Improvement of Mathematics Literacy in African-American Students: Preparation for Algebra and Higher Mathematics

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Project Summary

The proposed three-year study has two layers of research. Layer 1 will document in depth, and develop explanatory constructs for, practices in four urban schools where the schools and/or specific teachers have an outstanding record of placing or sustaining students in college preparatory mathematics: a San Francisco middle school with large numbers of African-American and Latino students; a Boston K-6 pilot school with a similar demographic profile; and a high school/feeder school pair in Jackson, MS, with 99% African-American students. In Layer 2, the researchers will examine dimensions and variables emerging from Layer 1 analyses in two sites, consider problems of measurement and "operationalization" for large-scale quantitative research, and develop indicators that will be pilot tested in the third site.

The first layer will use ethnographic methods to examine classroom teachers', administrators', youth teachers', and students' learning and teaching goals, beliefs, environments and interactions, in the context of the school and community. Classrooms and afterschool learning environments will be extensively videotaped, and interactions will be analyzed using the latest digital technology as now recommended by Stigler and colleagues at the TIMSS videotape study and from past research of investigator Greeno. The analyses will detail the development of mathematical ideas as well as the social processes of teaching and learning. The research draws on current theoretical perspectives and research methods on learning, including situated learning, integration of social and individual aspects of learning, communities of practice that influence students' learning and identities as mathematics learners, and methods for analysis of discourse, participant structures, and mathematics content.

The participating schools are members of the "Algebra Project," a middle school project founded in the mid80s to increase the proportion of minority students who complete algebra successfully in late middle school or high school and enter college preparatory studies. Each site will be studied intensively for one academic year, and student achievement followed up in subsequent years. The research will focus on four "communities of practice" that are assumed to exist and to have important influences on students' academic development: students with students, students with teachers, teachers with each other and others in the school; local and national communities that sustain the local project members.

Observations of teaching and learning will focus primarily on classroom and afterschool learning activities. Researchers will track students in at least two math classes (of the master teachers) throughout one academic year, and will follow up on student progress in subsequent years. Analysis will focus on students' development as mathematics learners, including their knowledge of mathematics (as demonstrated in tests, assignments, and classroom discussions) and their identity as mathematics learners. In the latter area, we will examine how the learning environment (including teachers and peer interactions) positions students as "authorities" and how they become "responsible for their own learning."

The research will provide: (a) foundational knowledge for improvement of mathematics education; (b) enhanced understanding of successful practice in urban settings, especially for African-American students; (c) new perspectives for teacher education and enhancement, and videotaped examples of best practices; (d) a videodatabase that can be used in future research; (e) a concept paper and pilot study of indicators designed for use in large-scale education research.

Improvement of Mathematics Literacy in African-American Students: Preparation for Algebra and Higher Mathematics

I. Problems Addressed and Outcomes Intended

This two-layer study addresses two problems: (1) the need to identify and characterize successful practices in the teaching and learning of mathematics for African-American students; and (2) the need to develop indicators for characteristics of successful practice that could be used in future large-scale research on student achievement in general.

The relatively low performance of U.S. secondary students in the most recent international study of mathematics achievement (TIMSS) has reconfirmed the urgent need to upgrade the U.S. secondary mathematics curriculum and to increase the proportion of students who master algebra early enough to pursue more advanced mathematics in high school. Research indicates that many low-income students do not take the rigorous mathematics courses needed for college entrance (U.S. Dept of Education, 1997). African-American and Latino students in particular are not expected to succeed, or prepared to succeed, in algebra and higher secondary mathematics, and are failing math and science subjects in disproportionate numbers (e.g. Tate, 1997). Although education leaders are now promoting the belief that "all students can learn," there is little in-depth documentation of successful practice using current theoretical perspectives and methods (Ladson-Billings, 1998). While research has indicated some promising practices (e.g. U.S. Dept. of Education, 1997), few researchers have examined them in depth.

