Reporting Categories: Checklist

1. **Participants: Who has been involved?**
   - What *people* have worked on the project?
     - Participant's Name(s)  Project Role(s)  >160 Hours
     - Thomas Smith  Principal Investigator  Yes
     - Laura Desimone  CoPrincipal Investigator  Yes
     - Koji Ueno  Graduate student  Yes
     - Alfred Dunn  Graduate student  No
     - Monica Bhatt  Graduate student  Yes
     - Rosario Basay  Graduate student  Yes
     - Susan E. Ansell  Graduate student  Yes
     - David E. Frisvold  Graduate student  Yes
     - Kristie J. Rowley  Graduate student  Yes
     - Bettie A. Teasley  Graduate student  No
     - Timothy L. Zeidner  Graduate student  No
     - Nataliya Rumyantseva  Graduate student  Yes
     - Meisha Fang  Graduate student  Yes
   - What *other organizations* have been involved as partners?
     - No other organizations were involved.
   - Have you had *other collaborators* or contacts?

We have continued to consult with Adam Gamoran at the University of Wisconsin, Madison on the analytical strategies that we have used in our analyses of mathematics teacher quality using the National Assessment of Educational Progress (NAEP) data and the Schools and Staffing Survey (SASS) data. We have also continued working with Dr. David Frisvold, a postdoctoral fellow at the University of Michigan, on analyses of teacher issues using NAEP data and Dr. Kristie Rowley Phillips, an Assistant Professor of Sociology at Brigham Young University, on analyses of the relationship between state policy and professional development using the Schools and Staffing Survey and the relationship between participation in professional development, teachers' change in their instructional practices and change in student achievement using the Longitudinal Evaluation of School Change and Performance (LESCP).

2. **Activities and Findings: What have you done? What have you learned?**
   - What were your major *research and education activities*?

Our study uses currently available national data to study the association between state, district and school policy, teachers’ professional development, and improvements in teaching and learning in mathematics and science.

Our major activities during the grant have been to (1) analyze measures of our study variables from the Schools and Staffing Survey (SASS) and the National Assessment of Education Progress, (2) complete construction of a State Policy Database from available state-level policy indicators, (3) conduct analyses that predict participation in high-
quality professional development based on teacher background variables and school level policy variables, and that predict the use of conceptual teaching strategies in both mathematics and science teaching based on teacher background variables and participation in professional development, (4) analyze relationships between the policy system, teachers participation in professional development, and student achievement using data collected by the US Department of Education’s Planning and Evaluation Service for the Longitudinal Evaluation of School Change and Performance (LESCP) in 1997, 1998, and 1999. Activities conducted as part of these projects are described below.

NAEP analyses.

Emerging patterns of professional development participation, forms of support for that participation, and teachers’ feedback on the value of that participation reflect many of the stated goals of standards-based reform (Smith & Desimone, 2003). As participation rates in content-focused professional development of at least moderate duration have been increasing, a first step in improving the quality of the teacher force, we undertook as part of this grant additional studies to understand how professional development opportunities were being distributed. Our primary interest was to assess whether professional development in mathematics is primarily performing an educative function by addressing weak teacher preparation, or a catalytic function by serving mainly teachers who already have a strong content knowledge of mathematics. The results, based on an analysis of the NAEP data, indicate that teachers with strong content knowledge in mathematics—measured by type of degree in mathematics and self-reported preparedness to teach different topics in mathematics—are more likely to take sustained content-focused professional development than teachers with weak content knowledge in mathematics (Desimone, Smith, & Ueno, 2006). These findings raise serious questions regarding how current professional development opportunities are being targeted towards teachers. If professional development is primarily serving teachers with already strong content area expertise in mathematics, rather than addressing content knowledge gaps for teachers less prepared to teach mathematics, it is unlikely that current forms of teacher learning opportunities will equip all teachers with the kinds of knowledge necessary to teach to national standards.

