Abstract Title: Student-Centered Teaching, Teacher Leadership Development and Student Success: The Mathematics Teacher Transformation Institute (MTTI)

MSP Project Name: The Mathematics Teacher Transformation Institute (MTTI)
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Strand: **Strand 2:** The use of student data to inform and refine MSP work

120 word summary:

We hypothesized that a positive relationship exists between teachers' stage of leadership development and their use of student-centered pedagogy. Students are thought to be more likely to be engaged in math as a result of teachers' use of a more student-centered approach. MTTI participants at Stage 2 and 3 of leadership development tended to use more student-centered pedagogy than those at Stage 1. Students' understanding of, attitudes toward, and motivation to do mathematics increased significantly as a result of teachers' use of action research. If student-centered teaching increases student math achievement then there could be links between use of a student-centered pedagogy, teacher -leadership development and student achievement.

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

Improving student achievement in mathematics and science has been a concern in the United States of America since the early 80s when international tests began showing U.S. students falling behind most developed countries in mathematics and science skills. Many U. S. students do not obtain the knowledge and skills, particularly in science, technology, engineering, and mathematics (STEM), which are required for success in the global marketplace of the 21st century (National Academies, 2006).

Educators, educational researchers, and policy makers have not always agreed about the reasons for the failure of U.S. students to perform. For some, many mathematics teachers have inadequate mathematical content knowledge themselves, and thus are unable to teach their students to the highest level (Ahuja, 2006; Ginsburg, Cooke, Leinwand, Noell & Pollock, 2005). Others (Darling-Hammond, 2007; U.S. Department of Education, 2004; National Science Board, 2006; Office of Science and Technology Policy, 2006) in part relate such an educational failure not only to the lack of qualified teachers with solid content knowledge in STEM, but also to a profound understanding of teaching and learning in grades K-12. For Brown and Borko (1992), and Ball and Bass (2000), content knowledge and understanding of the methods of inquiry in mathematics are at the core of effective teaching and learning.

The use of inquiry-based approaches to instruction, in which students have opportunities to construct their own understanding of basic concepts has been found to be most appropriate in developing students' understanding of mathematics and science concepts. Such approaches call for teachers to be able to engage students in critical, in-depth, higher-order thinking using manipulatives, technology, cooperative learning and other pedagogy that enables them to construct mathematics concepts on their own through reasoning, verifying, comparing, synthesizing, interpreting, investigating or solving problems, making connections, communicating ideas and constructing arguments (Grouws & Shultz, 1996; National Council of

Teachers of Mathematics [NCTM], 2000). This approach departs in significant ways from what occurs in "traditional" classrooms. Helping teachers make this fundamental shift in practice requires more powerful approaches to professional development.

One such response has been to identify and deploy a corps of teacher leaders to provide support to their colleagues in changing instructional practice (Lord & Miller, 2000). Despite evidence from research (Seashore et al., 2010) showing that leadership is second only to classroom instruction as an influence on student learning, not much is known about teacher leadership's effect in improving student achievement and the factors that lead to the development of a teacher leader.

- Section 2: **Conceptual framework**.

Lehman College's Mathematics Teacher Transformation Institutes (MTTI) is a National Science Foundation (NSF)-funded program designed to support the development of teacher leaders to strengthen mathematics teaching and learning in New York City, especially in Bronx middle and high schools. Rooted in the belief that sustained professional development should have a long-lasting impact on mathematics teachers' practices in their classrooms and within their schools, MTTI developed a three-year three-dimensional program that focuses on deepening participating teachers' content knowledge, broadening their pedagogical repertoire through the process of inquiry, and developing their leadership capacities across a number of domains within the context of a professional community.
The process of inquiry is at the center of MTTI's model of teacher leadership development. It engages teachers in a process that does not cease, in asking questions and understanding problems, continually revisiting critical issues relative to teaching and learning, designing plans to resolve the issues, implementing the plans, and collecting and analyzing data to assess the effectiveness of the designed plans. As teachers improve their pedagogical skills, they increase their ability to explain terms and concepts to students, interpret students' statements and solutions, engage students in critical, in-depth, higher order thinking, and consequently leading to increased student achievement (Grouws & Shultz, 1996; National Council of Teachers of Mathematics [NCTM], 2000; Copland, 2003; Hill, Rowan, & Ball, 2005).