Layer 1 of this study will document in depth, and develop explanatory constructs for, practices in four urban schools (in Jackson, MS, Boston, and San Francisco) where schools and/or specific teachers have a track record of success in preparing students in algebra and in their successful continuation in college preparatory mathematics. Two of the schools, a high school and its feeder middle school in Jackson, serve 99% African American students. The other two schools are an elementary school in Boston and middle school in San Francisco that serve diverse students populations including African American, Latino and other students (described further below). This layer will use ethnographic methods to examine classroom teachers', administrators', youth teachers', and students' learning and teaching goals, beliefs, environments and interactions, in the context of the school and community. Classrooms and afterschool learning environments will be extensively videotaped, and interactions will be analyzed using the latest digital technology as now recommended by Stigler and colleagues at the TIMSS videotape study and from Greeno's past research (see below). The analyses will detail the development of mathematical ideas as well as the social processes of teaching and learning.

In Layer 2, the researchers will examine dimensions and variables emerging from Layer 1 analyses and consider problems of measurement and "operationalization" for large-scale quantitative research. This layer is intended to provide an additional source of data for efforts by large-scale education researchers to define and "unpackage" factors that mediate student achievement, such as "enacted curriculum" and "opportunity to learn" (for example, Webb, Romberg & Shafer, 2000). We will develop and pilot test indicators in the third year of the study.

The intended outcomes of the research are: foundational knowledge for improvement of mathematics education; enhanced understanding of successful practice in urban settings, especially for African-American students, offering new perspectives for teacher education and enhancement; better research methods for describing mathematics learning, and a concept paper and pilot study of indicators designed for use in large-scale education research. Within the NSF/ROLE program, the study focuses mainly on Quadrants II and III, and provides a pilot study of methods for use in Quadrant IV research.

The proposed research will significantly contribute to NSF educational goals by describing factors that lead to successful participation of African American students, and other students, in the science and mathematics education enterprise.

Quadrant II: As explained further below, we will use the concept of "communities of practice," emerging from within the field of cognitive science, as a lens for social learning processes that characterize informal and formal learning environments, and the behavioral, cognitive, affective and social aspects of mathematics learning in those environments (Bransford, Brown & Cocking, 1999).

Quadrant III: The "communities of practice" concept also allows explicit consideration of multiple levels of practice that underlie students' mathematics learning, including teachers' development of pedagogical content knowledge and skills, school stakeholders' work to build teaching/learning environments enabling all students to achieve in the SMET enterprise, and other informal learning environments developed between students themselves.

Interaction between Quadrants II & III: We believe that seeking explanatory constructs that describe classroom interactions within other communities of practice (defining schools and their communities as an educational setting) will assist in reconciling fundamental research on individual and social learning with research on mathematics and science learning in educational settings.

Quadrant IV: The research involves examining, through the lens of communities of practice and using digital video technology, successful practice in urban four schools that are demographically and socioeconomically representative of settings where improvement in mathematics achievement is urgently needed. We believe that the ethnographic study will reveal aspects of teaching and learning that are important to the success of all students in these settings (not only African Americans), that are not yet well-documented, and that hold promise for developing indicators for large-scale, quantitative research.

II. Results from Prior NSF Support

The schools and teachers to be studied are members of the " Algebra Project," a middle school project founded in the mid80s to increase the proportion of minority students who complete algebra successfully in late middle school or high school and enter college preparatory studies. The project uses a broad strategy to address this goal, including a pre-algebra curricular intervention, teacher and trainer professional development, community development, and more recently, youth leadership development.

The project is unusual in that its instructional materials, implementation strategies, and notions of teaching competence have been developed by members of the main target population (African Americans) (Treisman, 1997). Project founders and teachers hold an explicit learning theory called the "five step curricular process" that is used in all of its learning environments (the classroom, afterschool activities for students, youth-led workshops, teacher professional development workshops, and community/school meetings).

