Scaling Up Mathematics Achievement (SUMA)

The purpose of this proposal is to adapt and scale up a district-based systems model for building capacity for mathematics achievement that has been successful in closing the achievement gap in mathematics for underrepresented students in a 94% Hispanic border district. The proposal addresses Grand Challenge #3 by researching a model built through strong collaboration among mathematicians, learning scientists, educational researchers, statisticians, math education professional development leaders, and school district leaders. This systems-based capacity building model, SUMA (Scaling up Mathematics Achievement), will result in a deepening of teacher and student content knowledge leading to an increased quality, quantity and diversity of students able to enter the STEM (Science, Technology, Engineering, and Mathematics) field. Increasing the capacity of the educational system to provide human resources for STEM is a critical national priority and will determine nothing less than our future economic viability as a nation.

Goals

(1) A goal of the proposed research is to investigate whether it is possible to successfully scale-up and adapt the Capacity Building Systems Model used in the Gadsden Mathematics Initiative (GMI) and improve mathematics achievement for all students. The study will explore not only the challenges of replicating this model in a larger setting but will conduct design-based research to refine the potential of this model for national application.

(2) A second goal of this research is to replicate success in broadening the participation of under-represented groups in entering STEM fields through closing the achievement gap and raising the achievement level of under-represented students in mathematics.

Research Questions

(1) Can the implementation of a capacity building systems model that closed the achievement gap in a rural New Mexico district also work in a larger district with mixed ethnicities?

(2) How does the model need to be modified by participating stakeholders in order to strengthen its potential replicability?

(3) Which elements of the model have the most positive effect on student achievement in the new district?

a) Do teachers gain pedagogical content knowledge as a result of the project and how does that interact with student achievement?
b) How does the level of administrative support affect achievement?
c) How does the level of teacher collaboration affect achievement?
d) What relationships exist between types of professional development and student achievement?
e) Does the level of classroom implementation of professional development affect student achievement?

Rationale

The model was developed and over the last ten years and was implemented and researched through the GMI, a National Science Foundation grant (2000-2006) which was a partnership between the Gadsden Independent School District (GISD) and New Mexico State University (NMSU). *This initiative was grounded in previous work by the researchers, mathematicians, math educators and school leaders who make up the authors of this systems capacity building research proposal*. In the 1990s our work, like many math reform programs during this period, focused on teachers and provided PD that was of high quality, but largely disconnected from

district, school and classroom cultures and practices. During a Star Schools grant (U.S. Department of Education, 1999) we collaborated on a three-state project [California, Colorado and New Mexico (NM)] to assist teachers to use technology and expanded pedagogy to improve student achievement in mathematics. The NM staff led the professional development efforts. After highly rated summer institutes with teachers, the grant leaders were disappointed when in follow-up visits they found almost no change in classrooms.

In 2002, the decision was made to change our professional development (PD) approach and co-construct mathematics PD with teachers around the learning needs of their students. Around this time, Lesson Study was being introduced to the U.S. and with the help of Dr. Catherine Lewis and Dr. Akihito Takahashi we introduced a modified form of lesson study in NM (Wiburg & Brown, 2007). We noticed that those teachers who working in districts with a common agreed-upon standards-based curriculum and had administrative support for collaboration had the most success in increasing student achievement. We also found through this collaborative work that teachers wanted to know more about the mathematics content and thus we invited mathematicians to collaborate with us in our work.

Based on this prior work, Kinzer, Wiburg, and Guzman in collaboration with the Gadsden Independent School District (GISD) developed a Local Systemic Change Initiative, the *Gadsden Mathematics Initiative* (GMI), (Award #0096674, 2001-2006). The GMI was a partnership with the university to improve teachers' knowledge and skills in teaching mathematics using standards based resources, specifically Investigations in Number, Data and Space and Connected Mathematics (CMP). This mathematics partnership between NMSU and the GISD was remarkably successful and further contributed to the development of a research-based model for a systems-based approach to capacity building for math achievement. This restructuring effort for students in grades K-8 in a low-income (100% free and reduced lunch) district with 60% English Language Learners (ELLs) resulted in closing the achievement gap, and in some cases surpassing state averages. Figure 1 shows where student achievement scores were when we started the project.