The overarching and ultimate goal being to improve student learning, this inquiry process should ultimately lead to the sharing of progress and challenges in the school, district and broader community in an ongoing effort to build greater capacity to include those who work in the school community, opening therefore multiple "Entry Points" and opportunities into leadership practices. Formal training in what constitutes leadership, its mechanism and roles is therefore necessary so that the teacher leader explores the different facets of being a leader, from conceiving goals and objectives and enacting strategies to making informed decisions about policy and practice. Because administrators in general assume that an outstanding teacher of students will also be a good teacher of teachers, many new teacher leaders lack training in new leadership roles they are asked to assume. Working with colleagues requires a different skill set (Dozier, 2007).

Findings from research indicate that seven major types of tasks/roles can be related to teacher leadership in mathematics (Lord & Miller, 2000; National Council of Supervisors of Mathematics [NCSM], 2008). A mathematics teacher leader can be engaged in: Type 1) in-classroom support of individual teachers, Type 2) professional development activities for groups of teachers, Type 3) indirect support benefiting several classrooms, Type 4) crisis management, Type 5) interactions with a larger educational community, Type 6) initiating extra-curricular mathematics activities, and/or Type 7) initiating personal growth and professional development in mathematics.

Furthermore, the NCSM (2008) recognizes that the practice of leadership activities lead to leadership growth through three stages of development: leadership of self (Stage 1), leadership of others (Stage 2), and leadership in the extended community (Stage 3). The Stage 1 leader is respected for his/her own knowledge, teaching and learning skills. The Stage 2 leader is respected for his/her interpersonal skills and commitment for leading change among teams of teachers among colleagues. Finally, the Stage 3 leader is known for his/her influence, engagement with the extended community, and knowledge and understanding of educational issues.

It is our belief that the teacher at the second stage of leadership development has the potential of having the greatest impact on students' learning. The teacher at this leadership development stage should possess the pedagogical skills that are more likely to motivate students by engaging them in authentic, personally meaningful, and relevant work. Student engagement plays an essential role in the learning process and is a strong predictor of student learning (Seashore et al., 2010). Indeed, research shows that engaged students experience greater satisfaction with school experiences, which may in turn lead to greater school completion and lower incidences of acting-out behaviors and the overarching goal of student success.

The definition of student success that is considered in this study will encompass two elements: the level of student engagement as described through the observations; and MTTI teachers' description of their students' success as it relates to their action research projects conducted through a course over a period of one to two years.

One of the sections of the observation protocol (COP) used in this study concerned the level of Student Engagement (SE) rated as high, medium, or low. During each observation, SE was rated as high when 80% or more of students were engaged, as low when 80% or more of students were off-task, and as mixed otherwise. An engaged student was seen as one who, during the time of the observation, was involved in the lesson in meaningful ways; that is, he/she participated in all classroom activities, collaborated effectively with the teacher and with other students, and was reflective about his/her learning. Whereas effective participation and willingness to collaborate are indications of intrinsic motivation, especially in urban areas where a lack of engagement has been especially pronounced for adolescents and minorities students, reflective learning is an essential prerequisite for the development of understanding. That, perhaps, explains why MTTI teachers believed more in the use of change in attitude and motivation as a measure of student success than in the use of the formal indicator of score or grade.