We followed-up this line of research by examining the relationship between the “visible signs” of teaching quality currently being mandated under the U.S. No Child Left Behind Act of 2001 and teachers’ use of standard-based instructional strategies, such as those advocated by the National Council for Teachers of Mathematics (NCTM) and implemented in the content standards of most states (Smith, Desimone, & Ueno, 2005). According to the legislation, "highly qualified" is defined as full certification, a bachelor's degree, and demonstrated content knowledge in all core subjects taught. Our analyses of 8th grade mathematics teachers in the National Assessment of Educational Progress, a nationally representative sample of students and their mathematics teachers, suggest that certification and degree level are weak predictors of teachers’ use of reform-oriented practices, while teachers’ content knowledge and level of participation in content-related professional development activities are associated with use of these kinds of instructional strategies. This article makes the case that the most uniformly enforced measure of
teacher quality under NCLB, certification, has little relationship to standards-based instruction and that additional policy and organizational supports are necessary to both reduce “out-of-field” teaching and to enhance teachers’ learning opportunities. We later documented similar findings in science (Smith, Desimone, Zeidner, Dunn, Bhatt, and Rumyantseva, 2007).


We recognized that state policies do not operate in isolation, in that they interact with each other and are largely interdependent. For example, strong authoritative policies with genuine teacher participation can counteract weaknesses in other strategies, such as lack of stability. Similarly, balancing the use of power and authority can be critical in eliciting changes in teachers’ instructions. Consistency can support or weaken power; for example, if high-stakes testing and school-based curricula are not aligned, leadership could be perceived as sending mixed messages, no matter how powerful the rewards and incentives attached to the high-stakes testing. There can also be an implicit trade-off between specificity and authority: Very prescribed reforms may be easier for teachers to implement, but they often leave little room for participatory decision-making, which may decrease authority. State policies may also affect implementation in complementary ways. For example, in the context of school reform at the district/school level, specificity is most related to implementation fidelity; authority is most related to depth and longevity of implementation; and power is most related to immediate, short-term effects. In applying the policy attributes framework to state policies, we felt it important to consider how the policies might work both independently and together to help districts, schools, and teachers achieve their goals for students.

Our three main research questions in this component of the project were (1) to what extent do state policy attributes predict change in state-average student achievement between 2000 and 2003? (2) to what extent do the relationships between state policy attributes and changes in state-average student achievement differ by proficiency level (basic, proficient, or advanced), race/ethnicity, and poverty level? and (3) do policy attributes have differential impacts on change in achievement among different mathematics content domains? We conduct the study in the context of 8th grade mathematics. An article based on these analyses was published in Educational

Next we examined whether state policy changes from 2000 to 2003 and whether NCLB-related mandates are associated with changes in the quality of teachers of children in poverty. A draft paper on this topic, based on the 2000 and 2003 National Assessment of Educational Progress (NAEP) Mathematics data, was presented at invitational conference titled *Will Standards-Based Reform in Education Help Close the Poverty Gap?* (sponsored by the Institute for Research on Poverty, the School of Education, and the Wisconsin Center for Education Research) at the University of Wisconsin, Madison in February 2006. Based on feedback that we received at the conference and written feedback from Adam Gamoran and anonymous reviewers, the Co-PIs and David Frisvold (a graduate student who was supported on the project) revised the analysis and re-drafted the paper during the summer of 2006. This paper has been published in a book edited by Adam Gamoran for Brookings Institution Press.


The results of these analyses were also presented in winter and spring of 2007 by the co-PIs at the Society for Research on Educational Effectiveness in Leesburg, Virginia in December 2006 and the American Educational Research Association Annual Meeting in Chicago in April 2007.

**SASS analyses.**

Recent research has shown the importance of professional development for teacher learning, and has documented the qualities that make professional development effective for improved instruction and student achievement. But how do teachers come to participate in either “effective” or “ineffective” professional development? In describing the policy environment on several dimensions, we sought to discover which types of policies are more or less influential in moving teachers into the types of professional development that research has shown to be most effective for improved teaching and learning, and whether these relationships differ for a high stakes subject—mathematics and a low-stakes subject—science.