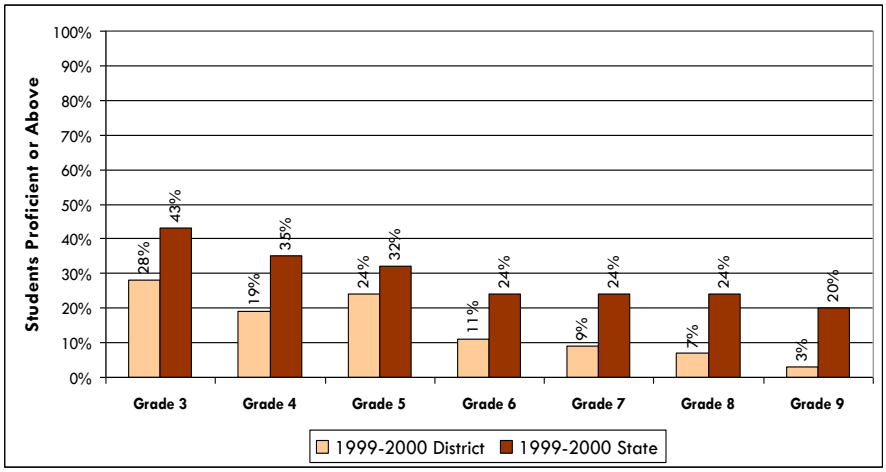


Figure 1
2000- Achievement Scores for GISD Students as Compared to the State

Figure 2 shows the proficiency levels for students in the district at the end of the five year program. Of special interest is the effect of the program on subgroups, especially ELLs who are now scoring far above all ELLs in the state. The students are above the state scores in grades 3 and 8. Students in those grades had spent the most time learning math in the GMI. There is a drop in 11th grade. The initiative was aimed at K-8 students and the effects seem to be maintained in grade 9 but drop off as students move further into high school. The GMI is fully sustainable by the district which is using operational funds to improve student achievement by continuing to have a math specialist at each school to support the mathematics PD.

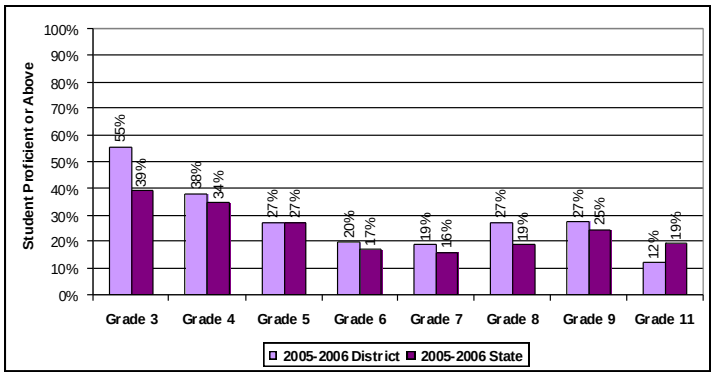


Figure 2 – 2006- Achievement Scores for GISD Students as Compared to the State

A summary of scores by sub-groups is provided in Table I below. A Student Outcomes Study was begun in 2003 to look for the effect of the GMI on student achievement. The final study showed that PD, level of implementation of the PD in the classroom, and teacher's collaborative work using modified lesson study all had a significant positive effect on student achievement. A mixed effect statistical model was used to show that variance decreased in student test scores during the initiative which lead to higher achievement for all students. The study also found changes in classroom instructional behaviors which included increased use of teacher questioning, more problem-modeling, increased student engagement and increased classroom discourse (Wiburg, Remmenga, Clason, Glasser & Yuh, 2007).

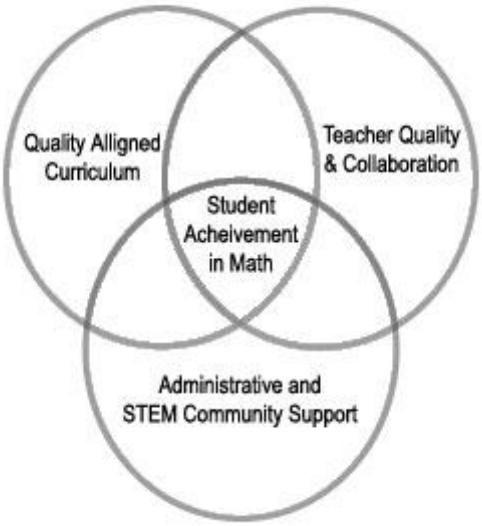
Table I: Percent of Students Proficient or Above (2005-2006) New Mexico Standards Based Assessments

	Grade 3		Grade 8	
	GISD	**STATE**	**GISD**	**STATE**
All Students	**56%**	**44%**	**28%**	**26%**
Hispanic Students	**55%**	**39%**	**27%**	**19%**
English Language Learners	**57%**	**33%**	**21%**	**8%**
Economically Disadvantaged	**56%**	**36%**	**28%**	**14%**
Students With Disabilities	**27%**	**20%**	**4%**	**3%**

Research on this initiative as well as related research in the field provides the basis for a systems-based capacity building model to support district-based mathematics achievement. The components in the capacity building model will provide the groundwork for the SUMA research study which will study the use of this model in a larger and more heterogeneous district.

Figure 3. Capacity Building Model for Mathematics Achievement

Aligned Curriculum
Includes data-driven analysis of learning needs; alignment of standards, instruction, assessment and accountability from local to state level; and use of quality curriculum materials



Teacher Quality
Knowledge of math content and expanded pedagogy through quality **collaborative** professional development

A successful mathematics program requires **Administrative and STEM Community support** including leadership from educational researchers, mathematicians, math educators, educators and school leaders.

The SUMA evaluative research will study the replication and adaptation of the model based on the original GMI model but modified over the next three years using a process of design-based research. The original mixed effects linear model would also continue to be used to study the empirical answers to specific research questions based on the model. The proposed work will be done in a larger district with more diverse demographics through a partnership with district leaders and teachers and STEM educators and researchers.

