## Abstract Title Page

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**Title:** Effects of Teacher Professional Development on Gains in Student Achievement: How Meta Analysis Provides Scientific Evidence Useful to Education Leaders

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## Abstract Body

*Limit 5 pages single spaced.*

### Background/context:

*Description of prior research, its intellectual context and its policy context.*

In the present education policy environment a high priority has been placed on improving teacher quality and teaching effectiveness in U.S. schools (Darling-Hammond et al., 2009; Obama, 2009). Standards-based educational improvement requires teachers to have deep knowledge of their subject and the pedagogy that is most effective for teaching the subject. States and school districts are charged with establishing and leading professional development programs, some with federal funding support, which will address major needs for improved preparation of teachers. The whole issue of teacher quality, including teacher preparation and ongoing professional development, and improving teacher effectiveness in classrooms, is at the heart of efforts to improve the quality and performance of our public schools.

More recently, several major research synthesis projects have broadly analyzed evidence on the effects of mathematics and science teacher preparation and development initiatives on student achievement. One approach to reviewing evidence across studies is to apply a logic model and to examine the relationship of teacher preparation on student achievement through effects on intervening variables such as teacher knowledge and instructional practices (Clewell et al., 2004; Ingvarson, Meiers & Beavis, 2005). This kind of full analytic model allows educators and leaders to identify key decisions about the organization, delivery and support of teacher development that are ingredients to positive outcomes.

State and local education agencies are responsible for directing and managing the use of federal funds for teacher development and improvement as well as guiding programs supported by states. Additionally, states are now required under NCLB to report on the qualifications of teachers in core academic subjects and the proportion of teachers that receive high quality professional development each year. Finally, states provide leadership for local systems on how to design, select, and implement professional development for teachers. Strong, research-based program designs, and evidence on their effects, are now in high demand across the U.S. States and in turn local districts seek models for designing and implementing effective professional development and particularly models supported by research evidence.

The intended audiences for the study's findings are education leaders, decision-makers and researchers. The study design builds on prior research and reporting on professional development programs and evaluation findings (Blank, de las Alas & Smith, 2007, 2008). The study was designed to measure and summarize consistent, systematic findings across multiple studies that show significant effects of teacher professional development on student achievement gains in K-12 mathematics or science.

### Purpose / objective / research question / focus of study:

*Description of what the research focused on and why.*

The meta analysis study focused on identifying and analyzing research studies that measured effects of teacher professional development with a content focus on math or science. The meta analysis was carried out to address two primary questions:

1) What are the effects of content-focused professional development for math and science teachers on improving student achievement as demonstrated across a range of studies?
2) What characteristics of professional development programs (e.g., content focus, duration, coherence, active learning, and collective participation of teachers) explain the degree of effectiveness, and are the findings consistent with prior research on effective professional development?

**Setting:**
*Description of where the research took place.*

The study took place in the United States over a period of two years from 2006 to 2008, with analysis extended to the first part of 2009.

**Population / Participants / Subjects:**
*Description of participants in the study: who (or what) how many, key features (or characteristics).*

Across all the studies reviewed, the focus was on teachers in public elementary and secondary schools teaching math or science at one or more grades K-12 and teachers who participated in a professional development program aimed to improve their teaching in math or science.

**Intervention / Program / Practice:**
*Description of the intervention, program or practice, including details of administration and duration.*

The meta analysis identified 16 studies of programs that had significant effect sizes and provided teachers with professional development in mathematics or science. The information available on program interventions indicated they included combinations of learning activities such as summer institutes, coursework, study group, classroom mentoring, and professional networking. Eight of the programs also offered teachers opportunities to put into practice newly-learned lessons from the professional development by leading classroom instruction, and seven of the programs bring teachers to observe a classroom with either an exemplary teacher modeling instruction or a peer teacher implementing lessons learned during the professional development. More details about program characteristics are available in Table 2. <Insert Table 2 here.>

**Research Design:**
*Description of research design (e.g., qualitative case study, quasi-experimental design, secondary analysis, analytic essay, randomized field trial).*

Meta analysis

**Data Collection and Analysis:**
*Description of the methods for collecting and analyzing data.*

The design for the meta analysis built on prior studies in education (Borman et al., 2002; Yoon et al., 2007; Lipsey & Wilson, 2001) and applied it to findings about professional development across states and districts.
The design had four steps:

1) identification and collection of potential studies,
2) determination of study eligibility and coding process,
3) data analysis,
4) reporting and dissemination.