We characterized the policy environment based on a theory that suggests certain attributes of the policy environment increase policy implementation: (1) authority, the
extent to which a policy is persuasive, (2) power, rewards and sanctions attached to a policy, (3) consistency, how aligned a policy is with other elements in the policy system, and (4) stability, how stable actors and ideas in the policy environment are.

Our analyses answered the following questions: Do attributes of the policy environment—authority, power, consistency, and stability—influence the likelihood that teachers will participate in professional development with research-based features of effectiveness (rather than classroom management, or no professional development)? Is this relationship between policy attributes and professional development participation different for high-stakes subjects (e.g., mathematics) than lower-stakes subjects (e.g., science)? An article describing based on these analyses has been published in *Teacher's College Record*. Primary findings are described in the next section.


A second paper examines the attributes of state policies within the context of both mathematics, a high-stakes subject, and science, currently a low-stakes subject. In describing state policy environments along several dimensions, we sought to discover which types of policies are more or less influential in moving teachers into the types of professional development that research has shown to be most effective for improved teaching and learning. Using a national sample of high school mathematics and science teachers from the Schools and Staffing Survey (SASS), we conducted a secondary analysis using a three-level hierarchical linear model (HLM) to predict teachers’ level of participation in different types of professional development. A paper based on this analysis has been drafted and is being revised for submission to the blind peer-reviewed journal *Education Policy*.

LESCP analyses.

Using the LESCp, a sample of teachers and students from 71 Title I schools located in 18 school districts in 7 different states, we measured the relationship between student math achievement and teacher practices and the relationship between those same teacher practices and teachers’ participation in professional development. In our teacher-level analyses, nine teacher practices were used as dependent variables. These same teacher practices were then used as predictors of achievement in the student-level analyses. We developed an indicator of how much time per day a teacher spent on mathematics; two composites were constructed to indicate a teacher’s topic focus—focus on basic math concepts and focus on advanced math concepts; three composites were created to indicate a teacher’s emphasis on procedural cognitive demands (memorizing facts, understanding concepts, and solving equations); and finally, three more composites were created to measure a teacher’s emphasis on conceptual cognitive demands (such as collecting and interpreting data, solving work problems, and solving novel problems). To investigate our research questions—namely, To what extent are teacher practices predictive of student mathematics achievement? Is teacher participation in content-focused professional development predictive of teacher practices?—we conduct two sets of analyses. Our first set of analyses focuses on predicting student math achievement over
time. To accomplish this, we use a cross-classified growth model using HLM 6.0 software. Because students change teachers over time, these data are not strictly hierarchical. That is, we cannot assume that each student belongs to one (and only one) teacher. This poses a problem for traditional hierarchical data. Because the students in our study cross contextual boundaries over time, a cross-classified model is necessary to assess the impact of teacher practices on student achievement (Raudenbush & Bryk, 2002).

The cross-classified model is constructed by including all time-varying student variables in the level-1 portion of the model. In our models, this includes the outcome variable (student math achievement) and a growth trajectory indicator. This indicator is a variable coded 0 for the 1996-1997 school year, 1 for the 1997-1998 school year, and 2 for the 1998-1999 school year. The row-level of the model includes all student-level time invariant variables. We include all student characteristics described above: student race, gender, free and reduced lunch participant, IEP status, and LEP status. The column-level of the model includes all classroom, teacher, and school characteristics: percent low performing students, years of experience, years of experience squared, minutes per day spent on math, focus on basic math topics, focus on advanced math topics, and emphasis on each of the following cognitive demands: memorizing facts, understanding concepts, solving equations, collect/interpret data, solve word problem, and solve novel problems. School characteristics—school enrollment and school poverty—are also included in this section of the model.

