers, who received intensive professional development in mathematics content and pedagogy as well as in instructional leadership with a focus on providing high quality learning opportunities in mathematics to diverse student populations. MLI's activities were designed to provide lead teachers with the ability to more effectively enhance student success. MLI's Summer Leadership Institutes (SLI) provided a mathematics learning experience grounded in problem-solving and focused on five major strands of university-level mathematics: (1) algebra and number theory; (2) geometry and trigonometry; (3) functions and analysis; (4) data analysis, statistics, and probability and (5) discrete mathematics and computer science (CBMS, 2001; NCTM, 1989, 1991, 1995, 2000) to develop lead teachers' deep understanding of effective precollege mathematics curriculum, instruction, and assessment. The content focus of the first SLI for each MLI Cohort focused on developing lead teachers' content knowledge of entry-level high school mathematics courses. This knowledge was necessary for them to be able to adequately support their students' success and to provide leadership for beginning and novice teachers of these courses with whom they worked. Content pre-/post-tests that focused on measuring their understanding of the content of algebra and geometry were created by the MLI directors and then refined by Rice University faculty in CAAM, MATH, and STAT. The second SLI for each cohort challenged lead teachers by having them explore mathematics not taught by many teachers in high school. The focus on combinatorics and statistics through a problem-solving approach at the level of a university capstone mathematics course stretched their thinking and as a result increased their self-efficacy in mathematics. Lead teachers felt exhilarated to be able to study mathematics at a rigorous level, something that they had not experienced since their university educations. As with the first summer, content pre-/post-tests focused on measuring lead teachers' understanding of this content. These tests were again written by the MLI directors and refined and

revised by Rice University faculty in CAAM, MATH, and STAT. To develop lead teachers' translation skills necessary for quality instruction (CBMS, 2001), connections were made between lead teachers' MLI mathematics experiences and the secondary mathematics curriculum they were expected teach. Furthermore, to develop MLI teachers' leadership capabilities to support the transfer of content and pedagogical knowledge to their classrooms, campuses, and districts; collaborative planning networking opportunities were provided and supported for the duration of MLI. Collaborative activities involved active engagement that was linked to MLI teachers' prior learning experiences, classroom practices and leadership responsibilities.

- Section 3: **Explanatory framework**

Lead teachers' content, pedagogical content knowledge, instructional practices, professional collaboration, and student achievement results were assessed. Lead teachers provided further evidence of student success to support achievement data. MLI's evaluation design is detailed in the following table:

Formative Evaluation		
Primary Questions	***Data Sources***	***Time Frame***
How knowledgeable are lead teachers about mathematics content, current mathematics education reforms, mathematics pedagogy, and diversity issues related to STEM?	Pre/post testing of lead teachers; Interviews with/Surveys of MLI implementation team, district and school administrators, guidance counselors, math chairs	Each academic year beginning in 2004-05 through 2008-09
How effective are lead teachers in their own classrooms?	Evaluations conducted by MLI directors and evaluators	
Summative Evaluation		
MLI Goals	***Data Sources***	***Time Frame***
Increase lead teachers' understanding of mathematics content and pedagogy as well as current research in mathematics education and diversity issues as they relate to STEM.	Pre- and post-tests completed by lead teachers, classroom observations, grades, number of lead teachers earning the Texas Master Teacher certification	Each academic year beginning in 2004-05 through 2008-09
Increase lead teachers' students' achievement in mathematics.	Texas Assessment of Knowledge and Skills (TAKS) math scores, A.P. Calculus and Statistics scores	Each academic year beginning in 2005-06 through 2008-09
Increase all students' mathematics achievement on participating campuses.	TAKS math scores, A.P. Calculus and Statistics scores	
Which activities were teachers on participating campuses offered to increase their knowledge in mathematics content and skills in mathematics instruction? In which activities did teachers participate?	Interviews with/Surveys of MLI directors, district and school administrators, lead teachers, campus teachers	Each academic year beginning in 2004-05 through 2008-09
Increase lead teachers' students' interest in and awareness of the importance of studying advanced mathematics.	Number of students enrolled in higher level mathematics courses, number of students entering college	Each academic year beginning in 2005-06 through 2008-09
Increase all campus students' interest in and awareness of the importance of studying advanced mathematics.	Number of students enrolled in higher level mathematics courses, number of students entering college	Each academic year beginning in 2004-05 through 2008-09

Evidence-based results or knowledge claims:

MLI established a procedure for identifying, developing, and supporting lead mathematics teachers. MLI was able to bolster the teaching of mathematics in AISD and HISD by establishing and supporting 80 highly knowledgeable and skilled, dynamic lead mathematics teachers. Currently, one to four MLI lead teachers are on each of 29 high school campuses. MLI lead teachers' mathematical content knowledge and pedagogical content knowledge increased, resulting in increased self-efficacy as teachers, instructional coaches, and advocates for strong mathematics programs in their schools and districts. This is evidenced by

pre- and post-program content tests and surveys completed by the three cohorts during the SLIs (McCoy, 2007; McCoy, 2010). One of the findings from MLI is the importance of developing lead teachers' skills in supporting their colleagues in providing high-quality mathematics instruction for all learners, in particular those traditionally underrepresented in STEM (Hill, McCoy, Papakonstantinou, Parr, & Sack, 2007). Structures within MLI schools that permitted collaboration were necessary to develop collegial exchanges with other educators that allowed for reflection and refinement of their teaching practice and to insure that reform was not merely cosmetic. The structures allowed sufficient time for collaboration and were based on an understanding of skills needed for effective teaching. Teaching practices and student interactions that encourage students' success were identified annually during observations of MLI lead teachers' classrooms. In spring 2009, teaching practices and student interactions included teachers' solid grasp of subject matter content inherent in lessons (98%), student engagement in thought-provoking activities requiring critical assessment of mathematical procedures (86%), teacher as a resource supporting student investigations (86%), students working independently (93%), teacher as listener (79%), and students engaged as members of a learning community, and students explained their understandings with a partner or within a small group (83%). MLI directors' observations and documented comments made by lead teachers and school and district administrators demonstrate enhanced rewards from lead teachers' collaborations with campus colleagues. Lead teachers' perceptions of growth in their own leadership skills were often prefaced with acknowledgement of MLI opportunities that facilitated their skill enhancements.

Results from the Texas Assessment of Knowledge and Skills (TAKS) indicate that students of MLI lead teachers have demonstrated statistically significant gains on average scale scores on the mathematics portion of the assessment throughout the duration of the grant (e.g., McCoy, 2010; Sack & Kamau, 2009). From 2005 to 2009, average scores on the Exit Level TAKS assessment given during the 11th grade increased from 2107 to 2282 for students of MLI lead teachers, showing more growth than AISD, from 2184 to 2262; HISD, from 2153 to 2255; or Texas, from 2201 to 2264, (McCoy, 2010; Texas Education Agency, 2010).

Conclusions and implications:

MLI lead teachers were provided an array of professional development opportunities to increase their mathematics knowledge and to improve their instructional expertise as well as their collaboration and leadership skills to better address the diverse needs of students in their urban schools. MLI provided an important form of support to develop and sustain highly-qualified teachers in the profession to positively impact student success. Lead teachers' growth on measures of mathematical content knowledge and pedagogical content knowledge and their students' assessment results reflect lead teachers' heightened abilities to support institutional change on their campuses. Lead teachers' experiences as advocates for rigorous, student-centered instruction in their mathematics classrooms, departments, schools, and districts are compatible with the literature on systemic change in educational institutions specifically, and within institutions in general. In addition, lead teachers' reports of change in their schools and districts offer important perceptions about factors within educational institutions that support or inhibit change. MLI lead teachers' implementation experiences, student success, and insights provide direction and encouragement for future MSP work to address obstacles that inhibit systemic change in the nation's schools and districts.

MLI lead teachers strive to be highly successful teachers who support student success in building strong mathematics foundations. Because of their experiences in MLI, lead teachers express an intensified desire and a greater capacity to help students appreciate and learn mathematics. MLI lead teachers thrive on their students' successes, which fuel lead teachers' quests to further enhance their professionalism to meet the needs of all students. MLI lead teachers have recounted powerful learning experiences they have facilitated with their own students. Additionally, they express gratitude for opportunities to share their insights and skills with colleagues. Lead teachers' colleagues who use these instructional models also report experiences of success with their students. Student success is what often entices administrators to re-examine and improve views, expectations, policies, procedures, and practices that are found to impact student success.

Interviews with MLI lead teachers, corroborated by classroom observations by MLI directors and evaluators, indicated that in many mathematics classrooms, the omnipresent goal was for students to meet minimal standards on the state-mandated assessment. Often this focus precluded teachers from engaging their students in rich mathematics activities which would have developed their conceptual understanding, problem-solving skills, and interest in mathematics. Moreover, when schools focus on the tested curriculum rather than

the entire curriculum, we observed that students lacked the preparation for advanced mathematics courses and the foundation for success in STEM careers. As MLI progressed, it became necessary to provide lead teachers with mechanisms to prepare their students for state assessments in creative ways which promoted higher-order thinking. To this end, MLI directors developed a plan to prepare students for these high-stakes tests using test-item stems from released standardized tests. Through this plan, lead teachers collaboratively develop differentiated problem sets for students to explore deeper mathematics by expanding the scope of the standardized assessment items. Moreover, student interest is promoted by having students create their own problem sets. Interviews with teachers who use this activity in their classrooms indicate that students are more engaged in the learning process than when participating in typical more procedurally-based activities often used to prepare students for standardized assessments. MLI directors continue to share this plan with the greater mathematics-science education community through work with other local school districts and presentations at state and national conferences.

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