The Effects of Sustained Professional Development on Middle School Mathematics Teachers in Urban Schools

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ABSTRACT

In this study, teachers from several middle schools in New Jersey who were enrolled in a graduate mathematics class for middle school teachers were observed in their schools to determine the effects of sustained professional development on standards-based teaching habits. These teachers, along with a control group from the same schools, were rated on a rubric and their scores compared using percent difference. From this data, there appears to be a positive relationship between taking the professional development class and better teaching scores.

INTRODUCTION

According to international studies in Mathematics education such as the Trends in International Mathematics and Science Study (TIMSS), the United States has fallen behind many other countries in mathematics. In order to improve American mathematics education, the National Council of Teachers of Mathematics adopted a set of national standards for both content and teaching processes that highlights problem solving, reasoning and proof to support answers, communicating mathematical ideas, connecting mathematics concepts to real world examples, and using different types of representations ("NCTM Standards for Mathematics"). In the recent TIMSS (2007), the United States has significantly improved, rising in the ranks of countries participating in the study to the top third for fourth grade math scores and the top fifth for eighth grade ("TIMMS 2007 Results"). The problem still remains, however, of how to get more mathematics teachers to adopt this new, student-centered approach into their lessons. Particularly in middle and high schools, teachers often regard lectures as the only way to convey information.

According to Schoen, Cebulla, Finn, and Fi, however, who conducted a year-long study, the use of standards-based curricula correlates with higher measures of student understanding and problem solving skills (229). Having collected data including student achievements, teacher questionnaire responses, classroom observations, and school demographics, they found that "teacher practice and concern . . . are significantly and positively associated with growth in student achievement" (233). Indeed, teachers in their study devoted very little class time to nonacademic activities, had high expectations for student work, used more group work, and fewer teacher-centered practices.

Recent studies suggest that professional development is useful in implementing new curricula. Balfanz, MacIver, and Byrnes, who worked with teachers at three middle schools, relied on what they called "Multiple Tiers of Sustained Professional Development" (37), which reflected the new mathematics curriculum. Teachers were invited to attend a summer professional development seminar to learn more about their new, reformed curriculum. Balfanz et al. made three important findings. First, they were able to reform a school's curriculum and sustain the changes. Second, schools that changed their curriculum had achievement gains. Students had a better curriculum, teachers were better trained, and the learning environment improved. Third, curriculum reform was not enough to close all achievement gaps between urban and suburban middle schools (57-58).

Heck, Banilower, Weiss, and Rosenberg studied professional development using questionnaires to ask teachers and principals to rate themselves on their "attitudes, perceptions of preparedness to teach, instructional practices, and participation in the [Local Systemic Change Initiative]" (122). Teachers who participated in this research were open to teaching a standards-based curriculum. They also found a correlation between professional development and approaches to teaching mathematics (145-146).

In a study by Huffman, Thomas, and Lawrenz, teachers were offered professional development classes through the state, and a university offered workshops. The teachers were allowed to select their method of professional development. The researchers discovered a correlation between teacher involvement in examining teaching practices and curriculum development, and their use of standards-based teaching (382).

At an urban middle school, Samuels, Rodenberg, Frey, and Fisher used professional development in all disciplines, including some on-site professional development courses. They found that teachers who were a part of their professional development classes were more likely to use literacy strategies in all disciplines, request follow-up support when needed, share lesson plans, and participate in other professional development activities (313).

METHODOLOGY

During our study of middle school math teachers, we worked with and observed a group of teachers from the greater Trenton area enrolled in a graduate mathematics course taught on-site by TCNJ mathematics professor Cathy Liebars. After about a semester in the course, we observed the teachers in their classrooms and rated them using a rubric. We also observed teachers in the same schools who were not taking the class as a control group.

The class, designed for middle school mathematics teachers who are not highly qualified to teach math, met once a week for two and a half hours in a local middle school. The teachers, who sat in groups of two to four, were taught using a mixture of student-centered and lecture approaches, with an emphasis on student-centered practices. They worked together on in-class activities designed to help them improve their understanding of mathematical concepts.

The class, called "Patterns, Functions, and Algebra for Middle School Teachers," focused on mathematics, not methodology, although discussion of pedagogy was woven into the content. The teachers learned about variables, patterns, graphs, linear equations, quadratic equations, and exponential equations. They did a lot of problem-solving using the TI-73, a graphing calculator for middle school students, and other manipulatives. Many of the problems on which they worked came from reformed middle school curricula, not higher level mathematics (though they sometimes thought about this next step). The class then discussed how to bring these practices into their middle school classrooms.