The Algebra Project has received two previous NSF awards. Project sites in Mississippi were evaluated in 1993-94 by a national expert panel.[1] The Program Evaluation & Research Group (PERG) at Lesley College, including the authors of this proposal, were subcontracted to coordinate the evaluation and served as staff to the expert panel. The panelists concluded:

> The Algebra Project is an important undertaking with a potential to bring about systemic reform through implementing a middle school mathematics curricular intervention, a teacher development process, and a community development process. Although in place for only two

[1] Panelists: Courtney B. Cazden, Harvard Graduate School of Education; Shirley H. Conner, Hollandale Public Schools, Hollandale, MS; Robert B. Davis, Rutgers Univ.; Lisa D. Delpit, Georgia State Univ.; Edgar L. Edwards, ret. Virginia State Dept. of Education; Jacqueline J. Irvine, Emory Univ.; Charles Payne, Northwestern Univ.; and Kenneth J. Travers, Univ. of Illinois/Champaign.

> years, we observed positive outcomes in teaching, in students' attitudes and engagement around mathematical ideas, in community involvement, and in movement toward systemic reform (Cazden et al., 1995, p. 8).

In 1997, the Algebra Project received an NSF Teacher Enhancement award to implement the major recommendations of the panelists: to integrate mathematicians and math educators into all phases of the project, and to further teachers' professional development and support in sites. This work was funded for six sites (three areas of rural Mississippi, Jackson, New York and Cambridge, MA) and recently expanded to include 20 school districts in the south. This award will expire on March 31, 2001. Lesley College PERG staff were subcontracted by the Algebra Project for the evaluation component (West, Davis, Lynch & Atlas, 1998).

In order to evaluate the project's potential to reach its goal of increasing student participation in the college preparatory mathematics track, PERG tracked middle school Algebra Project "graduates" into high school in those sites where the project had extended throughout the middle school grade levels, and had been in place for at least five years (Cambridge, San Francisco, and Jackson, MS). In all three sites, students were succeeding in a greater proportion than peers who were not in the project (see below).

The proposed study does NOT serve as further evaluation – it focuses on a small number of sites that have already proven successful – but it does intend to explain why they are successful. (The scientific verification of the explanatory constructs that emerge from this study will need to be pursued in another study in the future, that should include a large number of schools that range in degree of success.) The sites are:

(1) A San Francisco middle school with a diverse student population (35% African-American, 20% Spanish speaking, 9% Chinese and Filipino, 2% American Indian, 14% other nonwhite, and 4% other white); 68% qualify for free or reduced cost lunch;
(2) A new Boston elementary pilot school of about 70% African American and Latino students, the majority on free or reduced lunch; staff have a track record of success in the Cambridge, MA, Algebra Project; and
(3) A Jackson, MS, high school and its feeder middle school with 99% African-American students, more than 85% on free/reduced lunch.

San Francisco

The Martin Luther King Jr. Academic Middle School in San Francisco began to implement the Algebra Project in 1991 and eventually restructured the entire mathematics curriculum and added extra math classes in order to offer Algebra I to all students in Grade 8, beginning in 1995-96. By that time, 7 of the 8 math teachers had been trained. All grade 8 students, including the 20% identified for special education, were taking Algebra I. (This is the only middle school in SF with school wide grade 8 Algebra I.) With assistance from the SFUD research department, PERG staff tracked the math course enrollment and grades of King graduates in the 14 high schools in San Francisco, and compared that with those of graduates of other middle schools. All of the high schools offer basic math courses as well as college prep sequences, and most schools test the entering students to determine placement. In Dec. 1996, only 18% of King students were placed in basic math in grade 9, compared to 38% for a demographically equivalent group of nonKing students, and to 27% for all nonKing students. In 1997, 13% of King students were place in basic math, compared to 23% for a demographically equivalent group of nonKing students, and 21% for all nonKing students. By Grade 10, 64% of the 1996 King graduates were taking Geometry or IMP levels 3-8, compared with 37% for a demographically equivalent nonKing group, and 44% for all nonKing students.

Jackson, MS

In Jackson, MS, Bob Moses and project-trained teachers taught about half of the students in the Brinkley Middle School for grades 6, 7, and/or 8, from 1994 to 1996. Those students received a range of "dosages" of the project, from one to three years, and with or without additional afterschool/summer

project activities. Brinkley is one of 15 middle schools in Jackson, and enrolled the highest percentage of students in Algebra I (41%) of all middle schools in 1995-96.