Indeed, based on MTTI teachers' use of mixed methods to evaluate the performance of their students on their Action Research (AR) projects, and on their reflections and comments, we infer that their definition of student success is more about students' understanding of, attitudes toward, and motivation to do mathematics than scores on particular standardized tests. Although scores on pre- or/and post-test assessments were used as measures for almost all projects, emphasis was more on the qualitative results than on the quantitative ones. MTTI teachers argued the need to go beyond restating basic facts on multiple-choice or short-answer questions, and gave open-ended assessments, analyzed students work, observed and described students' interactions, and interviewed many students to assess their level of understanding and the misconceptions they displayed. We subsequently used the results and conclusions of 22 AR projects to do an analysis that allowed us to classify an AR project as having shown "Success, Mixed Success, No Success, or Inconclusiveness," qualitatively and quantitatively (Table 1).

Table 1: Action Research Projects and Level of Success

	Success	**Mixed Success**	**No Success**	**Inconclusive**	**Total**
Quantitative Measure	Evidence of significant change in performance was presented in the AR	Some evidence of significant change in performance was presented in some areas while not in others; or there was an improvement that was not statistically significant	No improvement in scores. No significant change found	The teacher's waiting to get more data before concluding	
Qualitative Measure	Teacher described evidence of significant changes in students' attitude, motivation or understanding	Teacher described evidence of some changes in changes in students' attitude, motivation or understanding; these may have occurred in some areas but not in others;	The teacher saw no changes in students' attitude, motivation or understanding	The teacher did not or could not describe changes in students' attitude, motivation or understanding	

- Section 3: **Explanatory framework**.

In this session, we will assess program participants' initial stage of Teacher Leadership Development (TLD) as determined by the frequency and extent to which they performed the different types of teacher leaders' tasks, roles and responsibilities; we will investigate relationships between teacher leadership and student-centeredness, and student-centeredness and student engagement. We will also examine student success as assessed qualitatively and quantitatively by teachers through their action research projects, and describe features of student-centered pedagogy that seem to have the greatest effects on student success.

We propose that there is a positive relationship between teachers' stage of leadership development and student-centeredness. Students are most likely to be engaged in learning when they are active as a result of teachers' use of a more student-centered approach in their teaching.

MTTI also hypothesizes that the practice of action research through teachers' use of the inquiry cycle leads to students' gains in performance and change in attitudes. Finally, as previously stated, it is our belief that teachers at Stage 2 of TLD are more student-centered and have the potential of having the greatest impact on students learning. What follows presents results of our investigations using partial data.

Evaluation and/or research design, data collection and analysis

At the time of this study, 33 certified teachers with 4-10 years of experience were enrolled in MTTI. There were 21 high and 12 middle school teachers. All were taking formal content and pedagogical knowledge courses, but had not taken formal leadership courses.

To determine teachers stage of leadership development, a 94-item Teacher Leadership Survey (TLS) mostly taken from the instrument developed Seashore et al. (2010) was designed using a 6-point scale from "None" (1) to "A Great Deal" (6). Forty-one (41) questions asked participants to determine the extent to which they practiced the seven different types of leadership roles and responsibilities. We classified teachers as high (HST), medium (MST), or limited (LST) based on their average ratings across all 41 roles: "Limited" (average rating: <2.5), "Medium" (average rating: 2.5-3.9) and "High" (average rating: 4 or more). Five were at the High Stage, 11 at the Medium Stage, and 14 at the Limited Stage (LST).

To determine teachers' student-centeredness, 97 observations of teachers were conducted during Fall 2009 and 112 during Spring 2010 using a Classroom Observation Protocol (COP) constructed through the selection of items that had been shown to be predictive of standards-based instruction and positive student outcomes (Lawrenz, Huffman, & Appledoorn, 2002). One of the COP sections described and rated the Type of Instructional Activities (lecture, hands-on…). Instructional activities were classified as teacher-centered, student-centered or in between. Participants were observed a minimum of three times (once a month during the fall semester) by three seasoned former mathematics teachers who retired as Assistant Principals or Principals as teachers taught a mathematics lesson.

We also analyzed the impact of teachers' AR projects on their students' success (Table 1). Overall, 769 students, 492 from high school and 277 from middle, were involved in 22 action research projects developed by 18 teachers. The primary goal for the AR projects was to improve students' understanding of concepts and attitude toward mathematics.