We observed five teachers who volunteered from the professional development class teaching in their schools, and counterparts from their schools who did not take the class, as a control group. We rated them on the TQE-R Observation Rubric designed for the course. The rubric was tested for internal validity by the three observers, each of whom rated the same lessons until they were within one level on each part of the rubric scale. The rubric (Figure 1) contained seven criteria for evaluating the teachers: Subject Matter Knowledge, Motivating Launch, Challenging Activities, Grouping of Students, Questioning, Using Technology and Manipulatives, and Closure and Sharing Student Work. These criteria were evaluated on a four-point scale: Exemplary, Proficient, Needs Improvement, and Serious Concern. Each teacher was evaluated by two of the three researchers, and the scores were averaged for each individual teacher, for each school, and by group (control and experimental).

RESULTS

During our observations, teachers were evaluated on each of the seven categories of the TQE-R rubric (Figure 1) and rated on their ability to teach effectively in all seven. Teachers who attended the professional development classes tended to teach lessons that were more engaging

and interesting, and scored higher on the rubric scale than those who did not take the course. For instance, one teacher who was taking the class taught a lesson on measurement, requesting her students to measure the area of the floor of the classroom. Students were able to get up, move around, and physically measure the room. The lesson showed her ability to motivate students, create challenging activities that engaged all students, and use manipulatives well.

By contrast, a teacher who did not take the course taught a lesson that was not at an appropriate level for his students. He was unable to answer any of their questions about the topic and they were frustrated, only having learned how to memorize a formula.

The results of the study (Tables 1–3) show differences between teachers who have attended the professional development classes and those who did not. Specifically, teachers who did not take the course scored an average of 1.668 on their ability to close and share student work, compared to teachers who took the class, who averaged 3.8, a 55% difference. In fact, the teachers who took the class averaged over 33% better in their ability to ask good questions that encourage students to think. This disparity highlights the overwhelming difference between the two groups.

Figure 1 – Mathematics Classroom Observation Rubric

	Exemplary	Proficient	Needs Improvement	Serious Concern
	4	3	2	1
1. Subject Matter Knowledge	The lesson shows that the teacher possesses solid content knowledge and has well researched the topic.	The lesson is free of inaccurate content.	The lesson shows little evidence of solid content knowledge or adequate understanding on the part of the teacher.	The lesson shows significant errors in content knowledge.
2. Motivating Launch	The launch includes an activity that increases motivation of all students. All or almost all students are highly motivated and actively engaged in the launch.	The launch includes an activity that increases motivation of most students.	The launch is included but is not very successful in motivating most students.	The launch is missing.
3. Challenging Activities	The activities are challenging and require students to use reasoning to support their mathematical conclusions and problem solutions. The activities may cause students to leave class thinking about possible strategies and solutions.	The activities are challenging and cause students to think.	The activities may require students to use a formula or memorized definition to arrive at a solution but do not challenge students to think.	The activities are not meaningful.
4. Grouping of Students	The teacher uses cooperative learning strategies appropriately. Interdependence and individual accountability are evident. Teacher and students monitor group process during the lesson. The groups function as teams.	The teacher uses cooperative learning strategies appropriately. Interdependence and individual accountability may be evident. The groups function as teams.	Students work in groups but there is no evidence that the groups function as teams. Interdependence and individual accountability are not evident.	Cooperative learning and group work are not used but it is evident that these techniques would be beneficial to the lesson.

5. Questioning	The teacher asks essential questions that are related to the topic and make students think. Questions scaffold learning. Many of the questions are at the higher levels of Bloom's Taxonomy.	The teacher asks essential questions that are related to the topic and make students think. Some questions are at or above the analysis level of Bloom's Taxonomy.	The teacher asks questions that have little substance. Few questions are at or above the analysis level of Bloom's Taxonomy.	The teacher asks questions that have no substance. None of the questions are at or above the analysis level of Bloom's Taxonomy.
6. Using Technology and Manipulatives	Technology and manipulatives are available and used appropriately. There is evidence these resources are used routinely.	Technology and manipulatives are available and used appropriately.	Technology and manipulatives are available but not used appropriately.	Technology and manipulatives are not available and should be used.
7. Closure and Sharing Student Work	In the closure session students share their work, justify their thinking, and engage in discussion.	In the closure session students share their work.	In the closure session, students review the lesson but do not share their work.	The closure session is missing from the lesson. There is no opportunity to share work or review the lesson. Time management is an issue.