The design for the meta-analysis was also informed by a review of findings on teacher development programs conducted by the American Institute for Research (Yoon, et al., 2007). Figures 1 and 2 illustrates the process in more detail. <Insert Figures 1, 2>. In particular, the meta-analysis study design centered on two areas: capturing the characteristics of the professional development programs discussed in the studies and documenting the resulting measurable student outcomes the studies attribute to the professional development programs.

The search process for potential studies included published and unpublished works as well as evaluation reports from funded state and federal professional development projects. The study authors conducted an intensive electronic search, using multiple and well-known databases and meta-databases. In addition, searches were conducted targeting certain periodicals in which evaluation studies of professional development programs would be featured. Publications and databases of major education research centers were also examined. Moreover, the study authors contacted principal investigators listed by program grants from the U.S. Department of Education Title II-B project evaluations and the research studies funded by the Institute of Education Sciences, the NSF Teacher Preparation Continuum and MSP project evaluations, and studies of the Local Systemic Initiatives. Lastly, cross-checks were carried out with findings from prior reviews and synthesis studies in teacher professional development. Four hundred sixteen studies or reports were identified for pre-screening. A review of the corresponding abstracts of those studies reduced the count to 74 studies. These remaining studies were screened by a team of trained coders who utilized a coding form based on a coding and reconciliation software program and form developed by AIR (Yoon, et al., 2007). Figure xx outlines the document review process and the resulting studies included in the meta analysis. <Insert Figure xx>. Meta regression analyses were conducted with the remaining sixteen studies, with the focus on studies that featured professional development in mathematics, since these studies produces the greater number of effect sizes than professional development in science.

**Findings / Results:**
*Description of main findings with specific details.*

The meta analysis of studies of teacher professional development programs in mathematics and science found that 16 studies reported significant effect sizes for teacher development in relation to improving student achievement. The evidence for the findings in the 16 studies was based on scientific research designs. These studies reported effect sizes for student achievement gains for a treatment group as compared to a control group and the studies provided adequate data and documentation for the research team to compute or re-analyze effect sizes. The large majority (12 of 16) studies were focused on analyzing mathematics teacher professional development and effects on student achievement in mathematics. The mean effect size for mathematics studies using a pre-post design is 0.21. These results show consistent positive effect on gains in student achievement in mathematics from teacher professional development in mathematics education. Table 1 details mean effect size findings for math studies by research design and measure type. <Insert Table 1>. Effect sizes were larger when measures of achievement were used that were specifically selected or developed to be aligned with the content focus of the professional development. However, the review of research did identify several studies with significant effects using large-scale statewide assessment programs.

Several common patterns were found across the sixteen studies on professional development program designs. The program designs included strong emphasis on teachers learning specific subject content as well as pedagogical content for how to teach the content to students. The implementation of professional development included multiple activities to provide follow-up reinforcement of learning, assistance with implementation, and support for teachers from mentors and colleagues in their schools. In terms of duration of development activities, 14 of 16 programs that were reported continued for six months or more. The mean contact time with teachers in program activities was 91 hours.

The numbers of teachers that were involved in the programs that were analyzed and found to be effective varied from less than ten to more than 90. The research and evaluation for the 16 studies employed multiple measures of student achievement and outcomes. The studies' analysis of effects on student achievement included scales to measure learning in specific content areas (e.g., algebra, measurement). The use of multiple measures allowed use of different types of test items. A majority of the studies analyzed professional development for elementary and middle grades teachers. The analysis of effects showed a pattern of stronger effects for elementary level professional development than for middle or high school teachers. Table xx details the professional development program features found in the studies.

The results for the 16 studies with effect sizes demonstrates to the education research and policy communities how meta analysis can and should be used in education to provide comparisons and aggregations of research findings over time and across many different studies. The process of review and analysis employed involved several thousand citations, initial pre-screening of 400-plus documents, and intensive coding and review of 74 studies. The methods of identifying, coding, and quantifying data used in the study can be employed for a variety of objectives in education research.