This district, the Las Cruces Public Schools, represents the changing national trends in student population. While states like New York and Texas struggle to meet the needs of diverse learners the changing demographics bears out the growing challenges for schools in all states including Wisconsin and Ohio (NCES, 2006).There is a need for effective capacity building models for mathematics achievement that can inform others in the broader mathematics community and contribute to expanding the quality, quantity and diversity of students who will have the mathematics background to enter the STEM fields. The theoretical framework for this systems model is included in the rationale section below.

The following proposal describes how a systems model for building capacity that was shown to be successful during the GMI initiative could be adapted for use nationally in other districts, A significant component of this proposal is to continue to expand the evaluative research begun during the student outcomes study and to use a continuous improvement process involving *design-based research* to further strengthen a *capacity building model*. This will be made possible by a strong, existing collaboration between educational researchers, mathematicians, mathematics educators and school district leaders with extensive experience over the last 10 years in building the capacity of districts for success in mathematics teaching and learning. While the GMI was successful in closing the achievement gap for Hispanic students in a 94% Hispanic district, we want to know if the same research-based systems model for building capacity can work in a district of mixed ethnicity where Hispanic students are currently scoring as much as 20% below Anglo students in the district by eighth grade.

This research effort will provide the opportunity to produce and disseminate new knowledge in the form of research findings, research tools, and a tested building capacity model that could positively impact student's mathematics learning across the country. In addition, we would like to find out if a focused professional development plan based on the building capacity model can be applied and tested in supporting full implementation of the K-8 NSF math curriculum in the Fall of 2007 and if this can be done through an intensive three year effort. Full implementation will include developing and coordinating all parts of the system, including curriculum alignment with teaching and assessment, the development of additional formative assessments, intense PD in mathematics content and teaching mathematics, support for administrators in the implementation process, and the integration of significant school-based support for teacher collaborative efforts (see Addendum __ LCPS PD plan). This proposal would provide the funding for researching these efforts while the district and other grants are providing funds for the implementation of the same standards-based curriculum used in the GMI.

A sustainable model that results in closing the persistent achievement gap for under-represented minority and low-income students in mathematics has potentially significant national value to Science, Technology, Engineering, and Mathematics (STEM) education. As the national demographics of our student population becomes increasingly diverse, it is imperative that educators address the achievement gap and make it possible to increase the quantity, quality and diversity of students capable of studying in STEM fields and eventually entering the national STEM workforce. A number of publications and reports ("*Waiting for Sputnik"*- Center for Strategic and International Studies, "*Rising Above The Gathering Storm: Energizing and*

Employing America for a Brighter Economic Future" - National Governors' Association, as well as the developing *American Competitiveness Initiative* call for urgent action to improve the preparation of our nation's youth to work in STEM fields.

Ethnically and linguistically diverse students are the largest growing proportion of new public school students with Hispanics being the largest growing "minority" population in the United States (US Census Bureau, 2000). Students from these populations are not achieving at the same rate of success in math as other populations (NCES, 2002). National Assessment of Educational Progress (NAEP, 2004) data indicates that at the national level the achievement gap for ELLs, various ethnic groups, and low-income students is not closing (Haycock, 2001). Hispanic students fall behind their Anglo counterparts in math at all grade levels (NCES, 2002), have lower participation rates in advanced math courses in high school and college, and are underrepresented in STEM related fields which require a strong background in math.

While mathematics is only one component of STEM education, knowledge of mathematics impacts deeply the study of science, technology, and engineering. In fact, in an interview with engineers for an NSF project (Bridges Project, 2002) when asked about what students needed to know to enter engineering in university, consistently, the engineers suggested that an understanding of mathematics and especially mathematical reasoning was an essential component to the study of every STEM discipline. It is a lack of mathematical knowledge that keeps children from studying further in the STEM fields (Moses & Cobb, 2002).

An important value of the proposed study would provide information about how a systems model for building capacity for mathematics learning can work in a larger district with mixed ethnicities and what level of effort and time are necessary to make such a model sustainable. One of the major findings of the GMI is that the problem does not lie with the children, their ethnicity or their income level, but with their lack of access to a system that provides all students with the opportunities to learn a rich and challenging mathematics curriculum. The GMI demonstrated what was first discovered in the *effective schools research* (McInerney, Dowson, & Van Etten, 2006), that schools can have a significantly positive effect on student learning, despite the fact that students are economically disadvantaged, have learning needs in terms of language and need to become part of an academic culture.

Theoretical Framework for the Capacity Building Model for Mathematics Achievement

The roots of the GMI systems approach to mathematics reform are grounded in both the literature in the STEM education field and in the extensive experiences of the mathematics educators and mathematicians who will be involved in implementing and researching the proposed systems research. Based on our own experiences and supported by Cohen and Hill's *Learning Policy* (2001), we believe that many educational reforms fail because teachers and the systems in which they work are not placed at the center of the reform.

As described earlier we found that variables affecting the success of lesson study included whether or not teachers had access to a quality standards-based curriculum, the school and district in which they worked had aligned teaching with the curriculum and the state standardized assessment, and the school and/or district had a system for supporting teacher collaboration. All of these factors were considered in designing the systems model used in the GMI. Critical elements included: (1) A commitment to using one standards-based curriculum for all schools and students that was district-wide and both top-down and bottom-up (2) The selection of an NSF-developed curriculum, namely *Investigations in Number, Data and Space and Connected Mathematics* (3) Alignment of the curriculum with teaching and assessment, including the use of formative assessments (4) Extensive professional development, including 130 hours for

teachers in mathematics content and teaching (5) Professional development for all administrators in how to support the new curriculum (6) Extensive academic year follow-up support in schools for teachers (7) Mathematics specialists at each school who give teachers immediate help and model lessons (8) Support and time for teacher collaboration.