Table 1 – Teachers Taking the Course:

	Subject Matter Knowledge	Motivating Launch	Challenging Activities	Grouping of Students	Questioning	Using Technology and Manipulatives	Closure and Sharing Student Work	Average
Teacher 1	4.0	3.0	4.0	1.0	3.0	3.0	3.5	3.1
Teacher 2	4.0	3.0	3.5	4.0	4.0	4.0	4.0	3.8
Teacher 3	4.0	4.0	3.75	3.0	4.0	4.0	4.0	3.8
Teacher 4	4.0	3.0	3.75	4.0	3.5	3.75	4.0	3.7
Teacher 5	4.0	2.5	2.5	2.25	3.25	3.25	3.5	3.0
Average	4.0	3.1	3.5	2.85	3.55	3.6	3.8	3.5

Table 2 – Teachers Not Taking the Course:

	Subject Matter Knowledge	Motivating Launch	Challenging Activities	Grouping of Students	Questioning	Using Technology and Manipulatives	Closure and Sharing Student Work	Average
Teacher 1	3.5	4.0	4.0	3.0	3.5	4.0	1.0	3.3
Teacher 2	2.0	2.0	1.25	1.0	1.0	3.0	1.0	1.6
Teacher 3	4.0	1.5	2.75	4.0	3.0	2.25	2.75	2.9
Teacher 4	3.0	3.0	2.25	2.25	2.0	2.5	2.0	2.4
Average	3.125	2.625	2.563	2.563	2.375	2.938	1.688	2.6

Table 3 – Comparing the Scores of Teachers in the Course with Teachers Not in the Course

	Subject Matter Knowledge	Motivating Launch	Challenging Activities	Grouping of Students	Questioning	Using Technology and Manipulatives	Closure and Sharing Student Work	Average
Teachers Taking the Course	4.0	3.1	3.5	2.85	3.55	3.6	3.8	3.5
Teachers Not Taking the Course	3.125	2.625	2.563	2.563	2.375	2.938	1.688	2.6
Difference	0.875	0.475	0.938	0.288	1.175	0.663	2.113	0.9
% Difference	21.875	15.323	26.786	10.088	33.09	18.403	55.592	26.742

DISCUSSION

The data clearly indicate that in every category of the rubric, teachers who participated in the professional development class offered as part of this grant project scored higher than the average of all participants in the study, while teachers who were not part of the class scored lower than average in all categories. This leads us to believe that the professional development class positively affected those who took it. They were more effective in teaching to the specifications of the rubric, even though they never saw it. These teachers taught different levels of mathematics, from sixth to eighth grade, from special education and remedial work to gifted and talented classes. Indeed, it is important to note that all of the standards-based ideas in the rubric can be used in all of these classes.

Our data supports our hypothesis that teachers who take the sustained professional development class perform better by our standards than those who have not. From this data, we can say that this sustained professional development is positively correlated with higher scores on our rubric, which we hope is correlated with better teaching skills and higher standardized test scores for students.

There are some intervening variables that may have affected the outcome of the study. First, all of the researchers involved in the study are connected in some way with the grant project. Because of this, there may have been some bias in the study. Two of the three observers were part of the graduate class and came to know the teachers in the study before observing them in their classrooms. This may have caused some bias in the data.

The experimental group was composed of teachers in the professional development class. This group of teachers received information about the class, and decided to attend for two and half hours on a Wednesday night after working all day. Thus, by self-selection, they may have been more highly motivated and willing to investigate new ideas and practices than their peers who did not enroll in the class. This may have biased the group of teachers that were available for observing. Also, in order to get a control group for this study, teachers in the experimental group asked other teachers in their schools to participate. The teachers in the control group were friendly with teachers in the experimental group and willing to allow observers into their classrooms. These teachers were chosen by the experimental group, not randomly, and therefore the results of the study may be skewed.

Nevertheless, our results are similar to those of other professional studies. The teachers that we observed reflected many of the good qualities listed in our TQE-R rubric, and matched those in studies done by Balfanz et al., Heck et al., Schoen et al., Huffman et al., and Samuels et al.

CONCLUSION

Future studies may be built upon our data. Perhaps teachers from the study can be observed in later semesters to follow their progress. Some of the teachers continue to take graduate mathematics classes every semester, some take them intermittently, and some take only one class. Comparing their scores over future semesters may allow researchers to determine how much professional development is optimal for middle school mathematics teachers. It may also be worthwhile to observe teachers who have signed up for the class before they start in order to have a baseline. This may allow us to establish a causation instead of a correlation relationship.

With more data to add to the study, it would be easier to determine significance. Even if the intervening variables have had no effect on the current data, more data may allow us to say with more conviction that our data have meaning outside of our small sample. It may allow us to extrapolate our data to outside sources, such as other types of sustained professional development. Our data only tells us that the teachers in our professional development class scored higher than teachers that we observed who did not take the class. Extrapolation to outside data could show us that similar professional development classes produce higher scores on the TQE-R rubric.

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