To test our second hypothesis—that content-focused professional development predicts the extent to which teachers use certain teaching practices—we run a series of hierarchical linear growth models. Nine models are run separately. We predict the amount of time teachers spend on math instruction, their focus on basic math topics, their focus on advanced math topics, and the emphasis they place on the following six cognitive demands: memorizing facts, understanding concepts, solving equations, collecting and analyzing data, solving word problems, and solving novel problems. The level-1 portion of each model includes time varying teacher and classroom variables. We included the growth trajectory indicator along with grade taught, percent low performing students in math, and all three measures of professional development participation. The level-2 portions of the models include all time-invariant teacher variables. In these models, we include years of experience and years of experience squared. At level-3, we include school characteristics—school size and school poverty. A paper based on this analysis is currently being revised for submission to the blind peer-reviewed journal *Educational Evaluation and Policy Analysis*. Our primary results are described in the findings section.

Analyses still in progress:

We also have examined data from the U.S. Department of Education study *Moving Standards to the Classroom: A Study of Mathematics Instruction* to examine whether policy attributes (rewards and sanctions; teacher involvement in standards setting, perceptions of how well aligned tests are to curriculum), influence the alignment of
teacher instruction (topics covered at different cognitive demands) with the content of state-level standards and assessments. Work on this topic was started by the Co-PIs in collaboration with two graduate students (Rosario Bassay, who was funded by this project, and Meisha Fang, whose time was covered by a fellowship from Peabody College). The data for these analyses was collected by the American Institutes for Research (AIR) for the *Moving Standards* study. Surveys of teachers, principals and district administrators we collect across six states in 2001. After collection, these data were never analyzed, beyond basic descriptive information, by AIR or the Department of Education. As the first group to make use of the alignment data collected on teachers using the *Survey of Enacted Curriculum* (as survey developed by the Council of Chief State School Officers and the Wisconsin Center for Education Research funded by NSF), much of summer and fall of 2006 and winter 2007 were spent cleaning the data and deciphering the files the content and structure of the data files that were received from AIR. Analysis of the relationship between teachers’ participation in content-related professional development, as well as their participation in in-school collaborations around teaching, and both the alignment of their instruction to both standards and assessments and the amount of emphasis they give to higher or thinking across specific mathematics topics began in spring 2007. A manuscript based on these analyses is still under development.

Qualitative data on teachers, principals, and district leaders’ perceptions of standards were also collected as part of this study. One of the Co-PIs has been coding this qualitative data. These analyses would support both explaining the quantitative results described above and to generate additional hypotheses for future work on how policy influences participation in professional development and alignment of instruction to standards and assessments.

- What are your major findings from these activities?

1. **Teachers who need professional development the most are not getting it.**

In our first study, we examined whether professional development in mathematics is primarily performing an educative function by addressing weak teacher preparation, or a catalytic function by serving mainly teachers who already have a strong content knowledge of mathematics. The data used are from the teacher surveys completed for the 2000 National Assessment of Educational Progress (NAEP). The results indicated that teachers with strong content knowledge are more likely to take sustained content-focused professional development than teachers with weak content knowledge in mathematics.

2. **Content knowledge and participation in professional development are better predictors of teaching quality than certification.**

In our second study, we examined the relationships between education credentials, content knowledge, participation in professional development, and high quality teaching for middle school math teachers using data from the 2000 National Assessment of
Educational Progress (NAEP). Our analyses of 8th grade mathematics teachers suggest that mathematics content knowledge and participation in content-related professional development activities are associated with higher quality teaching—measured in our study as increased emphases on conceptual and communicative teaching strategies.

3. Authority, not power, is associated with teachers taking more content-related professional development and increased interactions with other teachers around curriculum and instruction.

In our third study, we examine whether the policy environment influences what kinds of professional development teachers take. We characterize the policy environment based on a theory that suggests certain attributes of the policy environment increase policy implementation: (1) authority, the extent to which a policy is persuasive, (2) power, rewards and sanctions attached to a policy, (3) consistency, how aligned a policy is with other elements in the policy system, and (4) stability, how stable actors and ideas in the policy environment are. Using a national sample of high school mathematics and science teachers from the Schools and Staffing Survey (SASS), we find that authority more predictive than power of with teachers taking the kind of professional development that we know improves teaching and learning—activities focused on subject-matter content and instructional strategies, and active interactions with other teachers around curriculum and instruction. Similarly, we find that stability (measured by reduced teacher turnover), not the consistency of professional development with other reforms, is associated with taking effective professional development.