In 1996-97, across the 8 Jackson high schools, Brinkley students enrolled in the mathematics sequence in higher proportions than their peers. District-wide, 20% of grade 9 students were taking "general math," 58% were taking Algebra 1, and 19% were taking Geometry or Algebra 2. As of Dec. 1997, nearly all of the Brinkley Algebra I graduates (92%) were taking Geometry in grade 9. The percentage of all Brinkley graduates taking Geometry was 38%, highest of all 15 middle schools. Their course grade profile is similar to the district-wide profile. Their mean scaled total score on the state Algebra I test (286.8, n=73) was similar to that district wide (284.9, n=2546). (Statewide mean was set at 300.) These results were achieved even though Brinkley did not enroll students in Algebra I as selectively as did other middle schools, and even though only half of the school was participating in the project. Across the 15 Jackson middle schools, there is a negative correlation (r=-.54) between percentage of students in the school who took Algebra I, and mean scaled score on the Algebra I test.

Bob Moses and Dr. Wilma Morris, of Tougaloo College, are now teaching courses in Algebra I, Geometry, and Algebra II in Jackson at Lanier High School, using Algebra Project methods. At Lanier, there is an obvious increase in enrollment in college preparatory math sequence since they began, and the school has voted not to offer any General Math courses in the future. Over the past five years, grade 9 Geometry enrollment has increased from 6% to 39%, and grade 10 Geometry has increased from 26% to 40%. Enrollment in grade 10 Algebra 2 has reached 33%, the highest ever at the school. Lanier High School has the highest enrollment in grade 9 Geometry of the eight Jackson high schools and close to the top for Grade 10 Algebra 2. Evaluators are continuing to track the mathematics courses and performance of Brinkley graduates and Lanier students and examining the relationship with their middle school instruction, including their “dosage” of the Algebra Project.

Another Algebra Project component in Mississippi -- workshops led by Algebra Project trained youth -- was associated with higher scores on the state Algebra I test. The workshops were held in Jackson and W. Tallahatchie MS. In Jackson, students who had the Algebra Project at least in sixth grade, and who attended the grade 8 youth-led workshops averaged 293.39 (n=18), above the Brinkley average of 286.8. In W. Tallahatchie, a rural district with median household annual income of $12,000, Algebra I was not offered until grade 9. The mean scaled score for all district students was 289.4 (n=91), and the mean for Algebra Project students was 300.6 (n=36). The mean for 19 project students who also took the afterschool workshops was 315.9. The superintendent attributed the district’s removal from probationary status to the presence of the Algebra Project.

In the proposed study of the Jackson site, we will study the classrooms of Bob Moses (grades 9 and 10 at Lanier High school), and the workshops of the Young People's project at Brinkley Middle School and Lanier High School.

Cambridge, MA

Bob Moses and several teachers founded the Algebra Project at the King Open Program in the mid80s. It continued as a school-wide intervention, although Bob Moses was not involved after 1990. Beginning with graduates of 1991, PERG tracked seven cohorts of King students into the one Cambridge high school. With exception of one cohort, between 76% and 92% of King Open graduates enrolled in courses above Algebra I in grade 9. In 1995-96, for example, 92% of AP graduates were taking Geometry in grade 9, compared with 47% for the district as a whole.

The project teachers and parents played a large role in the system’s passing a district-wide mandate in 1992 that all students be offered Algebra I in grade 8. Several Algebra Project teachers were also hired by the school system as district-wide staff developers, and they led institutes not only in Algebra Project materials/pedagogy but also in TERC, EDC and Chicago Math materials.

Now that the Cambridge Algebra Project has had a significant impact on mathematics reform in Cambridge, several members of the Cambridge Algebra Project have gone on to found a Boston pilot school that is serving high numbers of low-income students and students of color. Algebra Project

teachers are teaching grades 5 and 6, and the principal is a former Algebra Project teacher. We will study the classroom of Lynne Godfrey who was a founder of the Algebra Project in Cambridge and was hired by the school system to do staff development district wide from 1992 to 1999.