**Conclusions:**

*Description of conclusions and recommendations based on findings and overall study.*

Based on the results of the meta analysis of findings from teacher professional development studies, several recommendations can be made about use of meta analysis methods and their use for researchers, evaluators and education leaders.

- The meta-analysis design and procedures employed in the study proved to be effective in identifying a set of common findings regarding effects of teacher professional development on student achievement, and the procedures proved useful to determine which studies and their results met high standards for scientific validity and reliability.
- A scientific research design can be efficiently employed to evaluate teacher professional development, and a design to measure effects of teacher development on subsequent student achievement should be strongly considered for each funded program for teacher and teaching improvement.
- The use of research designs involving treatment and control groups should become a regular practice and built into the plan and organization for professional development and other initiatives.

- Measures of implementation of professional development are critical to evaluation design in order to document and measure activities to reinforce and extend learning for teachers in their school setting.
- Multiple measures of student achievement should be included in the research design if possible to provide for different types of assessments of learning and analysis of subject content learned.
- State and local education leaders should ensure that data systems are structured so that data on teacher development initiatives can be linked to student achievement measures, and these data can be effective for evaluation even where individual identifiers are removed.
- Procedures for meta analysis modeled in this study provide a consistent, quantified methodology for application and use in other studies, including initial identification, multiple coding and validation of reviews, comparison of research design with established criteria, and consistent procedures for effect size analysis and coding of treatment variables.

This meta analysis review did not include systematic identification or review of intervening measures of the professional development treatment, such as measures of gains in teacher knowledge, improvement in practices, or fidelity of implementation of what was learned. Several of the studies identified did report analysis of differences on these kinds of measures between teachers in the treatment and control groups. Further analysis across studies would provide stronger evidence and useful information about the relationship between professional learning of teachers from a specific initiative and subsequent improved learning by students.

## Appendices

*Not included in page count.*

### Appendix A. References

*References marked with an asterisk (*) indicate studies included in the meta analysis.*


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## Appendix B. Tables and Figures