4. States tend to enact different attributes of standards-based reform policy simultaneously, with policy enactment associated with greater gains in procedural knowledge in mathematics.

Using data from the 2000 and 2003 NAEP, we found moderate correlations among four policy attributes (consistency, specificity, authority, and power), which suggest that in many states, at least in design, standards-based reform is working as advocates imagined—aligned content standards and assessments established, backed up by detailed guidelines and frameworks, incentivized by rewards and sanctions, and supported with extra resources and programs for struggling students and their teachers. Regarding achievement gains, our findings suggest that specificity and authority may be related to improvements in procedural knowledge, and no change in problem solving or conceptual understanding, while power (accountability) may be associated with a small decrease in all types of learning. We also found that disadvantaged students showed gains in procedural knowledge and did not lose ground in either conceptual understanding or problem solving.
5. There is little evidence of substantial improvement in teacher quality for disadvantaged (high-poverty) student between 2000 and 2003 and how states have structured their standards based reform policies do not appear to be linked with changes in the size of this teacher quality gap.

The central impetus for the 'No Child Left Behind' act was that many children were being 'left behind' in our education system. Our analyses focused on how students from high-poverty families might be 'left behind' in terms of teacher and teaching quality. We examined NAEP mathematics data for the time period from 2000 to 2003, and found no evidence of substantial improvement in teacher quality for disadvantaged (high-poverty) students. Further, we found that some policies seem to be working in the expected direction, but in no case have the NCLB-related policies that states have put into place had a major 'impact' on teacher quality.

6. Eighth grade science teachers who majored in science and participated in content-oriented related professional development activities were more likely to use reform-oriented practices.

While inquiry has long been used to characterize good science teaching and learning, few quantitative studies have examined the 'technical' barriers preventing widespread use of inquiry teaching (Anderson, 1996). The technical dimension includes 'limited ability to teach constructively, prior commitments (e.g., to a textbook), the challenges of assessment, difficulties of group work, the challenges of new teacher roles, the challenges of new student roles, and inadequate in-service education' (Anderson, 2002, p. 9). While we measured only a limited range of activities using the objectives that eighth-grade teachers self-report employing in science classes in the 2000 National Assessment of Educational Progress in science, we found relatively strong associations between reform-oriented practice and the majors of degrees that teachers earned as part of their formal schooling, as well as their current levels of participation in content-oriented professional development activities. This finding is consistent with earlier findings by Druva and Anderson (1983) that student outcomes in science are positively associated with teacher preparation in education and academic work, particularly in science training; and that the relationship between a teacher's training in science and cognitive student outcomes is progressively higher when they have taken higher-level science courses.

7. Many of the perceived barriers to implementing greater use of conceptual teaching strategies in mathematics in the United States do not seem to work as impediments in other countries.

Conceptual teaching strategies that require students to investigate, conjecture and problem solve with less reliance on computation and memorization are thought to foster greater student understanding and achievement. Previous research indicates that U.S. teachers have been slow to adopt conceptual approaches to teaching, especially compared to high-achieving countries. In this study we examine five commonly perceived barriers to the increased use of conceptual teaching in mathematics in the U.S. related to (1) teacher autonomy, (2) tradeoffs with computational strategies, (3) student achievement, (4) class size, and (5) teacher qualifications. We examine these barriers using data from
nationally representative samples of eighth grade mathematics classrooms across 38 nations from the Third International Mathematics and Science Study – Repeated (TIMSS-99), and follow-up analyses with data from the high-achieving nations of Japan and Singapore. Our findings suggest that most of the perceived barriers are not impediments to the use of conceptual teaching strategies in other countries, and the comparative findings hold promise for alternative paradigms for organizing better mathematics instruction in the U.S.