III. Theoretical and Methodological Frameworks

A. Explaining Success: Some Features to be examined in the Ethnographic Study and Analysis of Interactions

The Algebra Project has features, ideology, and an explicit learning theory that project members, and various observers, believe might explain its success. However, our study does NOT assume that these features do explain success. Rather, we intend to document teachers' and others' beliefs about their practice, actual practice, and students' mathematics learning. We will by describe the "communities of practice" that bear on students' learning, and how they are developed or sustained, by using ethnographic observation and by microanalysis of videotaped teaching and learning interactions. In our analyses, we will develop our own explanatory constructs/hypotheses, and we will consider these in relation to hypotheses that project members or other researchers may propose. Below is a discussion of important features for our consideration.

(1) Ownership and cultural continuity: Some researchers have noted that reforms rarely "trickle down" successfully into culturally diverse communities of learners, in part because they have not been explicitly conceptualized in relation to these communities or dynamic notions of culture (e.g. Secada, 1989). Educators are also debating the role of cultural traditions or relevance in effective teaching. For example, African-American researchers have outlined characteristics of effective African-American teachers that differ from some mainstream notions, and are consistent with recognized features of African-American traditions (e.g. Irvine & Fraser, 1998; Delpitt, 1995). The Algebra Project is unusual in that it has been designed and implemented by the target population (Treisman, 1997). However, it is not clear exactly how this feature may or may not be connected with student success. Davis and West have noted that, while the project engages students in shared experiences, it does not feature culture-specific content, and that the schools and teachers are succeeding with all students, not only the African American students. We will consider whether and how these successful teachers (and schools) use cultural traditions in engaging students in the diverse classrooms as well as in the homogeneous African American classrooms.

(2) Systemic approach: Some would point to the project's systemic approach as an important determinant of its success. The project views improvement in mathematics literacy as an essential step in improving the economic and civil rights of minority students in inner cities and rural areas, and believes that reaching this goal requires fundamental and systemic reform in mathematics education. It has initiated curriculum reform efforts, youth and professional development activities, and activities aimed at engaging a larger community of stakeholders in school reform work. Project founders believe that progressive demonstrations of student achievement of mathematics literacy to various audiences are necessary for sustaining and enlarging groups willing to solve the obstacles to increasing mathematics literacy. The project strategies embrace several of the critical drivers defined by the NSF as necessary for successful systemic reform (Kahle, 1998; NSF, 1999). While the successful sites do embrace some of these drivers, we need to study sites in depth to identify what drivers are actually operating, and how. Since the project has had notable success in several sites, we believe it is an important and rich context for fundamental research that seeks to explore successful mathematics learning and teaching processes, and to relate such research based knowledge to the practical problems of educational improvement.

(3) Theory of learning: Project members hold an explicit theory of learning that is featured in initial teacher training and ongoing professional development, as well as in experiences designed for community development. In this classroom, this process describes learning and teaching that is anchored in reflection upon a physical experience, translated first into visual or intuitive representations, then into ordinary language, and then represented in a structured and symbolic language. Learners are seen as becoming engaged in a social-cognitive process that can move them, for example, from rich, complex and shared experiences to conceptual understanding and skillful use of symbolic mathematical representations.

The process results in extensive classroom discussions that incorporate mathematical reasoning. Such reasoning is implicated as distinguishing stronger from weaker classrooms by the recent TIMSS videotape study of classrooms (Manaster, 1998). Some examples of classroom interactions and how they generate mathematical thinking in an Algebra Project classroom are presented in articles in which project members and researchers have collaborated (Godfrey & O'Connor (1995) and by O'Connor, Godfrey, & Moses (1998). However, there has been no opportunity to document how teachers implement the theory in their everyday teaching, and to relate evident learning to the presumed processes.

(4) Students' sense of agency: Other research would suggest that these students succeed in mathematics learning because their classrooms are social contexts in which they feel comfortable and eventually develop a sense of agency, both as groups and individually (cf. Holland, Lachicotte, Skinner & Cain, 1998). In this view, developing out of investigator Greeno's research, the positioning of students, along with their teachers, as legitimate sources of mathematical ideas and representations, the grounding of classroom discourse in experience that the students have shared, and the continuity that is established between classroom practices and the students' cultural backgrounds, all contribute to the development of students' identities as constructive, authoritative knowers and learners of mathematics. This line of thinking will be empirically examined.