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**Figure 1: Logic Model**

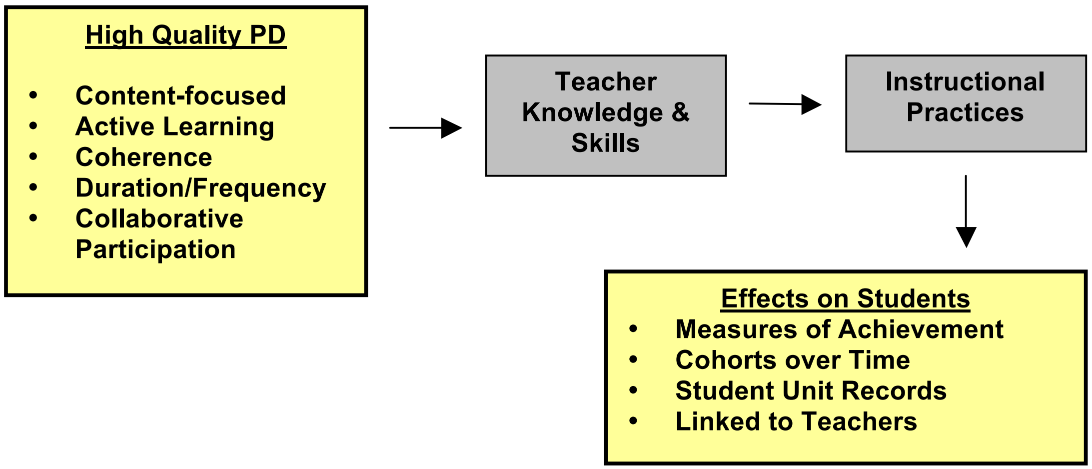

**Figure 2   Steps in Study Design**

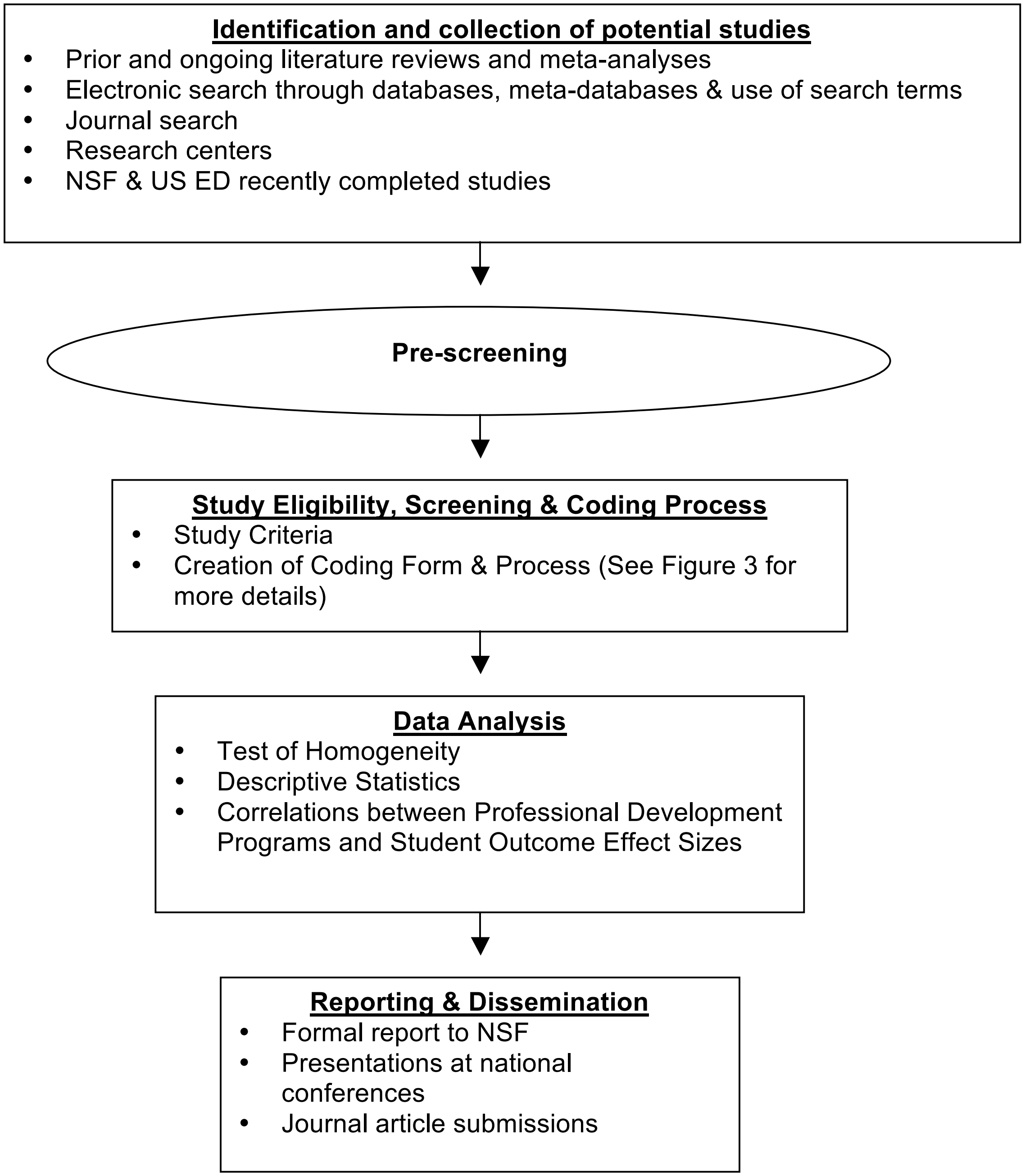
Identification and collection of potential studies
Prior and ongoing literature reviews and meta-analyses
Electronic search through databases, meta-databases & use of search terms
Journal search
Research centers
NSF & US ED recently completed studies
Pre-screening
Study Eligibility, Screening & Coding Process
Study Criteria
Creation of Coding Form & Process (See Figure 3 for more details)
Data Analysis
Test of Homogeneity
Descriptive Statistics
Correlations between Professional Development Programs and Student Outcome Effect Sizes
Reporting & Dissemination
Formal report to NSF
Presentations at national conferences
Journal article submissions