8. Middle school students and their mathematics teachers do not agree on many aspects of what goes on in their classes.

We sought to improve the use and understanding of survey data in education policy research by asking: How different are student and teacher reports of classroom instruction? Do student, class, or teacher characteristics account for any of the differences? Using National Assessment of Education Progress (NAEP) data, we compared the responses of middle-school students and their teachers to the same questions about mathematics instruction. We found low correlations and small significant mean differences between student and teacher reports; we also found that student reports are sensitive to key student and class variables, most notably to individual and class achievement, student race/ethnicity, income, parent education, and motivation. This analysis suggests that student reports on instruction are not consistent with teacher reports, although it does not allow us to assess which is more valid.

9. Participation in math focused professional development significantly predicts 8th grade math teacher’s covering advanced mathematics topics and increased coverage of advanced topics is associated with an increase in student math test scores.

Here we examined two research questions: (1) To what extent are teacher practices predictive of student mathematics achievement? And (2) Is teacher participation in content-focused professional development predictive of the practices that are related to increases in student achievement? For this study we used longitudinal data collected by the U.S. Department of Education, the Longitudinal Evaluation of School Change and Performance (LESCP) during years 1997, 1998, and 1999. We used a cross-classified growth model to predict student math achievement over time, and a series of hierarchical linear growth models to link teacher practices to participation in professional development. We found that participation in math focused professional development significantly predicts teacher’s covering advanced mathematics topics. We also found that coverage of advanced topics is associated with an increase in student math test scores.
10. Attributes of local- and state-level policy are more predictive of teacher participation in effective professional development in high-stakes subjects (mathematics) than in low stakes subjects (science)

Research demonstrating the relationship between state and local policies and teachers’ participation in effective professional development is sparse. This connection between policy environments and teacher-based outcomes becomes increasingly important as educational reforms (such as No Child Left Behind and others) place new demands on teachers. Since professional development is one of the critical mechanisms by which we intend to improve our educational system, we address the extent to which state and local policies are associated with teachers’ participation in content-focused, “effective” professional development. We consider such state policies within the context of both mathematics, a high-stakes subject, and science, currently a low-stakes subject. In describing state policy environments along several dimensions, we seek to discover which types of policies are more or less influential in moving teachers into the types of professional development that research has shown to be most effective for improved teaching and learning.

Using a national sample of high school mathematics and science teachers from the Schools and Staffing Survey (SASS), we conduct a secondary analysis using a three-level hierarchical linear model (HLM) to predict teachers’ level of participation in different types of professional development. We find that policy at both the local- and state-level is more predictive of teacher participation in effective professional development in high-stakes subjects (mathematics, in this case). We also find that the alignment between state standards and assessments is a key attribute of state-level policies that tend to promote teacher participation in effective professional development in high-stakes subject areas. Even though state-level policies are important in promoting participation in effective professional development, we also find that policy environments are strongest when they are closest to the teacher. Therefore, state policies tend to be somewhat removed from schools and teacher behaviors.

- What opportunities for training and development has the project helped provide?

Eight of the eleven Vanderbilt graduate students that have worked on this project had little exposure to K-12 standards-based reform policy before starting to work on the project. Through their work in the development of our State Policy Database, collecting and reading state documents, and indicators of state policy from CCSSO, Education Week, AFT, etc., they have developed their knowledge and appreciation for educational reform in mathematics and science. Further, three students who are being paid a salary from this grant, Ms. Rowley, Mr. Frisvold and Mr. Ueno, have in the course of conducting analyses, learned new software (e.g., ML Win and Stata) and techniques (e.g. fixed and random effects modeling) for analyzing multi-level data. Each of these students has also attended training seminars in how to analyze the NAEP data, sponsored by the National Center for Education Statistics. Other students have learned how to access, clean, and analyze a range of additional secondary data sources, including the Schools and Staffing Survey (SASS), the Trends in International Mathematics and Science Study (TIMSS), the Longitudinal Evaluation of School Change and Performance (LESCP), and
data from Moving Standards to the Classroom: A Study of Mathematics Instruction. Students on the project have been co-authors all of our papers accepted for publication.

- What outreach activities have you undertaken?

None

3. **Products: What has the project produced?**
- What have you published as a result of this work?
  - Major Journal Publications


*Denotes a graduate student supported by our ROLE grant.
• Books and other one-time publications None
• What Web site(s) or other Internet site(s) reflect this project? None
• What other specific products have you developed?