(5) Collaboration: the project offers a promising context for examining social processes in learning. Much of the work of the Algebra Project deliberately involves social processes. For example, work in classrooms and other mathematics learning environments emphasizes collaborative inquiry into mathematics. Teacher professional development activities emphasize collaborative work in improving educational practice and policy. Community organizing activities emphasize the collaborative development of solutions to problems that are obstacles to achieving mathematics literacy. We will characterize these social settings and processes and their apparent relationships to learning.

B. Theoretical and Methodological Framework

To address issues such as the above, we propose an ethnographic study that uses the notion of "communities of practice" to define the research foci and to suggest the social processes to be studied. The concept of "communities of practice" has been discussed by Lave and Wenger (Lave, 1991; Lave & Wenger, 1991; Wenger, 1998). The idea has been applied in analyzing mathematics learning by Greeno and the Middle-School Mathematics through Applications Group (1997) and in analyzing professional communities of mathematics teachers by Stein, Silver, and Smith (1998).

A community of practice is a group of individuals who work together for some purpose, or who are "mutually engaged" in a "joint enterprise," and who, in the work of achieving that purpose or enterprise, build knowledge and ways of working together or what may be called a "shared repertoire" (Wenger, 1998). The ways in which different individuals participate in a community, or their "positional identities" (Holland et al., 1998), are shaped by the experiences and cultural backgrounds that they bring, and by the affordances that the community provides for members to act with agency, creativity, and responsibility in their participation. Conversely, each community in which an individual participates contributes to the development of that person's identity, which is made up of the individual's "trajectory of participation"(Wenger, 1998), including her or his family, cultural and religious organizations, and neighborhood and peer-group activities, as well as school.

From our preliminary analysis of successful Algebra Project sites, we believe it may be important to capture the work of four communities of practice, examining patterns of interaction and development of students' and teachers' identities as they participate in mathematical learning and teaching activities. The communities we will examine are:

- student communities of practice: the work of students with each other in learning mathematics;

- classroom communities of practice: the work of students with teachers in learning mathematics;

- teacher and school communities of practice: the work of teachers with each other and with other stakeholders in schools to produce a high quality mathematics program; and

- local site and national communities of practice that sustain and develop the work of the project in local communities and in the nation.

The proposed research will analyze classroom communities of practice in the three sites in depth, including extensive classroom observations and interviews with students and teachers to investigate aspects of their growth in mathematical knowledge and understanding and their identities regarding mathematical knowing and learning. Teacher and school communities of practice with also be analyzed in depth through observations of teachers' meetings in which mathematics teaching is planned and evaluated and interviews with teachers and administrators about the school's educational goals and approaches, especially involving mathematics. Student communities of practice and local site and national communities of practice will be studied in less detail with selected interviews. We also will conduct interviews of the school "graduates"and with their high school teachers, to obtain information about how these learning environments can be supportive or inhibiting of mathematical success following the students' completion of middle-school mathematics that included the Algebra Project.

This work will also draw on work by Greeno and others in describing and analyzing classroom episodes in the teaching and learning of mathematics and science (e.g. Rosebery, Warren & Conant, 1992; Brown & Campione, 1994; Greeno, Benke, Engle, Lachapelle & Wiebe, 1998). Investigating aspects of students' growth in mathematical knowledge and understanding, including the hypotheses embedded in the Algebra Project's "five-step curricular process" requires observing and tracing the outcomes of practices that are supposed to enable students and teachers to learn and develop mathematically valid concepts, representations, and patterns of reasoning, and to "own" mathematical ideas, problems, and conjectures by building cognitive "ramps" from complex physical experiences to conventional abstract symbolic representations used in mathematics. To evaluate these hypotheses, our research will examine how learning practices in Algebra Project classroom communities position students and teachers as authoritative sources of mathematical ideas, participants in mathematical sense-making, and evaluators of mathematical representations, explanations, and arguments. Evidence of students' learning and development would include their performance in classroom assessments and their participation in class discussions, group work, and interviews, which we will analyze regarding their understanding of mathematical concepts.