**Table 1: Identified Studies and Key Characteristics & Effect Sizes[†]**

| Study | Study Design | Grade/ School Level; Content Area | Treatment Teachers N Size (All Teachers) | Median Effect Size | Number of Effects | Student Outcome Measure |
|---|---|---|---|---|---|---|
| Carpenter, et al., 1989 | RCT | Elementary; Math | 20 (40) | .39<br><br>.68<br>.32 | 7 | ITBS (Level 7)<br><br>Oral test<br>Study-specific tests (Scale 1,2,3) |
| Dickson, 2002 | QED | Gr. 8-10; Science | 4 (8) | .1<br><br>.43 | 2 | Texas Assessment of Academic Skills<br><br>EOC Biology Test |
| Heller et al., 2007 | RCT | Gr. 2, 4, 6; Math | 48 | .69 | 6 | Math Pathways and Pitfalls pre-posttest gain |
| Jagielski, 1991 | QED | Gr. 3-8; Math | 43 (70) | .77 | 20 | MCIP/89 using released NAEP pre-posttest gain |
| Lane, 2003 | QED | Elementary; Math | 12 (22) | .13 | 2 | Constructed CSAP pre-posttest gain |
| META Assoc., 2006 | QED | Gr. 6-8; Math | 19 (34) | .13 | 6 | Colorado Student Assessment Program pre-posttest gain |
| META Assoc., 2007 | QED | Gr. 6-8; Math | 17 (40) | -.19 | 2 | Colorado Student Assessment Program pre-posttest gain |
| Meyer & Sutton, 2006 | QED | Gr. 6-8; Math | 31 (155) | -.02<br><br>.10 | 10 | Metropolitan Achievement Test posttest<br><br>Criterion Referenced Test posttest |
| Niess, 2005 | RCT | Gr. 3-8; Math | 24 (42) | .11 | 4 | Technology Enhanced State Assessment pre-posttest gain |

[†] *For Cohen's* d *an ES > 0.0 ≤ 0.3 is a "small" effect, >0.3 and <0.8 a "medium" effect and ≥0.8 a "large" effect.*

**Table 1 – continued**

| Study | Study Design | Grade/ School Level; Content Area | Treatment Teachers N Size (All Teachers) | Median Effect Size | Number of Effects | Student Outcome Measure |
|---|---|---|---|---|---|---|
| Palmer & Nelson, 2006* | QED | Gr. 5-10; Science | 16 (43) | .11 | 5 | Northwest Evaluation Association assessments pre-posttest gain |
| Rubin & Norman, 1992 | RCT | Middle; Science | 7 (16) | .64 | 8 | Middle Grades Integrated Process Skill Test pre-posttest |
| | | | | .12 | | Group Assessment of Logical Thinking Test pre-posttest |
| Saxe, Gearhart, & Nasir, 2001 | QED | Elementary; Math | 17 (6) | xx | | Study-specific assessments (Computational Scale) |
| | | | | 1.63 | 6 | Study-specific assessments (Conceptual Scale) posttest |
| Scott, 2005 | QED | Gr. 3; Science | 3 (6) | .20 | 2 | Iowa Test of Basic Skills pre-posttest gain |
| Siegle & McCoach, 2007 | RCT | Gr. 5; Math | 7 (15) | .20 | 2 | Math Achievement Test |
| Snippe, 1992 | RCT | High; Math | 87 (198) | -.01<br>.20<br>.06 | 21 | Terra Nova<br>ACCUPLACER<br>WorkKeys |
| Walsh-Cavazos, 1994 | QED | Gr. 5; Math | 4 (6) | .26 | 2 | PSG Achievement Assessment pre-posttest gain |