Quality Aligned Curriculum:

Research (Wiburg & Korn, 2006) on the GMI , shows that it is possible to raise the scores of all students and close the achievement gap, when a whole district implements a rigorous standards based curriculum consistently across all schools and provides the necessary instructional and administrative support to teach the curriculum effectively. In other studies, student performance was related to curriculum focused PD (Cohen & Hill, 2000). Similarly, Hill and Ball (2004) found that content focused PD led to improvements in teacher's content knowledge. Whitehurst (2002) concluded that, "…when professional development is focused on academic content and curriculum that is aligned with standards based reform, teaching practices and student achievement are likely to improve." Student learning can increase and the achievement gap could diminish when there is a coherent aligned system of PD, assessment, and a quality curriculum (Schoenfeld, 2002). The district adopted NSF curricula for this study have been revised within the last year. Most NM teachers need support in helping students develop problem solving and communication skills that are required for 50% of the State test on open ended tasks. The National Research Council (2004) urges research at the district level that documents PD activities to curricula and learning and curriculum use to student outcomes.

Teacher Quality and Collaboration:

The *National Commission on Teaching and America's Future* is emphatic in its message that teacher content knowledge and strategies affect student achievement (NCTAF, 1996). Studies have shown that if students have effective teachers for 3-5 years in a row, the achievement gap can be closed or eliminated (Jordan et al. 1997; Rivkin et al. 2002). Darling-Hammond (1999) also found that teacher ability is a stronger determinant of student achievement than poverty, race, or parents' educational attainment. The Horizon Research Study (Weiss, 2003) of math and science reported that the most influential factor affecting instructional strategies was a teacher's knowledge, beliefs and experience.

Teacher PD has gone through profound changes over the last 5 years, moving from "additive" models to "transformational" models (Thompson & Zeuli (1999). New models envision teachers as life-long learners who are members of professional learning communities (PLCs). Organized opportunities for collaboration and assessment are part of an ongoing cycle of continuous improvement which allows teachers to study mathematics content, curriculum, pedagogy, and assessment. (Dufour, 2004; Elmore, 2005.) Student achievement goals can be realized by the formation of PLCs (Wenger, McDermott, & Snyder, 2002).

The current PD emphasis is to embed knowledge and skill acquisition within a framework of teacher growth and development, foster professional communities, build collaborative programs, provide ongoing support, and include interactive research within a community of learners (Sprinthall et al., 1996). Loucks-Horsley, et al. (2003) emphasized the essential components of high-quality PD as continuous and sustained over time, focused on helping teachers deeply understand content with the goal of increasing student learning and teacher engagement and collaboration in designing PD experiences that lead to improved learning and teaching.

Teacher collaboration also has a positive impact on implementation of mathematics curriculum. In the GMI, schools with high collaboration between teachers increased

implementation of what was learned in PD into their classrooms. Las Cruces Public Schools (LCPS) is using a school-based Professional Learning Communities (PLC) model. As a district wide initiative LCPS administrators and teachers have received PLC training. The attributes of PLCs include collective inquiry, reflective dialogue, and a collaborative culture of learning (DuFour, 2004). This PLC model is supportive of the aligned quality curriculum required for building capacity for mathematics achievement.

Administrative and STEM Community Support:

Hill and Cohen (2001) suggested that many research efforts fail because the focus of reform ignores what needs to happen with teachers in classrooms. In order to reach the classroom level and be sustained over time, an educational change initiative must be supported at all levels of the system – university, district, school, and classroom. This support must be systematic in nature and touch all components of the system that impact mathematics teaching and learning. The improvement of math instruction requires collaboration between mathematicians and math educators and close connections with classroom practice (NRC 2001; Cohen & Hill, 2000). Marzano (2005), Elmore (2003), and Dufour (2003) suggest that such a system includes capacity building for leaders as well as mathematics pedagogical content development for teachers. Marzano's (2005) meta-analysis of the leadership research identifies those behaviors which have well-documented effects on student learning and achievement. These include understanding effective practices in curriculum, instruction, and assessment, making systems goals and purposes clear, building the capacity of schools and teachers to meet high expectations, allocating time for teachers to meet collaboratively on a regular basis, monitoring the instructional program, and establishing a culture of accountability and mutual trust. The National Commission on Mathematics and Science Teaching for the 21st Century (2000) states that partnerships with mathematicians and districts focus on the mechanisms for sharing knowledge, expertise and resources. McLaughlin and Talbert (2001) determined that strong professional cultures are "essential to change the norms of practice and pedagogy". Learning occurs at collaborative school based communities through district wide structures including STEM educators and researchers. SUMA partnership structures include stakeholders from K-20 all focused on improving all students' mathematics learning.

Based on this review of the literature and our findings from previous research, our plan of work will involve the collaborative study of a systems-based model for building capacity for mathematics achievement.