We had developed a State Policy Database that will provide comprehensive, detailed information on state-level policy attributes for each of the 50 states. This Database can be merged with existing state-representative databases, such as the SASS and the NAEP to allow the examination of the relationship between state policy, school policy, and student achievement in mathematics and science. We will make this database available to researchers upon request.

4. Contributions: How has the project contributed?
• To the development of the principal discipline(s) of the project?
  Our project is focused on understanding how policy can be improved to increase achievement in mathematics and science. Our main contribution so far is to provide evidence that teachers who most likely are teaching the weakest mathematics students are not receiving the best professional development. Further, our findings suggest that better mathematics instruction is related to high-quality professional development and teachers’ content knowledge, and not to certification. We have also found that polices that teachers believe in, either because they had a hand in creating them or they believe in their effectiveness, have a stronger influence on participation in the kinds of professional development advocated by standards based reform than school-level rewards and sanctions.

  • To other disciplines of science or engineering? none
  • To the development of human resources?
    Our project has provided graduate students with the opportunity to conduct research on mathematics teaching and learning. The project is supporting their development of analytic research skills and analysis techniques, as well as an understanding and appreciation for the complexity and challenge inherent in efforts to improve mathematics and science teaching and learning.

  • To physical, institutional, and information resources that form the infrastructure for research and education? none
  • To the public welfare beyond science and engineering? None
1. **Teachers who need professional development the most are not getting it.** In our first study, we examined whether professional development in mathematics is primarily performing an educative function by addressing weak teacher preparation, or a catalytic function by serving mainly teachers who already have a strong content knowledge of mathematics. The data used are from the teacher surveys completed for the 2000 National Assessment of Educational Progress (NAEP). The results indicated that teachers with strong content knowledge are more likely to take sustained content-focused professional development than teachers with weak content knowledge in mathematics. The graph below shows that teachers with no major or minor in math or math education, both with and without controlling for self-reported preparedness to teach math, are less likely to take sustained content-focused professional development than their colleagues with more background in math.

Changes in the probability of teachers with different mathematics credentials taking brief, medium-length, and sustained content-focused professional development, according to whether or not self-reported preparedness is controlled.
2. Content knowledge and participation in professional development are better predictors of teaching quality than certification. In our second study, we examined the relationships between education credentials, content knowledge, participation in professional development, and high quality teaching for middle school math teachers using data from the 2000 National Assessment of Educational Progress (NAEP). Our analyses of 8th grade mathematics teachers suggests that mathematics content knowledge and participation in content-related professional development activities are associated with higher quality teaching—measured in our study as increased emphases on conceptual and communicative teaching strategies.

Figure 2: Eighth grade mathematics teachers’ predicted emphasis on conceptual learning goals by level of degree in mathematics, with and without holding level of preparedness to teach content constant

Figure 3: Eighth grade math teachers predicted emphasis on conceptual learning goals, by hours of participation in professional development workshops and in-service training in mathematics and mathematics education participated in during the previous year

Figure 4: Eighth grade math teachers predicted emphasis on conceptual learning goals, by number of college or university courses in mathematics and mathematics education participated in during the previous 2 years
3. Authority, not power, is associated with teachers taking more content-related professional development and increased interactions with other teachers around curriculum and instruction. In our third study, we examine whether the policy environment influences what kinds of professional development teachers take. We characterize the policy environment based on a theory that suggests certain attributes of the policy environment increase policy implementation: (1) authority, the extent to which a policy is persuasive, (2) power, rewards and sanctions attached to a policy, (3) consistency, how aligned a policy is with other elements in the policy system, and (4) stability, how stable actors and ideas in the policy environment are. Using a national sample of high school mathematics and science teachers from the Schools and Staffing Survey (SASS), we find that authority more predictive than power of with teachers taking the kind of professional development that we know improves teaching and learning—activities focused on subject-matter content and instructional strategies, and active interactions with other teachers around curriculum and instruction. Similarly, we find that stability (measured by reduced teacher turnover), not the consistency of professional development with other reforms, is associated with taking effective professional development.