**Table 2: Professional Development Features**

| Study Authors, Year | Professional Development | Location | Contact Hrs. | Duration (in mo.) | PD Components |
|---|---|---|---|---|---|
| Carpenter, et al., 1989 | Cognitively Guided Instruction | 24 schools in Madison, WI metropolitan area | 80 | 4.5 | Coursework<br>Mentoring, Network<br>Study group<br>Summer institute |
| Dickson, 2002 | Inquiry Institute Science | Suburban school district north central Texas | 24 | 8 | Internship<br>Networking |
| Heller et al., 2007 | Mathematics Pathways and Pitfalls | Five diverse districts across the U.S. | 10 | 8 | Internship<br>Leading instruction<br>Summer institute |
| Jagielski, 1991 | Mathematics Curriculum Improvement Project | Chicago, IL | 36 | 8 | Conference<br>Leading instruction<br>Networking<br>Study group |
| Lane, 2003 | Problem-solving and reasoning Math | Five schools from one district in Colorado | 17 | 8 | Classroom observation<br>Developing assessment<br>Study group |
| META Assoc., 2006; 2007 | Northeast Front Range Math/Science Partnership | Five school districts in Colorado front range | 120 | 7.5 | Coaching<br>Devel. assessment<br>Leading instruction<br>Mentoring, Network<br>Summer institute |
| Meyer & Sutton, 2006 | Math in the Middle Institute Partnership | Lincoln, NE | 540 | 16 | Coursework<br>Summer institute |

**Table 2 - continued**

| Study Authors, Year | Professional Development | Teachers Location | PD Provider Agency | Contact Hrs. | Duration | PD Components |
|---|---|---|---|---|---|---|
| Niess, 2005 | High Desert MSP Math teaching | Five school districts in central Oregon | Oregon State University | 304 | 8 | Classroom observation<br>Leading instruction<br>Networking<br>Summer institute |
| Palmer & Nelson, 2006 | REC Lesson Study Science | Ten school districts in Minnesota | University, Global Resources | 60 | 8 mos. | Classroom observation<br>Developing assessment<br>Networking<br>Leading instruction<br>Study group<br>Summer institute |
| Rubin & Norman, 1992 | Systematic Modeling Strategy Science Teaching | Detroit, MI | Wayne State University | 30 | 3 mos. | Courses<br>Mentoring |
| Saxe, Gearhart, & Nasir, 2001 | Integrating Mathematics Assessment | Los Angeles metropolitan area | Researchers/ Authors | 41 | 8 mos. | Classroom observation<br>Developing assessment<br>Internship, Study groupLeading instruction<br>Mentoring, Network Summer institute |

**Table 2 - continued**

| Study Authors, Year | Professional Development | Teachers Location | PD Provider Agency | Contact Hrs. | Duration | PD Components |
|---|---|---|---|---|---|---|
| Scott, 2005 | TEAMS Professional Development Model | Suburban-Urban district Texas metropolitan area | School District | 168 | 8 mos. | Classroom observation<br>Coaching<br>Conference<br>Leading discussion<br>Mentoring<br>Networking<br>Study group<br>Summer institute |
| Siegle & McCoach, 2007 | Self-Efficacy Teaching Strategies & Implementation Math | Ten districts varying urban, suburban, rural in six states (MA, MD, MI, MT, NC, NE) | University of Connecticut | 2 | 1 day | Coaching<br>Leading instruction<br>Networking |
| Snippe, 1992 | National Research Center for Career/ Tech Education | Teachers from several states; providers traveled to each location | University of Minnesota | 14 | 3 days | Classroom mentoring<br>Networking<br>Study group |
| Walsh-Cavazos, 1994 | Probability, Statistics, and Graphing Module | South Texas school district | Researcher/ Author | 12 | 3 days | In-service activity |
| | | | *Mean*<br>Range | *91 hrs.*<br>2 - 540 hrs. | *6 mos.*<br>1 day–16 months | *3.3 activities*<br>1 - 6 activities |

**Table 3: Mean Effect Sizes for Teacher Professional Development Effects On Student Achievement, Mathematics Studies [include only part a math]**

| Categories | Pre-Post Effect Size (SE) | N Effects | Post-Only Effect Size (SE) | N Effects |
|---|---|---|---|---|
| **Math Studies** | 0.21 (0.08) | 21 | 0.13 (0.03) | 68 |
| **Research Design** | | | | |
| **RCT** | 0.27 (0.13) | 5 | 0.26 (0.05) | 35 |
| **QED** | 0.17 (0.08) | 16 | 0.04 (0.04) | 33 |
| **Measure Type** | | | | |
| **PD Specific** | 0.32 (0.08) | 15 | 0.28 (0.09) | 25 |
| **State Criterion- Referenced** | 0.01 (0.08) | 6 | -0.07 (0.14) | 7 |
| **National Norm-Referenced** | -- | -- | 0.17 (0.04) | 25 |
| **Local Test** | -- | -- | 0.05 (0.02) | 11 |

*N Effects* = number of effect sizes per category (across studies identified with at least one significant effect size); details on statistical tests in Appendix.