Anticipated Products

(1) A researched and proven professional development systems model for building mathematics achievement in a district.
(2) Published research results that describe the process of using design-based research to adapt and improve the effectiveness of implementation of the capacity-building model.
(3) Guidelines and tools that can be used by other districts and partners interested in replicating this model.

Work Plan

Setting. The study will involve the analysis of the implementation of the model in the Las Cruces district in terms of how each of the three theoretical components of the capacity building model - Quality Aligned Curriculum, Quality Teaching Quality and Collaboration, and

Administrative and STEM Community Support- affect student achievement. The unit of analysis for this study is the district. The research will be conducted in LCPS District that is currently facing many of the challenges found at the beginning of the GMI grant where each school is using their own curriculum and there has been no centralized effort to improve mathematics instruction for all students, or to facilitate standards-based pedagogy and assessment consistently across all schools. Las Cruces Public Schools (LCPS) district is located in southern NM. The district is almost 70% Hispanic. (PERCENTAGE ELL?) The district has 35 schools: 24 elementary schools, seven middle schools (grades 6-8), four high schools (grades 9-12), and an alternative secondary school and one special education training center. Student enrollment is at almost 24,000. The district has just adopted the same NSF mathematics curriculum that was used in the GMI. It is problem-solving based and closely aligned to NM Content and Process Standards. LCPS is committed to reforming their mathematics program and providing the resources needed for establishing an intensive and on-going PD program for teachers and administrators based on the capacity building model and measured through the research study process and tools. (LCPS Support Letter_Appendix).

The district will provide curricula, funds for PD and plans to hire mathematics specialists for the schools. This will allow the SUMA staff to focus on evaluative research on the effects of the model on the district, schools, administrators, teachers, and students as well as use design-based research methodologies for modification of the model as it is being implemented.

The work plan is built from the capacity building components and includes the activities, objectives and how they will be accomplished and measured. The LCPS District will be using the capacity building model as framework to guide the activities and process. However, the iterative nature of the research design allows the partnership research team to transform the implementation process of the building capacity model as the data is gathered and analyzed based on established benchmarks and used as measurements to make decisions (see Work and Evaluation Plans). The ultimate goal is to improve student achievement. The research study will be co-lead by university researchers and district administrators in the LCPS. The purpose of this proposal is to fund research and evaluation on the effectiveness of the model for building capacity for achievement. This research grant is based on the premise that the research team is an integral part of the planning, measuring, and enactment of the Quality Curriculum, Teacher Quality and Collaboration, and Administrative/ STEM community support.

Research Design

The proposed evaluative research utilizes a mixed methodology (Tashakkori & Teddlie, 2003) that includes an empirical evaluation design utilizing a hierarchical mixed effects model within a design-based research approach. This research approach will guide the team in evaluating and modifying the implementation of the Capacity Building Model in a new district. The mixed methodologies involved are described below in terms of procedures and timelines.

The overarching research question for this systems research is:

1. Can the implementation of a capacity-building systems model that closed the achievement gap in a rural New Mexico district also work in a larger district with mixed ethnicities?

The next two questions will guide the research. The first question refers to the use of design-based research to modify and refine the model as it is being implemented in a new setting. The second question describes the procedures for answer the empirical questions related to the effect of the model on student achievement. The procedures to be used for the collection of data are included after each question.

2. How does the model need to be modified by participating stakeholders in order to strengthen its potential replicability?

The modification will be addressed through the use of design-based research (Design-based Research Collective, 2003) to support continuous improvement in the implementation of the model. Design-based research provides a useful methodology for researchers, practitioners and content area specialists to work together to produce meaningful change in context of practice Kelly (2003). This is systems-based research within a school setting the lens of design-based research is promising and needed. S*ustainable innovation requires understanding and how and why an innovation works within a setting over time (Kelly, 2003).* The research design involves multiple cycles of design, enactment and study. This approach will be used to constantly improve the strength of the model as it is being introduced in this new district setting. Using design-based research (Sandoval & Bell (2005), involves including the perspectives of all stakeholders in a research project which then become a part of a continuous formative evaluative process that can be used to shape and refine the systems model as it is implemented throughout the district. Frequent formative assessments can be extremely powerful for keeping a project on track and ensuring that all components of a model are working in tandem with one another. Design-based research views a successful intervention as a joint product of the designed intervention (the Capacity-Building Model) and the context in which it occurs. Models can be generalized through this work and model building is the goal of SUMA.

Design-based research can compose a coherent methodology for studying educational practice. Because design-based research is grounded in local needs, constraints, and interactions of local practice, a lens for understanding the implementation of a model and how it can transform educational practice. The goal is usable knowledge that can be used to modify educational change in practice (Design-Based Research Collective, 2003). Models of successful innovation can be generated from this approach. This project will be assisted in implementing this methodology through an internal and external evaluation team. The research team has a scheduled work plan to collaborate and based upon the data and measurement benchmarks will determine and document next steps.

3. Which elements of the model have the most positive effect on student achievement in the new district?

A mixed effects model will be used to analyze each year the data gathered in answer to the following questions as related to the effects of each component of the Capacity Building Model on student achievement. The three components of the Model are correlated to the appropriate research question below:

Component 1: Quality Aligned Curriculum

1a: What relationships exist between types of professional development and student achievement?

