

# Ameliorating Pedagogical Competencies in Mathematics for Secondary School Teachers

Rebecca R. Robichaux<sup>1</sup>, Paulette Rodrigue<sup>2</sup>, Anthony J. Guarino<sup>3</sup>

<sup>1</sup>Curriculum Education, Mississippi State University, Starkville, USA

<sup>2</sup>Curriculum Education, Nicholls State University, Thibodaux, USA

<sup>3</sup>Massachusetts General Hospital, Institute of Health Professions, Boston, USA

Email: [ajguarino@gmail.com](mailto:ajguarino@gmail.com)

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This article reports the efficacy of the *Multidimensional Content-Based Mathematics Professional Development Project* in ameliorating pedagogical competencies in mathematics for secondary school teachers. The project protocol is an intensive two week all day summer session with six all day Saturday sessions scheduled throughout the following fall semester. Participants were 28 secondary mathematics teachers randomly selected from schools identified as low-performing. Data were analyzed by conducting a repeated measure analysis of variance and a polynomial regression analysis. Results indicated a statistically significant 28% improvement in mathematics pedagogical competencies. Implications of this study are discussed.

**Keywords:** Mathematics Education; Pedagogy; Professional Development

## Introduction

A comprehensive literature review documents that many middle and high school teachers lack pedagogical content knowledge in mathematics (Ball, Hill, & Bass, 2005). This lack of competent pedagogy is a major cause of students' substandard performance on standardized mathematics exams across the United States (Hill & Lubienski, 2007). To ameliorate teachers' pedagogical competencies, some regional postsecondary institutions form partnerships with secondary schools. Through these partnerships, the postsecondary academy delivers professional development programs to the secondary educators on current evidence-based teaching practices. One such professional development program is the *Multidimensional Content-Based Mathematics Professional Development Project*. This project was developed at a Doctorate-granting University located in southeastern United States. This innovative program was devised to advance pedagogical competencies in mathematics education for both new and veteran teachers. The activities of this program present the current research-based teaching strategies and assessment techniques to advance student mathematics performance (Marzano, Pickering, & Pollock, 2001). While current research supports the overall successes of partnership programs in general (Ball, Thames, & Phelps, 2008), the principal aim of this study was to evaluate the efficacy of the *Multidimensional Content-Based Mathematics Professional Development Project* to ameliorate pedagogical competencies in mathematics for middle and high school teachers.

## Method

### Participants and Procedure

The cohort of 28 mathematics teachers was randomly selected from middle and high schools identified as low-performing. The majority of these teachers were female ranging in

age from 19 to 56 with teaching experience ranging from 3 to 17 years. The teacher-participants enrolled in a six-hour graduate course scheduled all day for two-weeks in the summer and concluded with six all day Saturday sessions the following fall semester. These sessions on pedagogical content presented meaningful and relevant activities for the teacher's current classroom needs. These exercises are endorsed by the national standards (NCTM, 2000) as well as documented by evidence-based practice to advance student achievement (Marzano, Norford, Paynter, Pickering, Pollock, & Gaddy, 2001). The participants first observed the activity from the program mentor then performed the activity to the cohort allowing for meaningful dialogue concerning the strategies and how to effectively implement them in their classrooms. To receive graduate credit, participants were required to develop a number of projects. Examples of these projects included a literature search to review two current research articles on any topic within the domain of mathematics teaching and then present a synopsis to the cohort. Another project involved evaluating the legitimacy of Websites for mathematics teaching. The participants created a rubric to assess such criteria as (a) type of domain, (b) author's credentials, (c) well-documented sources, and (d) how others critiqued the page (Barker, 2004). This evaluation of the websites led to the identification of ten useful, reliable sites which were then summarized and presented to the cohort. These websites provided a solid resource in developing their lesson plan project. The literature research activities and the website evaluations provided the foundations for the lesson plan project. The lesson plan project required participants to select and develop a five-day mathematics unit of their choice that incorporated research-based strategies and addressed appropriate state and national mathematics standards.

### Instrumentation

A 20 item examination was developed to assess the partici-

pants' competencies on evidence-based mathematical pedagogical content. Possible scores ranged from 0 to 100 percent and assessments were recorded at baseline and at post intervention.

### Statistical Analyses

Statistical tests for this study included a repeated measures analysis of variance (RM-ANOVA) and a polynomial regression analysis. All statistical tests were conducted using IBM SPSS v19 with alpha set at  $p < 0.05$ .

### Results

The pretest pedagogical competencies scores were  $M = 69.36\%$  ( $SD = 11.88$ ) while the post-test scores were  $M = 88.68\%$  ( $SD = 7.45$ ) indicating a 27.84% improvement, which is a statistically significant increase,  $F(1, 27) = 139.98$ ,  $p < 0.001$ ,  $\eta^2 = 0.84$ , an extremely large effect. A polynomial regression analysis was conducted to determine the relationship between pre and post scores. The results indicated that the quadratic relationship was superior to the linear relationship with coefficients of determination of 0.57 and 0.42 respectively. In other words, greater gains appeared to occur with those who had lower pre scores, while smaller gains were observed for those with higher pre-scores.

### Discussion

Although further research is recommended to validate these positive results, these preliminary findings provide convincing evidence of the project's effectiveness with significant statistical and practical amelioration in mathematics pedagogical competencies for secondary teachers. Not only did the results of the post-test scores indicate overall pedagogical gains by the participants, but those who scored lower on the pre-test actually "caught up" with their higher scoring pre-test peers. Thus, at the completion of the intervention, the majority of the participants were at equivalent levels of mathematical pedagogical competencies. Post intervention interviews substantiated the program's success. Examples included the secondary teacher participant who reported, "Professionally I have learned to reflect on my teaching practices. I now provide more problem solving experiences and alternative assessments. I have made professional friendships with other math teachers. Networking was great!" Another teacher participant noted, "The program helped me to vary my instructional strategies... and helps to

increase content knowledge and improve instructional practices. I have learned to adapt activities into more student-centered activities". The program illustrated that effective professional development can directly impact teachers' instructional practices regardless of the teacher's prior experience when professional development contents are meaningful and relevant to teachers' current classroom needs. These preliminary results strongly suggest the implementation of this project for math teachers aspiring to develop their pedagogical mathematical competencies and subsequently advance students' mathematics performance.

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