The Middle School Math Problem: Professional Development Challenges
Structured Poster Session

American Educational Research Association Annual Meeting
Chicago, April 10, 2007

Presenters:
Vince Cyboran, Ed.D., Roosevelt University
Peter A. Drake, M.A., DePaul University
Steve Ponisciak, Ph.D., Consortium on Chicago School Research,
University of Chicago
Barbara Radner, Ph.D., DePaul University

This presentation is based on a research grant
funded by the Institute of Education Sciences,
U.S. Department of Education, Award Number R305M040127

Project Team
Barbara Radner, Ph.D., DePaul University, Project Director
Lynn Narasimhan, Ph.D., DePaul University, Co-Project Director
Vince Cyboran, Ed.D., Roosevelt University
Peter A. Drake, M.A. DePaul University
Joseph R. Ferrari, Ph.D., DePaul University
Steve Ponisciak, Ph.D., Consortium on Chicago School Research,
University of Chicago

Project Website:
http://teacher.depaul.edu/AlgebraConnections.html

Abstract
The session reports on findings about the influence of professional development of teachers on math achievement of middle school students. Findings from an IES-sponsored experimental research project that analyzed effects of a three-component intervention to increase teachers' competence to teach math will be reported. The session will present data and introduce a framework for content analysis of teacher development. Participants will discuss findings in terms of the balance between content and process for teacher education about mathematics; issues of fidelity of implementation in studies based in urban schools; and implications for pre-service and in-service teacher education. The following report is an overview of research based on an intensive professional development intervention to increase middle school student math learning outcomes in Chicago public schools. A more complete report on this research is available at http://teacher.depaul.edu/AlgebraConnections.html.

Background and Need

The design of this professional development initiative represents a balanced response to an issue that is particularly critical for middle school grades: multiple needs of middle school teachers to develop students' math competence. Research has identified three areas that are essential to competence math teachers for middle school students:
1) increased teacher competence in mathematics; 2) increased effectiveness of instructional strategies; 3) increased application of formative evaluation principles (Hill; Swafford). An analysis of the need for improved math learning by students has led to an emphasis on teacher professional development, including programs that range from sequences of math courses through workshops that emphasize teaching strategies. Prior research indicates that both content knowledge and instructional competence are necessary. This current IES-sponsored research examined a model that includes courses to develop content knowledge, on-site facilitation to develop teachers' abilities in instruction and in formative evaluation, and scaffolds for students—guidesheets that organized student responses and provided a basis for teachers to identify student needs.

Theoretical Framework

The research is about an intervention that is based on the following premises. (Sources for these components of the design are identified in the bibliography.)
1. Job-Embedded learning increases the application of what is learned.
2. Teacher learning increases student learning when it is transferred.
3. Writing by students provides a basis for formative evaluation.
4. Formative evaluation when practiced consistently and responsively increases student learning.
5. Writing is an effective method to increase learning of any subject, including math.
6. Responses to open-ended prompts about teaching by teachers indicates their current teaching priorities.
7. An on-site facilitator increases fidelity of implementation.
8. Teacher interaction through cohort in course and within schools increases learning by teachers.
9. Algebra develops thinking abilities that are essential not only to succeed in high school but to develop problem-solving abilities.
10. Teachers need increased knowledge of mathematics at the elementary level.
11. The teacher is the critical variable in student learning.

Setting

The participants are two cohorts of teachers and students at Chicago public neighborhood schools that serve primarily African-American or Latino students from low-income families. Twenty-eight (28) Chicago Public School teachers and their students in grades 5-8 participated in a treatment through the project during its first two years. Students of an additional 19 teachers completed a limited treatment. The average poverty level of the participating students is 93.97%, with a range of 80.1% to 99.8%, and a median poverty level of 98%. The teachers represent a diversity of teaching backgrounds, including a range of teaching years from 2-34, with a mean of 12.68 and a median of 10 years.

Approach

The initiative included three correlated components in the treatment: course work in algebraic thinking; course work on formative evaluation with classroom applications; site-based teacher coaching and facilitation. The intervention was designed to influence teachers to develop students' ability to think mathematically and to embed algebraic thinking in ongoing instruction.

The content of the courses and on-site work correlate with NCTM standards for mathematics instruction. The instructional model itself was based on Whitehead's Rhythm of Learning in which learners start with "romance," then develop greater "precision," and then apply their learning in "generalization". That instructional sequence was followed in the teachers' courses and in the guidance to them for their own work with students. The romance stage emphasized allowing students to seek creative ways to solve problems strategically. The precision stage emphasized providing models from algebraic thinking to expand students' repertoires of strategies. The generalization stage emphasized writing by students to clarify their learning. Standardized tests were incorporated in the initiative as one outcome, although teachers were urged to expand their focus to students' thinking about problem solving rather than a test score outcome. A model for analyzing the progress of students as problem-solvers was developed based on the work of Neuman and Schwarz (Marshall; Neuman). Their work was applied in the development of a content analysis framework that will be presented during the session.