1b: Does the level of classroom implementation affect student achievement?

Component 2: Teacher Quality and Collaboration

2a: Do teachers gain pedagogical content knowledge as a result of the project and how does that interact with student achievement?

2b: How does the level of teacher collaboration affect student achievement?

Component 3: Administrative and STEM Community Support

3a: How does the level of administrative support affect student achievement?

The section below describes the procedures for gathering and analyzing data to answer the research questions. Table IV outlines the data collection and analysis and answers the following:

1) What evaluation instruments will be used?
2) Who is responsible for the collection of data?
3) Who is responsible for the analysis of the data?
4) What is the timeline for each evaluation?

Table IV: Data Collection and Analysis for SUMA

Evaluation	*Evaluation Instruments*	*Responsible for Collection*	*Responsible for Analysis*	*Timeline*
Measure what teachers implement in their classrooms from their professional development through classroom observations	**a) Levels of Use Observational Rubric** (used to observe at least 10% of the classrooms in the district to determine if what is presented in PD is being used in the classroom)	District Math Specialists and R. Benedicto, Project Coordinator S. Nakamura, and S. White District Reps. K. Korn, Internal Evaluator	Research Team K. Wiburg K. Korn M. Remmenga D. Kurtz	Random classrooms will be observed twice a year with both observation instruments for each year of the grant.
	b) Classroom Lesson Observation Instrument (used to observe at least 10% of the classrooms in the district to determine if what is presented in PD is being used in the classroom)			
Measure growth in teacher pedagogical content knowledge through pre and post assessments	**Survey of Content Knowledge for Teaching Mathematics (University of Michigan)**	District Math Specialists Project Coordinator Internal Evaluator	Research Team	Year 1, teachers will be assessed during summer training and again at the end of the school year. In Years 2 and 3, teachers will be assessed only at the end of the school year.
Analyze student achievement on the state criterion-referenced test by teacher classroom (Summative Evaluation)	**New Mexico Standards-Based Assessment Results (NMSBA)**	District Math Specialists District Reps. Internal Evaluator	Research Team	NMSBA is administered in March of each year. Results become available in September.
Analyze student achievement on district selected short cycle assessments (Formative Evaluation)	**The short-cycle assessments will be determined by the district.**	District Math Specialists District Reps. Internal Evaluator	Research Team	Short cycle assessments will be administered at least four times per year for each year of the grant.
Measure the level of administrative support	**a) Teacher Surveys** (to determine the level of administrative support)	District Math Specialists District Reps. Internal evaluator	Research Team	A random selection of teachers will be surveyed once per semester for Year 1 and once per year for Years 2 and 3.
	b) Teacher Focus Groups (to determine the level of administrative support)	District Math Specialists Internal Evaluator	Research Team	At least one teacher focus group per campus will be convened each year of the grant.
Track hours and type of	**a) Professional Development**	District Math	Research	Data must be collected

PD received by teachers, principals, and district administrators	**Teacher Sign-In Sheets** (to demonstrate the quantity and type of professional development teachers have attended)	Specialists District Reps. Internal Evaluator	Team	and compiled after each PD session. Data will be analyzed yearly.
	b) Professional Development Principal/Administrator Sign-In Sheets (to demonstrate the quantity and type of PD principals /administrators have attended)	District Math Specialists District Reps. Internal Evaluator	Research Team	Data must be collected and compiled after each PD session. Data will be analyzed yearly.
Measure participants' satisfaction with the PD attended	**Professional Development Teacher and Administrator Evaluations** (to determine the quality of the PD and to help adjust PD to the needs of the people attending PD)	District Math District Reps. Internal Evaluator	Research Team	Data collected and compiled after each PD session. Data will be analyzed at least twice each semester to determine the quality of on-going PD and to make adjustments to training.
Measure how much time teachers are given at each grade level at each campus for collaboration	**School Schedules** (to determine if time is built into each school's schedule for collaborative activities)	District Math District Reps. Internal Evaluator	Project Coordinator	School schedules will be collected at the beginning of each school year.
	Teacher Focus Groups	District Math District Reps. Internal Evaluator	Project Coordinator	The amount / quality of collaboration time will be discussed during yearly teacher focus groups.
Measure the district's ability to sustain positive change in mathematics instruction after the grant is over	**a) District Budget—**(level of fiscal responsibility taken by the district to hire District Math Specialists and other personnel to sustain the mathematics initiative)	P.I. & Co-P.I. District Reps.	P.I. & Co-P.I. Project Coordinator	A study of the district budget will be completed at the beginning of each fiscal year.
	b) District Budget—(level of fiscal responsibility taken by the district to replenish mathematics materials as needed)			

Table V. answers questions concerning the reporting of the research findings.

1) Who is responsible for producing the reports?
2) To whom will the reports be presented?
3) Who will make the presentations?
4) When will the results be presented?
5) Who will make decisions based on the research results?

The reported results will be used by the design-based research teams to assist in modification of the model to increase its effectiveness.