Results

Leadership Development Stages

Using the classification into HST, MST, and LST, we analyzed the relationship between these stages and the seven types of leadership activities. We found that at the initial point of leadership development, teachers are most likely to have responsibility for teacher-leadership (TL) activities that fall within Types 1, 2 and 7. They are least likely to have responsibility for Types 3, 5, and 6. Univariate ANOVA and post-hoc analyses showed significant differences among the three stage groups for Types 1- 7 as well as where these differences laid. For Types 1, 2, and 7, HST teachers rated their roles as significantly more active than both MST and LST teachers, while MST teachers rated their roles as significantly more active than LST teachers. For Types 5 and 6,

no difference existed between MST and LST teachers' ratings, while both rated significantly lower than HST teachers.

Additional ANOVA and post-hoc tests showed that LST teachers performed Type 7 roles significantly more than Types 3, 5, and 6, MST teachers performed activities of Types 1, 2, and 7 significantly more than those of types 5 and 6 ($p < .05$), and no significant differences among the types of leadership ratings for HST teachers.

Relationship between Teachers' Stage of Leadership Development and Student-Centered Pedagogy

In the Fall 2009 semester, MTTI participants in the Limited teacher-leadership category (n=14) used student-centered pedagogy for 33% of the time across observations. Those in the Medium category (n=11) used student-centered approaches 52% of the time, and those in the High category (n=5) for 40% of the time. One-way ANOVA showed there was a significant difference among the means. Post hoc analysis (Tukey HSD) showed that for Fall 2009, the mean percent of student centered observations was significantly higher for the Medium leadership category than the Limited category (Mean difference = 19.26, $p = .007$).

In the Spring 2010 semester MTTI participants in the Limited teacher-leadership category (n=13) used student-centered pedagogy for 19% of the time across observations. Those in the Medium category (n=11) used student-centered approaches 31% of the time, and those in the High category (n=4) for 25% of the time. One-way ANOVA showed that the means were not significantly different.

It may be that there were no significant differences for the Spring 2010 data due to the small numbers in the samples, particularly the High teacher-leadership category. Therefore, effect sizes were calculated (Cohen's *d*) for both the 2009 and 2010 data. Cohen's *d* measures the distance between two means in standard units, and a Cohen's *d* value of about 0.25 is considered small, one of 0.5 is considered moderate, and one of 0.75 or above is considered large. The results for Spring 2010 show there was a large difference in Cohen's *d* between the Limited and Medium teacher leadership categories (0.82), and a moderate to large difference between the Limited and High leadership categories (0.64). The results for Fall 2009 show that there was a very large difference between the Limited and Medium teacher leadership categories (1.28), and a moderate to large difference between the Limited and High leadership categories (0.45).

Overall, the results for this section indicate that, in the early stages of the project, MTTI participants in the Medium and High teacher-leadership categories tend to use more student-centered approaches to teaching than those in the Limited category. And if the assumption that student-centered teaching approach leads increase in student achievement is true, and if our hypothesis is confirmed by the analysis of future data, then this could be a breakthrough in finding a link between teacher leadership development and student achievement.

Changes in Students' Level of Engagement over Time

The following results are based on 97 classroom observations conducted during the Fall 2009 semester and 112 observations conducted during the Spring 2010 semester. Level of student engagement was recorded for each five-minute interval across the lesson. The frequency of each

level of engagement was then calculated across intervals and observations. In Fall 2009, a total of 896 recordings were made, compared to 737 recordings in Spring 2010.

The occurrence of each level of engagement was assessed. The three possible levels were: low engagement; medium engagement; and high engagement. The occurrence of each level of engagement was then expressed as a percentage of total occurrences. For both Fall and Spring semesters the instances of low engagement were few (less than 10% of all observations). For the Fall semester, medium and high engagement were observed at about the same frequency (45% of the time). By contrast, in the Spring semester, high engagement had increased to 63.5% of observations, and medium engagement had decreased to 28.5% of observations. This change in level of engagement from Fall 2009 to Spring 2010 was significant (Chi-square (2) = 62.6, $p<.001$).