Research Methods

A stratified sample of teachers from Chicago public schools was included in the study. The sample was stratified by school and by interest. Twenty schools serving high poverty area communities were invited to participate. The schools then were randomly assigned to a treatment group or a limited treatment group. Teachers at grades 5 through 8 were invited to participate from each school. Teachers who volunteered then were selected randomly to participate or to participate in a subsequent year implementation. The Full Treatment group participated in a three-course sequence in algebraic thinking and one course in formative evaluation that continued throughout the one-school-year initiative. They also received on-site coaching by a peer teacher working full-time to facilitate the project and guidesheets for students that scaffolded student response to math problems. The guidesheets organized student problem-solving responses, requiring students to identify elements of the problem they were to solve and to explain in writing how they solved a problem The Limited Treatment group received those guidesheets and no additional support. The Full Treatment group received guidance on using the student responses to formatively evaluate and respond to student progress.

In addition to the treatment and limited treatment groups, a control group was identified that had no intervention. The achievement test gains for students of teachers in all three groups were analyzed for significant differences. The research emphasizes quantitative analysis to identify impact on student achievement of teacher participation in the initiative. There were two cohorts, one during 2004-5, one during 2005-6. Standardized tests, the ITBS, were used to identify gains by students using a value added model for cohort 1 (2004-5). Results of the Illinois state standards-based mathematics tests also were analyzed for cohort 2 because the Chicago public schools discontinued use of the ITBS in 2005-6.

The project incorporates qualitative analysis of both teacher development and of student learning. That qualitative analysis was completed through content analysis of teacher-written and student-written explanations of their learning. Pre-testing post- testing was completed using a set of math problems for students from the NAEP. Students completed surveys at the beginning and end of the treatment, including open-ended questions that required students to communicate their perceptions of the ways they best learned math. Teachers responded to pre-treatment and end of initiative assessments of their perceptions of math priorities and effective instructional strategies. Teacher work was collected to assess fidelity of implementation as well as to assess their learning progress in terms of embedding the principles presented through the treatment in their instruction and assessment.

Implementation

Urban school research faces obstacles to implementation and sustainability that affect all school-centered research projects but particularly those based in urban schools. Exogenous and endogenous variables that affect teaching and learning in urban schools also affect the fidelity of implementation of a treatment and the validity of research conducted in schools. One uncontrollable variable is teacher retention, which affected the size of the samples. For reasons including health problems, teacher transfers, and competing needs for priorities other than improving math teaching (such as family issues, school changes), there was attrition by teachers each year. The fidelity of implementation also was affected by teacher ability, as some teachers had greater difficulty than others in learning the mathematics that was presented through the courses and therefore were not as able to transfer that mathematics knowledge to students[1].

Results

Analysis of achievement data indicates that there are some significant effects at different grades for cohort 1 and for cohort 2, but not for all participating grades. The project established two measures relating to teacher performance: increase in competence, including knowledge of mathematics and problem-solving ability of the teachers; commitment, which included measures of fidelity of implementation—lesson planning, course attendance, course work, and assessments based on the course in assessment. The relationship between teacher commitment and student gains was identified as significant for some classrooms in that the treatment effect was greater in classrooms in which teachers more consistently implemented the intervention. The relationship between teacher gain in competence was significant in some instances.

[1] A more extensive discussion of the obstacles to fidelity of implementation is provided in "Solving the Math Problem," a paper prepared for the Association of Teacher Educators 2007 Annual Conference, available at: http://teacher.depaul.edu/AlgebraConnections.html.

During spring 2007, the project will complete the analysis of teacher surveys about their ongoing implementation of strategies gained through the treatment. The results of that analysis and the analysis of student achievement on the 2007 ISAT tests will provide a basis for assessing relatively long-term outcomes of the initiative.

Recommendations

The project has implications for the design of professional development initiatives in mathematics and on the development of mathematics competence in pre-service curricula. The need to improve mathematics learning by students requires a transfer of knowledge and abilities from teachers. Vygotsky's theory of proximal knowledge is particularly relevant to any professional development program. There are limits on the transferability of the content of professional development: teacher knowledge; student knowledge. If the classroom teacher has limited knowledge and abilities, the transfer will be minimal. If the classroom teacher has the current knowledge base to proceed to more sophisticated math knowledge and abilities, the teacher may be able to transfer that knowledge to students more effectively. The emphasis on formative evaluation by teachers is essential to that transfer, however, because the second limit, the knowledge of students and the identification of what is proximal to them, is essential to their development.