Table V: Analyzing and Reporting of Research Results

Evaluation	***Who will be responsible for producing the reports?***	***To whom will the reports be presented?***	***Who will do presentations?***	***When will results be presented?***	***Who will make decisions based on results?***
Initial meeting of	Program	Research Team	Internal	Meet before	Research Team

Evaluators/ Researchers and LCPS Reps to set Benchmarks/Measurements for 3 year project to align model/data for decision making	Coordinator	and Internal and External Evaluator	Evaluator	the project begins and Monthly thereafter	and Internal and External Evaluators
Measure what teachers implement in their classrooms from their professional development through classroom observations	Research Team, P.I. Project Coordinator	Principals District Math Specialists Other district personnel	P.I. & Co-P.I.	Twice yearly—February and September	Co-P.I. District Reps. Principals
Measure growth in teacher pedagogical content knowledge through pre and post assessments	Research Team, P.I. Project Coordinator	Principals, District Math Specialists Teachers Other district personnel	P.I. & Co-P.I. Project Coordinator	August of each year	P.I. & Co-P.I.
Analyze student achievement on the state criterion-referenced test by teacher classroom (Summative Evaluation)	Research Team, P.I. & Co-P.I. District Reps	Superintendent Principals, Other district personnel (Parents and community members will receive similar data without teacher info.)	P.I. Research Team	October of each year (results don't arrive in districts until September)	Superintendent Principals Other district personnel
Analyze student achievement on district selected short cycle assessments (Formative Evaluation)	Research Team, P.I. & Co-P.I. District Reps.	Principals Teachers Other district personnel	Co-P.I. District Reps. District Math Specialists	As short cycle assessments are given (four times per year)	Principals Teachers
Measure the level of administrative support	Research Team, P.I. & C0-P.I. District Reps.	Superintendent Principals Teachers	P.I. Research Team	Year 1: Jan. and August Years 2 & 3: August	Superintendent Principals Other district personnel
Track hours and type of PD received by teachers, principals, and district administrators	Research Team, District Math Specialists	Superintendent Principals Teachers Community members	P.I. & Co-P.I. District Reps.	August	Superintendent Principals Other district personnel
Measure participants' satisfaction with the PD attended	Research Team	P.I. & Co-P.I. Project Director District Reps.	Research Team	At least twice per semester	P.I. & Co-P.I. Project Director District Reps.
Measure how much time teachers are given at each grade level at each campus for collaboration	Project Director	P.I. & Co-P.I. District Reps.	Project Coordinator	August and May	Co-P.I. District Reps.
Measure the district's ability to sustain positive change in mathematics instruction after the grant is over	P.I. & Co-P.I. District Reps.	Superintendent Principals	P.I. & Co-P.I. District Reps.	During the preparation of the district budget and at the beginning of each fiscal year	Superintendent District Budget Committee

Instrumentation

The work will begin with (a) an assessment of each school and teachers' readiness to implement a standards-based curriculum and (b) pedagogical content knowledge test. Through our collaborative projects, we have developed a means for evaluating a school's capacity for change toward reform-based mathematics and a sequenced level of PD options based on the needs of each school. District administrators and principals will be asked to assist their school's readiness for change using the Quality Mathematics Education Model (QMEM). Other instruments include the Levels of Use (LOU), Classroom Lesson Observation (CLO), Classroom Snapshot, and Survey for Teacher Knowledge for Teaching Mathematics, and PD logs record the categories and amount of Professional Development. They are included in the Appendix and Work Plan. Other measures include State Criterion-referenced Tests and Short-cycle assessments for mathematics. The timeline for the using the instruments is specified in the work plan on pages __.

Evaluation Plan

The research team includes vertical integration of stakeholders from K-20 and an internal evaluator and external evaluation team. The validity and reliability will be established through the adequate size of data (about 500 teachers and their students) and the strong theoretical foundation established by our prior work research in the field. The instruments have been validated and are reliable. There is triangulation through multiple methods that help to produce robust results.

Evaluation and Quality Assurance of Research Procedures:

Wexford Inc. is the external agency that will conduct the research project oversight and evaluation in addition to all project quality assurance directly related to the research. As an independent research, evaluation and development organization, Wexford has the unique capabilities to: monitor the quality assurance process and coordinate it with the evaluation process; continually assess the project needs, goals and objectives; use the evaluation process to assist the project in moving forward with the research design and in answering the research questions; include all researchers in the ongoing collaborative research and evaluation; and coordinate data collection with the internal evaluator.

Dr. Deborah Jolly will be the lead evaluator with the Wexford group along with Sheila Cassidy and the Wexford Quality Assurance staff. Working closely with the NMSU internal evaluator and principal investigator they will provide full quality assurance of the research initiative and will insure that all project activities are completed to highest level. In addition, they will work with the NMSU research participants to ensure the appropriate identification, analysis and reporting of all descriptive, qualitative and quantitative data and its incorporation into the research design. All four types of evaluation (Descriptive, Formative, Implementation Analysis, Impact and sustainability) will be used to assess the progress of the NMSU research team in answering the research questions. In addition Wexford will provide input and analysis for the research project decision-making and in assessing progress towards research goals. They will work closely with the NMSU research team to determine the most reliable information for sustainability and replicability.

Major Goal 1: Investigate the scaling-up and the adapting of the capacity-building systems model used in the GMI and improve mathematics achievement for a larger group of diverse students.