Our research will focus especially on the development of students' identities as knowers and learners. Issues concerning learners' identities have been studied by Belenky, Clinchy, Goldberger & Tarule (1986) and Eckert (1998) among others. Belenky et al. distinguished between identities of "receptive knowing" and "connected knowing." Receptive knowers consider their knowledge to be supplied by others, rather than considering themselves as legitimate authorities in the construction of knowledge. Connected knowers consider their knowledge to be the results of constructive activity in which they participate in collaboration with other people, and with productive agency regarding the conceptual and representational resources of conceptual domains. The way in which mathematics is taught can shape students' identities in relation to learning mathematics. Boaler and Greeno (in press) found that most students in advanced placement calculus classes that were taught didactically considered themselves as receptive knowers in mathematics. In contrast, many students in calculus classes taught with more discussion of concepts considered their knowledge of mathematics as resulting from their interactions with their teachers and peers, in which they constructed meaningful conceptual understanding.

Our observations of classrooms will look for discourse markers of students adopting and granting each other positions of authority. Evidence regarding teachers' support of their students' development of identity would include their supporting students' authoritative positioning in discourse and connecting mathematical inquiry with students' experiences.

We will identify factors of classroom practice between teachers and students that appear to draw on social-cultural communities of practice. For example, we will examine the presence of classroom interactions that involve "shared" understandings of the "meaning" and "norms" of social interaction

(Delpit, 1995; Irvine, 1991; Irvine & Fraser, 1998), and students' perceptions of themselves as learners that are related to experience in urban and rural schools in which there are expectations about learning connected to race and class (Ogbu, 1992; Fordham, 1996; Steele, 1997).

We believe that our research will lead to explanatory construct(s) that capture interrelated concepts about participation in a classroom (process in a mathematics learning and teaching environment), personal and social identities negotiated in classrooms (teachers' and students' conceptions of themselves as teachers and learners of mathematics), and epistemological beliefs (teachers' and students' concepts of learning and of mathematics) that are necessary and more informative in describing efforts leading to student success in mathematics education. In addition, we expect that such explanatory constructs also require understanding aspects of other overlapping communities of practice, particularly those in which students and teachers interact with their peers in formal and informal ways. Such constructs may lead to hypothesis-testing research on a larger scale. Our "second layer" of research attempts to operationalize or scale these constructs and is an important bridge to this large-scale research.

IV. Data Collection and Analysis

The research will involve collaboration between the researchers and the participating schools and teachers. The research team will include: three senior researchers representing the needed areas of expertise; three master Algebra Project teachers whose classrooms will be followed (Bob Moses/Jackson, Lynne Godfrey/Boston, Marian Currell/San Francisco); three site documentors (one per site) who are familiar to the Algebra Project, who will be trained by the senior researchers to collect videotaped and live observations in schools, afterschool events, community meetings, etc.; an expert videographer from the Southern Initiative of the Algebra Project (Al White) who is experienced in creating professional videos for research and who will prepare special edited videos where needed; three graduate assistants (one per site) who will analyze observational data (live and videotaped) according to protocols developed by the team; and three youth representatives (one per site) who will collect data from student meetings and interviews, and review videotapes (during team meetings) to insure that students' perspective is adequately captured in the research.

The data collection will focus primarily on classroom and afterschool learning activities. We will examine students' learning of mathematics by analyzing the mathematics evident in classroom discussions, assignments and tests. Teachers' views of their curriculum and pedagogical goals and of their students' learning will be closely followed throughout the year and documented. We will track students and teachers in at least two math classes (of the selected Algebra Project master teachers) throughout one academic year using extensive videotaping, as well as live ethnographic observations, and interviews.

The latest technology for videotaping and videoanalysis will be used (Jordan & Henderson, 1995; Stigler, Gonzalez, Kawanaka, & Serrano, 1999). The equipment and software will replicate the system in use by Stigler and colleagues for the TIMSS videotape study. The video database resulting from the study will therefore be available for analysis by other researchers in the future.