This significant change in students' engagement could be perhaps explained for the fact that class attendance went significantly down from Fall 2009 to Spring 2010. We hypothesize that less able and more troubled students may have lost hope for succeeding on the looming standardized tests scheduled for May or June resulting in a drop of their motivation to attend school on a regular basis, and showing thus more engagement from the more able and motivated ones. We will follow this hypothesis closely as the program enters its third year.

Relationship between Student Centered Teaching (SCT) and Student Engagement

To determine if there was a relationship between SCT and Student Engagement, we derived two groups of participants; Group A (High Student Centeredness) consisted of the six participants who were observed to display the most student-centered teaching techniques as assessed by the classroom observers across both the Fall 2009 and Spring 2010 semesters; and Group B (Low Student Centeredness) consisted of the six MTTI participants who exhibited the least student-centered teaching techniques assessed in the same manner across the same time period.

Table 2 shows the percentage of student-centered teaching techniques for Group A (High Student Centeredness) and Group B (Low Student Centeredness) for the Fall 2009 and Spring 2010 semesters, and the average percentage use across both semesters. The high student centeredness group displayed a significantly greater percentage of student-centered techniques than the low group in the Fall 2009 semester ($t_{10} = 3.66$, $p=.004$), the Spring 2010 semester ($t_{10} = 7.45$, $p<.001$), and the average across both semesters ($t_{10} = 7.47$, $p<.001$).

Table 2: Student Centeredness Teaching by Semester

	Student Centeredness Group	N	Mean	Std. Deviation
Spring 2010	high	6	43.3851	18.75922
	low	6	13.5044	6.89540
Fall 2009	high	6	60.0697	9.74697
	low	6	21.5150	8.10215
Average Spring and Fall	high	6	51.7274	9.77503
	low	6	17.5097	5.48340

Table 3 shows student-centeredness ratings for the two groups by levels of student engagement in the lesson as observed by the independent classroom observers for the Fall and Spring semesters combined. There were no statistically significant differences between the means of the two groups. However, an effect size analysis (Cohen's *d*) showed that those MTTI participants in the high student centeredness group were somewhat less likely to have low engaged students than those participants in the low student centeredness group (Cohen's $d = 0.34$).

Table 3: Student Centeredness by Levels of Student Engagement

	Student Centeredness	N	Mean	Std. Deviation
Low Engagement	high	6	7.3033	14.66736
	low	6	12.0950	13.31650
Medium Engagement	high	6	31.8183	29.55777
	low	6	32.8933	26.88842
High Engagement	high	6	60.8783	29.46982
	low	6	54.9617	32.07754

Table 4 displays the mean rating for the two student-centeredness groups for the following two observation ratings: Rating Three (Students were reflective about their learning) and Rating Five (Interactions reflected collaborative working relationships among students). These ratings were thought to reflect student engagement in the lesson, therefore the greater the mean rating, the greater was thought to be the level of involvement.

Table 4: Student Centeredness by Engagement Rating

	Student Centeredness	N	Mean	Std. Deviation
Rating Three Average	high student centeredness	6	2.9850	.84011
	low student centeredness	6	2.7217	.37467
Rating Five Average	high student centeredness	6	3.1800	.95572
	low student centeredness	6	2.7483	.81629

There were no significant differences between the means of the two groups for either Rating Three or Rating Five. Even though Rating 3 and 5 scores did not correlate with the engagement scores for these two groups, it did for the whole large group.

Teachers Use of Inquiry and Student Success

The only quantitative evidence that has emerged so far that relates student centeredness to success in student engagement has been that highly student-centered teachers (Group A) were somewhat less likely to have low engaged students than low student- centered teachers (group B). Other evidence from the AR projects seems to indicate stronger link between teachers'

student centeredness and student success.