Quality Assurance (QA) Marker	Who	Yr 1	Yr 2	Yr 3	Benchmark
1. Research models and procedures are in place and implemented according to plan	QA Team	X	X	X	Review by Wexford National Quality Assurance (QA) Team
2. Implementation of the Capacity Building Model in a new district	QA Team		X	X	Review by Wexford QA
3. Overall work plan and action plan for research design is in place and on schedule	External evaluation	X	X	X	Review of all work plans and research designs
4. Successful implementation is attained in the designated district	External evaluation		X	X	Intervention correlates with both the design-based research and the context of the district (research team notes)
5. Continuous formative evaluation is used to assess and redesign project activities	External evaluation	X	X	X	Review of all procedures, reports, research designs, etc from project logs
6. Reporting of all research results is completed in a timely manner and within the standards of the research community	External evaluation	X	X	X	Timelines for research markers Data logs

Major Goal 2: Replicate success in broadening the participation of under-represented groups in entering STEM fields through closing the achievement gap and raising the achievement level of all students in mathematics.

Quality Assurance Marker	Who	Yr 1	Yr 2	Yr 3	Benchmark
1. Advance the procedural knowledge regarding each research question	Research Team			X	Information disseminated in the field & to the professional community (field notes)
2. Modifications through Design-based research works to implement and sustain meaningful change in the context of practice	Research Team Internal evaluator External evaluation			X	Changes in the field (district) are occurring (CBAM)
3. Data sets are complied & analyzed to reflect student achievement, administrative support, hours of PD, collaboration hours	Research Team Internal evaluator External evaluators	X	X	X	Data reflects the benchmarks set at the beginning of the project
4. Design-based research methodology is used to direct the research effort	Research Team Internal evaluator External evaluators	X	X	X	Design-based research model drives all aspects of the process

Note: Process for continuous improvement and specific timelines for work scope provided in the detailed evaluation plan.

Dissemination and Sustainability

We will have public dissemination of well substantiated results. SUMA will be disseminated broadly through articles, conferences and other published modes of communication.
This research project will disseminate its findings to the broader educational community through strategies that begin at the local level, and then broaden to the state, national and international level. At the national level the research findings will be submitted for publication in the *Journal for Research in Mathematics Education, American Education Research Journal,* or other professional journals. Practice-based articles with be submitted to journals like NCTM's *Teaching Children Mathematics* and *Mathematics Teaching in the Middle School.* The project and its findings will be proposed for presentation at the National Council of Teachers of

Mathematics (NCTM) Research Presession, Joint Meetings of the American Mathematics Society (AMS) and Mathematics Association of America (MAA), National Association of Bilingual Educators (NABE), American Educational Research Association (AERA), National Council of Supervisors of Mathematics (NCSM) and other national conferences. This team has presented at numerous conferences and additionally will publish a monograph to share this research project.

Quality of Key Personnel

Administration: The project will be directed by **Dr. Cathy Kinzer**, currently Project coordinator for the Mathematically-Connected communities and methods professor for Elementary Math Methods. She also serves as the chair for TODOS schools on the TODOS-Mathematics for all organization, was a Presidential Awardee, and the state president for New Mexico's Council of Teachers of Mathematics. Liz Maruffo, Curriculum Director of Las Cruces Public Schools will serve as co-P.I. and assist in ensuring the research project is a collaborative effort between the university and the public schools. They will be assisted by a Project Coordinator, Rocio Benedicto, who is a specialist in effective pedagogy for helping English Language Learners learn mathematics and an experienced project coordinator for multiple projects. They will be assisted by a graduate research assistant and a part-time accountant paid for by the Education Research and Budgeting Center in the College of Education at New Mexico State University;

The Research Team: **Dr. Karin Wiburg**, Co-P.I. and Associate Dean for Research at NMSU, author of the Student Outcomes Study for the Gadsden mathematics initiative, a frequent presenter on technology and mathematics education and author of multiple books and studies, will work with the following co-researchers. **Dr. Doug Kurtz**, Associate Dept. Head for the Department of Mathematical Sciences at NMSU, and co-P.I. for Mathematically-Connected Communities; **Dr. Marta Remmenga,** Professor of Statistics and head of the University Statistics Department; **Ken Korn**, former Director of Program Evaluation and Accountability for the Gadsden Independent School District and Director of Assessment for the El Paso (Texas) Independent School District, and currently an instructor for administrative courses for the College of Education and an independent evaluator; **Sheryl White,** Director of Professional Development for Las Cruces schools and **Sandy Nakamura**, Director of Science and Mathematics Education for Las Cruces Public Schools. Wexford, Inc. will serve as an external research team lead by Dr. Deborah Jolly to assist with the research.

Teacher Researchers: Three teacher-researchers with strong knowledge in mathematics will be hired to assist in gathering data for this project. These teachers will help build sustainability for research-based curriculum development in the district, and work directly with teachers in helping them understand achievement data and learn from student work. Vitaes for key personnel are including in the Appendix.

Results from Previous Research

GMI (Student Outcomes Study and evaluation in appendix Y) Recommended as a Golden Nugget and do have hard evidence that it is possible to close the achievement gap in a low-income (average $10,026/year), high ELL (60%) and 95% Hispanic/Latino District.

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