We plan to videotape the classrooms/afterschool settings continuously at several times of year: For the first six weeks of school; again for two weeks in November, two weeks in January, and for four weeks near the end of the year. We will use two videocameras (one stationary, one "roving") as well as supplementary audiotape recorders that will capture conversations in small group work in various parts of the classroom.

Our methods for analyzing classroom interactions, activity segments, discourse, and mathematics content will include methods of video-based interaction analysis (Jordan & Henderson, 1995) used in studies by Greeno et al. (1998), Hall & Rubin (1998), and many others. After creating a log of a videotape's content (which provides indexes to the topics discussed and significant types of interaction) selected episodes will be examined and analyzed in detail to identify patterns of discourse and interpersonal interaction that change across time and that are candidates for explaining these changes. The development of mathematical ideas during the interactions will be tracked and described.

Periodically, the entire site team including teachers, site documentor, and youth assistant, will meet to view videotapes and to discuss the method of analysis and emerging results.

In each site, an individual who can work smoothly in the school will be trained by the senior researchers to serve as a "site-based documentor" – to collect live observations and interviews, and set up and monitor the stationary videocamera and audiorecorders in the classrooms. The documentor will work full time throughout the academic year. A graduate student will work half time throughout the calendar year. This student will also visit the school and do observations at first, and then will be responsible for the ongoing logging of videotapes, preparing video and audiotape for team analysis, and carrying out any coding or other analyses developed by the team. The graduate student will also carry out follow-up documentation and interviews during the subsequent years of the study.

The first step of the "second layer" of the study will involve consultation with Advisory Board member Norman Webb, T. Romberg and colleagues, and others, on questions such as: do their scales link with the foci of our research, including authoritative positioning of students in discourse, connecting math to experience, and mathematical sensemaking? Are there other key dimensions identified in their research that we should consider? After the first two years of data collection, we will consider the implications of our data collection and analyses for the development of indicators. We will develop and pilot test potential indicators in the third year, in the third site.

Resources of the study are:

- a strong Advisory Board (see below);
- long-term collegial relationships between PERG staff, NSF, and other education researchers;
- well-established, long-term collaborative relationships between the senior investigators and Algebra Project members in all three sites;
- previous experience of the master teachers in research efforts;
- an existing videotape archive of Algebra Project classrooms and events, that could be used in pilot testing of methods;
- existing documentation of Algebra Project events where project members have explicated their theories of the learning process and issues of implementation.

V. Research Plan

The three-year study will focus on one site per year, ideally San Francisco in Year 1 (which has implemented the project as a whole school for the longest period); Jackson in Year 2, and Boston in Year 3 (to allow time for this new school to develop).

The project will begin with a meeting of researchers and project members from the three sites, and a meeting or conference call of the Advisory Board. Other researchers working on the large-scale quantitative research related to the "second layer" will be consulted. Data will then be collected in each site in sequence (probably San Francisco Year 1, Jackson Year 2, and Boston Year 3.) Additional meetings of the entire project team, which will grow as sites are added, will be held once a year in the site being studied. Senior researchers and possibly some Advisory Board members will also meet annually at AERA. The Advisory Board is expected to hold two conference calls a year, and to meet once possibly in Year 1, to give input into planning.

In each site, during the research year, initial meetings will be held for the team as well as for school principals and others. Senior researchers will visit the site. The site documentors will be trained, and procedures for videotaping and observing will be arranged with input from the teachers. Algebra Project students who are now in high school will be interviewed about critical ingredients of their project

experience. The site documentor and graduate student will begin work. Later, the expert videographer will make three 5-day visits per year to provide more professional videos with a "roving" camera. Senior researchers will make at least two more visits and team meetings will be held.

The layer 2 work will begin with consultation with colleagues, and continue with updates and conferences with them about twice a year. At the end of Year 2 we expect to draw some tentative conclusions about the implications of the ethnographic research for the development of indicators for use in large scale research on student achievement. We will develop possible indicators and pilot test them during Year 3.

During Year 3 we will also develop final reports on both the ethnographic study and the indicator development

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