Success in the projects was measured both quantitatively and qualitatively, through pre- and/or post-test assessments, and observations and interviews of students. Table 5 shows evidence of student success since 77% of students scores improved significantly or partially after treatment. More importantly, 95% of students showed a total or partial change in understanding, attitudes, or motivation leading 92% of the teachers to think that the AR process was changing their students as learners and themselves as teachers. They stated for evidence that:

> Students were gaining more self confidence in math; talked more, and expressed themselves more often; were getting better at communicating their reasoning, and presenting their work; were a little more open to doing word problems; showed improvement in the concepts that they were assessed in; showed more motivation; were having a more favorable experience in math; were becoming aware of their own learning as they learn about the mistakes they make as they answer questions; were relieved to find that they were not the only one to make the mistake and to prevent future ones; were using their class notes as references for their class work instead of asking the teacher to help them; were more engaged and felt more successful; were more self reflective; increased their communication skills; were more motivated to do well on their Math Regents Exams; were more able to articulate their weaknesses during the one-on-one sessions; were using more math vocabulary; were less afraid to come to the board and share- out.

Table 5: Action Research Projects and Level of Success

	Success	Mixed Success	No Success	Inconclusive	Total
Quantitative Measure	11 (50%)	6 (27%)	4 (18%)	1 (5%)	22
Qualitative Measure	13 (59%)	8 (36%)	1 (5%)	0 (0%)	22

For one teacher, **"**Last term my students test average was not only higher than the schools but also higher than the City. Many of the students who were in my research group either improved their raw score or a whole level. The students also changed the way they view and handle math (improved outlook)."

Finally, a comparison between the eight (8) AR projects of Group A teachers and the nine (9) AR projects of Group B teachers (Table 6) showed that the high student-centered teachers had significantly more student success, at least quantitatively, than the low student-centered teachers. This led us to believe of a possible link between student-centeredness and student performance as measured by a grade.

Table 6: Group A vs. Group B Level of Student Success

		Success	Mixed Success	No Success	Inconclusive	total
Group A						
Highly student-centered teachers	Quantitative Measure	7	1	0	0	8
	Qualitative Measure	5	3	0	0	
Group B						
Lowly student-centered teachers	Quantitative Measure	2	4	2	1	9
	Qualitative Measure	7	1	1	0	
Total						17

Features of Student-Centeredness

Two strategies, both deemed student-centered by essence, seem to have produced the best effects on students, both quantitatively and qualitatively: "Student Error Analysis," used by 8 teachers, and "Problem Solving Strategies," used by 6 teachers. Four of Group A teachers (high student-centered) used "Student Error Analysis," and showed more student success. When surveyed at the end of the AR course, nine teachers asserted using the error analysis regularly in all their teaching. Teachers' comments on the use of error analysis can be summarized with the following students' quotes: "I like working on finding the misconception because it makes me feel like the teacher and I like helping my friends." Or, "I am more interested when I work on finding mistakes with some other people because they keep me on task and help me to see where the problem went wrong."

One teacher, who implemented a 10-minute problem solving session three times a week, noticed a great change in students' attitudes: "My students are very happy with the problem solving skills that I have exposed to them this year. They look forward to the 10 minute session that we have three times a week. Although it is taking some students a little more time, some are doing extremely well, and I do believe that they will use these skills in high school."

Directions for future research

The six high student-centered teachers (Group A) were all at Stage 2 of leadership development whereas only one of the six low student-centered teachers (Group B) was beyond Stage 1 of leadership development. Since Group A teachers showed more quantitative success in their inquiry projects, this led us to think of a possible relationship between leadership development, student centeredness and student performance.

We intend to conduct a meta-analysis of the data from the action research projects. This will enable us to derive a general measure of MTTI participants' students' success across all projects. Then we intend to examine the relationship, if any, to the students' performance on state-mandated math tests. This should enable us to see if links exist between MTTI participants' pedagogy, their students' engagement and performance in the classroom, and their achievement on state-wide tests.

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