The analysis of mathematical progress of students should not be limited to standardized tests because they do not measure some kinds of changes that are essential to math such as the ability to envision a problem and the thinking a student does to decide how to solve the problem. The project's development of a framework for the analysis of student- and teacher-written communication about math is a resource that can contribute to the continuing examination of progress that is not captured in standardized tests. As NCLB increases the emphasis on the testing of math, it is essential for teacher educators to maintain a broader scope for the course work in math and math education than the kinds of skills that some standardized tests measure.

Bibliography

Sources for the Development of a Framework for Qualitative Analysis of Student Work

Marshall, Sandra P. *Schemas in Problem Solving*. New York, NY: Cambridge University Press, 1995.

Neuman, Y., & Schwarz, B. (1998). Is self-explanation while solving problems helpful? The case of analogical problem-solving. *British Journal of Educational Psychology* 68, 15-24.

Neuman, Y. and Schwarz, B. (2000). Substituting one mystery for another: the role of self-explanations in solving algebra word-problems. Learning and Instruction 10, no. 3.

Research Base for Treatment Premises

1. Job-Embedded learning increases the application of what is learned.

Loucks-Horsley, Susan. "Professional Development and the Learner Centered School." *Theory into Practice* 34, no. 4 (1995).

Munger, Linda. "Job-Embedded Staff Development in Norwalk Schools." *Journal of Staff Development* 16, no. 3 (1995).

Norton, John. "Grounded in Research." *National Staff Development Council* (Summer 2001).

Wood, Fred H., and Joyce E. Killian. "Job-Embedded Learning Makes the Difference in School Improvement." *Journal of Staff Development* 19, no. 52 (1998).

Wood, Fred H., and Frank McQuarrie Jr. "On-the-job learning." *Journal of Staff Development* 20, no. 3 (1999).

2. Teacher learning increases student learning when it is transferred.

Banilower, Eric R., Sally E. Boyd, Joan D. Pasley, Iris R. Weiss. "Lessons from a Decade of Mathematics and Science Reform: A Capstone Report for the Local Systemic Change through Teacher Enhancement Initiative." Prepared for the National Science Foundation by Horizon Research, Inc. Prepublication copy, February 2006.

Committee on How People Learn, Suzanne Donovan and John D. Bransford, eds., Division of Behavior and Social Sciences and Education, National Research Council. *How Students Learn: Story, Mathematics, and Science in the Classroom*. Washington, D.C.: National Academies Press, 2005.

3. Writing by students provides a basis for formative evaluation.

Bloom, Benjamin S., J. Thomas Hastings, and George F. Madaus. *Handbook on Formative and Summative Evaluation of Student Learning*. New York: McGraw-Hill Book Company, 1971.

Boston, Carol. "The concept of formative assessment." *Practical Assessment, Research & Evaluation* 8, no. 9. Retrieved June 13, 2006 from http://PAREonline.net/getvn.asp?v=8&n=9 .

4. Formative evaluation when practiced consistently and responsively increases student learning.

Bloom, Benjamin S. *Human Characteristics and School Learning*. New York: McGraw-Hill Book Company, 1976.

Committee on the Foundations of Assessment, James W. Pellegrino, Naomi Chudowsky, and Robert Glaser, eds, Board on Testing and Assessment, Center for Education, Division of Behavioral and Social Sciences and Education, National Research Council. *Knowing what Students Know: The Science and Design of Educational Assessment*. Washington, D.C.: National Academy Press, 2001.

5. Writing is an effective method to increase learning of any subject, including math.

Langer, Judith A., and Arthur N. Applebee. *How Writing Shapes Thinking: A Study of Teaching and Learning*. Urbana, IL: National Council of Teachers of English, 1987.

Shield, Mal, and Peter Galbraith. "The Analysis of Student Expository Writing in Mathematics." *Educational Studies in Mathematics* 36, no. 1 (1998).

Stonewater, Jerry K. "The mathematics writer's checklist: The development of a preliminary assessment tool for writing in mathematics." *School Science and Mathematics* 107, no. 7 (2002).

6. Responses to open-ended prompts about teaching by teachers indicates their current teaching priorities.

Good, Jennifer M. "Encouraging Reflection in Preservice Teachers through Response Journals." *The Teacher Educator 3*7, no 4. (2002).