4. States tend to enact different attributes of standards-based reform policy simultaneously, with policy enactment associated with greater gains in procedural knowledge in mathematics. Using data from the 2000 and 2003 NAEP, we found moderate correlations among four policy attributes (consistency, specificity, authority, and power), which suggest that in many states, at least in design, standards-based reform is working as advocates imagined—aligned content standards and assessments established, backed up by detailed guidelines and frameworks, incentivized by rewards and sanctions, and supported with extra resources and programs for struggling students and their teachers. Regarding achievement gains, our findings suggest that specificity and authority may be related to improvements in procedural knowledge, and no change in problem solving or conceptual understanding, while power (accountability) may be associated with a small decrease in all types of learning. We also found that disadvantaged students showed gains in procedural knowledge and did not lose ground in either conceptual understanding or problem solving.
5. There is little evidence of substantial improvement in teacher quality for disadvantaged (high-poverty) student between 2000 and 2003 and how states have structured their standards based reform policies do not appear to be linked with changes in the size of this teacher quality gap.

The central impetus for the 'No Child Left Behind' act was that many children were being 'left behind' in our education system. Our analyses focused on how students from high-poverty families might be 'left behind' in terms of teacher and teaching quality. We examined NAEP mathematics data for the time period from 2000 to 2003, and found no evidence of substantial improvement in teacher quality for disadvantaged (high-poverty) students. Further, we found that some policies seem to be working in the expected direction, but in no case have the NCLB-related policies that states have put into place had a major 'impact' on teacher quality.
6. Eighth grade science teachers who majored in science and participated in content-oriented related professional development activities were more likely to use reform-oriented practices.

While inquiry has long been used to characterize good science teaching and learning, few quantitative studies have examined the 'technical' barriers preventing widespread use of inquiry teaching (Anderson, 1996). The technical dimension includes 'limited ability to teach constructively, prior commitments (e.g., to a textbook), the challenges of assessment, difficulties of group work, the challenges of new teacher roles, the challenges of new student roles, and inadequate in-service education' (Anderson, 2002, p. 9). While we measured only a limited range of activities using the objectives that eighth-grade teachers self-report employing in science classes in the 2000 National Assessment of Educational Progress in science, we found relatively strong associations between reform-oriented practice and the majors of degrees that teachers earned as part of their formal schooling, as well as their current levels of participation in content-oriented professional development activities. This finding is consistent with earlier findings by Druva and Anderson (1983) that student outcomes in science are positively associated with teacher preparation in education and academic work, particularly in science training; and that the relationship between a teacher's training in science and cognitive student outcomes is progressively higher when they have taken higher-level science courses.
7. Many of the perceived barriers to implementing greater use of conceptual teaching strategies in mathematics in the United States do not seem to work as impediments in other countries.

Conceptual teaching strategies that require students to investigate, conjecture and problem solve with less reliance on computation and memorization are thought to foster greater student understanding and achievement. Previous research indicates that U.S. teachers have been slow to adopt conceptual approaches to teaching, especially compared to high-achieving countries. In this study we examine five commonly perceived barriers to the increased use of conceptual teaching in mathematics in the U.S. related to (1) teacher autonomy, (2) tradeoffs with computational strategies, (3) student achievement, (4) class size, and (5) teacher qualifications. We examine these barriers using data from nationally representative samples of eighth grade mathematics classrooms across 38 nations from the Third International Mathematics and Science Study – Repeated (TIMSS-99), and follow-up analyses with data from the high-achieving nations of Japan and Singapore. Our findings suggest that most of the perceived barriers are not impediments to the use of conceptual teaching strategies in other countries, and the
comparative findings hold promise for alternative paradigms for organizing better mathematics instruction in the U.S.

Figure 9: Scatter plot of the percentage of 8th grade students math teachers who report using 3 or 4 conceptual teaching strategies most or every lesson by the percentage reporting that they ask students to practice computational skills most or every lesson, by country and income level.