**[**

**Table 4: Correlation Table of Math Post-Only Professional Development Design Elements**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Time** | | | | | | | | | | | | | |
| 1. Contact Hr. | 1 | | | | | | | | | | | | |
| 2. Frequency | .741** | 1 | | | | | | | | | | | |
| 3. Duration | .834** | .623** | 1 | | | | | | | | | | |
| **PD Activities** | | | | | | | | | | | | | |
| 4. Summer Institutes | .577** | .399** | .655** | 1 | | | | | | | | | |
| 5. College Courses | .744** | -.171 | .596** | .618** | 1 | | | | | | | | |
| 6.Conferences | -.196 | .094 | .146 | -.403** | -.249* | 1 | | | | | | | |
| 7. Study Group | -.694** | -.253 | -.602** | -.524** | -.369** | .287* | 1 | | | | | | |
| **Active Learning** | | | | | | | | | | | | | |
| 8. Lead Discussion | -.196 | .094 | .146 | -.403** | -.249* | 1.000** | .287* | 1 | | | | | |
| 9. Learning Network | -.657** | .048 | -.601** | -.351** | -.471** | .249* | .796** | .249* | 1 | | | | |
| 10.Develop Assessments | -.138 | .398** | .135 | .345** | -.249* | -.172 | .021 | -.172 | .155 | 1 | | | |
| 11. Observe Teachers | -.154 | .562* | .084 | .418** | -.360** | -.249* | -.298* | -.249* | -.093 | .692** | 1 | | |
| 12. Classroom Mentoring | -.421** | -.571** | -.742** | -.394** | -.028 | -.347** | .579** | -.347** | .502** | -.347** | -.502** | 1 | |
| **Coherence** | | | | | | | | | | | | | |
| 13. Link to curriculum, Goals | .043 | -.161 | .106 | -.406** | -.244* | .221 | .163 | .221 | -.158 | -.080 | -.324** | -.059 | 1 |

Two-tail test: * significant at p<.05; ** significant at p<.01

**Appendix: Detailed significance tests for Table 3**

| | Pre-Post | | Post Only | |
|---|---|---|---|---|
| **Categories** | **95 % CI** | ***Q* statistic** | **95 % CI** | ***Q* statistic** |
| **Math Studies** | (0.06, 0.36) | $Q_T$ = 153.72* | (0.07, 0.20) | $Q_T$ = 328.78* |
| **<u>Research Design</u>** | | $Q_B$(1) = 46.12* | | $Q_B$(1) = 66.72* |
| **RCT** | (0.01, 0.53) | $Q_W$ = 53.24* | (0.16, 0.35) | $Q_W$ = 78.37* |
| **QED** | (0.01, 0.34) | $Q_W$ = 54.35* | (-0.04, 0.11) | $Q_W$ = 183.70* |
| **<u>Measure Type</u>** | | $Q_B$(1) = 84.46 | | $Q_B$(3) = 90.43* |
| **PD Specific** | (0.16, 0.49) | $Q_W$ = 46.81 | (0.10, 0.46) | $Q_W$ = 91.73* |
| **State Criterion- Referenced** | (-0.15, 0.16) | $Q_W$ = 22.45 | (-0.35, 0.21) | $Q_W$ = 111.25* |
| **National Norm-Referenced** | | -- | (0.10, 0.24) | $Q_W$ = 16.33 |
| **Local Test** | | -- | (0.02, 0.09) | $Q_W$ = 19.05* |

Notes: *$p$ < .05; if $Q_T$ is significant a random-effects model is applied. See further If $Q_W$ is not significant a fixed-effects model is applied. If $Q_W$ is significant a random-effect model is used for that category. $Q_B$ refers to differences between groups.