Lindsey, Jill. "Culture's Role in Teacher Identity: Prompting Teachers to Explore their Cultural Background." *Action in Teacher Education* 25, no. 4 (2004).

Watts, Mike, Alsop, Steve, and Gould, Gillian. "Prompting Teachers' Constructive Reflection: Pupils' Questions as Critical Incidents." *International Journal of Science Education* 19 (1997).

Xu, Jianzhong. "Promoting School-Centered Professional Development through Teaching Portfolios: A Case Study." *Journal of Teacher Education* 54, no. 4 (2003).

7. An on-site facilitator increases fidelity of implementation.

Barkley, Stephen G., and Bianco, Terry. "Part Digital Training, Part Human Touch." *Journal of Staff Development* 23, no. 1 (2002).

Jobst, Lou. "Fine Points of Facilitation: It's Exhilarating, Challenging, Fulfilling." *National Staff Development Council* 25, no. 2 (2004).

Kovaleski, Joseph F., Gickling, Edward E., Morrow, Henry, and Paul R. Swank. "High Versus Low Implementation of Instructional Support Teams: A Case for Maintaining Program Fidelity." *Remedial and Special Education* 20, no. 3 (1999).

Salpeter, Judy. "Shoring up Your Staff: Timely and Sustained Teacher Support." *Technology & Learning* 25, no. 4 (2004).

Sharon, Palsha A., and Wesley, Patricia W. "Improving Quality in Early Childhood Environments Through On-site Consultation." *Topics in Early Childhood Special Education* 18, no. 4 (1998).

Stringfield, Sam, Datnow, Amanda, and Steven M. Ross. "Scaling Up School Reconstructing in Multicultural, Multilingual Contexts: Early Observations from Sunland County." *Center for Reasearch of Education and Diversity* (1998).

Szuminski, Kathleen A. "Creating New Avenues for CTE Teacher Development." *Techniques* 77, no. 5 (2002).

8. Teacher interaction through cohort in course and within schools increases learning by teachers.

Brownwell, Mary T., Yeager, Elizabeth Anne, Sindelar, Paul T., vanHover, Stephanie, and Tamar Riley. "Teacher Learning Cohorts: A Vehicle for Supporting Beginning Teachers." *Teacher Education and Special Education* 27, no. 2 (2004).

Dinsmore, Jan, and Kerri Wenger. "Relationships in Preservice Teacher Preparation: From Cohorts to Communities." *Teacher Education Quarterly* 33, no. 1 (2006).

Hanley, Betty, and David Mather. "Cohort grouping and preservice teacher education: effects on pedagogical development." *Canadian Journal of Education* 24, no. 3 (1999).

Smith, Sean J., and Suzanne Robinson. "Technology Integration Through Collaborative Cohorts: Preparing Future Teachers to Use Technology." *Remedial and Special Education* 24, no. 3 (2003).

Wenzlaff, Terri L., and Katherine C. Wiseman. "Teachers Need Teachers to Grow." *Teacher Education Quarterly* 31, no. 2 (2004).

9. Algebra develops thinking abilities that are essential not only to succeed in high school but to develop problem-solving abilities.

Jonassen, David H. "Instructional design models for well-structured and ill-structured problem-solving learning outcomes." *Educational Technology Research and Development* 45, no. 1 (1997).

Maccini, Paula, and Charles H. Hughes. "Effects of a Problem-Solving Strategy on the Introductory With Learning Disabilities." *Learning Disabilities Research and Practice* 15, no. 1 (2000).

Nathan, Mitchell J., and Kenneth R. Koedinger. "An Investigation of Teachers' Beliefs of Students' Algebra Development." *Cognition & Instruction* 18, no. 2 (2000).

10. Teachers need increased knowledge of mathematics at the elementary level.

Hill, Heather C., Rowan, Brian, and Deborah Lowenberg Ball. "Effects of Teachers' Mathematical Knowledge for Teaching on Student Achievement." *American Educational Research Journal* 42, no. 2 (2005).

Swafford, Jane O., Jones, Graham A., and Carol A. Thornton. "Increased Knowledge in Geometry and Instructional Practice." *Journal for Research in Mathematics Education* 28, no. 4 (1997).

11. The teacher is the critical variable in student learning.

Miller, Kirsten. "School, Teacher, and Leadership Impacts on Student Achievement." *Mid-Continent Research for Education and Learning*. (November 2003).

Trigwell, Keith, Prosser, Michael, and Fiona Waterhouse. "Relations between teachers' approaches to teaching and students' approaches to learning." *Higher Education* 37, no. 1 (1999).