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CAN I TEACH MATHEMATICS? A STUDY OF PRESERVICE TEACHERS' SELF-EFFICACY AND MATHEMATICS ANXIETY

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This paper presents two studies (qualitative and quantitative) with the shared goal of exploring preservice teachers' (PSTs') experiences of mathematics anxiety and self-efficacy for mathematics teaching. Findings indicate that PSTs experience high levels of mathematics anxiety, impacting current learning and preference for teaching the content, as well as the development of self-efficacy for teaching mathematics and conceptions of ideal teaching. Findings regarding anxiety (fear) of evaluation and concern about being able to inspire students in their future classrooms converged across studies.

Keywords: Mathematical Knowledge for Teaching; Teacher Education–Preservice

Mathematics education researchers agree that a confident and competent mathematics teacher is a vital necessity in the classroom (Oswald, 2008). Yet many elementary preservice teachers (PSTs) and in-service teachers experience relatively high levels of mathematics anxiety (e.g., Beilock Gunderson, Ramirez, & Levine, 2010; Swars, Smith, Smith, & Hart, 2007), and have histories of confronting anxiety and feelings of failure in mathematics during their own K-12 experiences (McGlynn-Stewart, 2010; Sloan, 2010). Further, definitions of mathematics anxiety suggest a relationship between anxiety of failure and self-beliefs such as self-efficacy (Trujillo & Hadfield, 1999). In efficacy theory, mathematics anxiety may be a source of physiological arousal that impedes the development of positive self-efficacy. Importantly, Lee (2009) found in a study of PISA results that mathematics anxiety and self-efficacy for mathematics were independent predictors of mathematics performance, indicating the need to not only measure them separately, but to understand how they differentially impact mathematics learning and achievement.

Thus, in this study, mathematics anxiety is investigated as a potential source of negative physiological arousal that impacts, but is not synonymous with, self-efficacy for teaching and learning mathematics. To the extent that PSTs feel anxiety when contemplating teaching mathematics (or learning mathematics content and pedagogy deeply enough to be effective in teaching mathematics), their experience of self-efficacy for teaching mathematics is negatively impacted (Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006). However, there are some indications that experiences gained in mathematics education methods courses can help decrease mathematics anxiety (Gresham, 2007; Vinson, 2001). Yet little is known about what aspects of courses are efficacious in reducing mathematics anxiety and how these effects can be maintained. Thus, we undertook both a quantitative and qualitative exploration of mathematics anxiety and self-efficacy experienced by PSTs with the goal of further understanding how these perceptions impact PST education.

Methods and Data Sources

This paper reports on both a qualitative and quantitative study to explore different aspects of PSTs' experiences of mathematics anxiety and self-efficacy. PSTs were recruited while enrolled in their teacher preparation programs at a southwestern university. The PSTs who participated in the qualitative study ($n = 3$) were recruited during the 2010-2012 academic years while participating in a larger ongoing research project, [TEACH MATH] that follows PSTs from their preparation programs and into early career classrooms. PSTs in the quantitative study ($n = 53$) were recruited during the

2013-2014 academic year. Participants in both studies were primarily interested in teaching early elementary (39.6%) or upper elementary (45.3%) grade levels and thus planned to teach all core subjects, including mathematics.

For the qualitative study, the participants (Estelle, Phoebe, and Roxanne) were selected because their mathematics autobiographies (an assignment written for their mathematics methods course) spoke clearly and powerfully about feelings of mathematics anxiety. Additional data such as individual and group interviews as well as semi-structured prompts were collected over the course of three semesters during their methods courses and student teaching. An iterative analysis (Bogdan & Biklen, 2006) was used to demarcate the narratives that pertained specifically to mathematics anxiety and self-efficacy. For each participant, narratives were identified within text passages that included key words specific to anxiety and self-efficacy. An emergent coding scheme (Marshall & Rossman, 2006) was utilized to organize and sort each participant's narratives.

For the quantitative study, PSTs were recruited from teacher education courses to participate in an evaluation of online teacher professional development for elementary mathematics. Quantitative anxiety measures [based on the Hopko (2003) and Hadley & Dorward (2011) revisions of the *Mathematics Anxiety Rating Scale - Revised*], self-efficacy measures [based on the *Mathematics Teaching Efficacy Beliefs Instrument* by Enochs, Smith, & Huinker (2000)], subject area preference measures, and amount of vicarious experience PSTs had in classrooms were collected at pre-post. This study reports on baseline measures (prior to exposure to the professional development content).

Results

Qualitative Findings

All three of the women viewed mathematics as a content area to learn as students and to know as teachers, but one that held little appeal for them. Estelle saw mathematics as something that she could not escape (i.e., that mathematics was “everywhere”). Phoebe found mathematics to be a subject area that she *strongly* disliked and believed she was just not a “math person.” As a result, she often reached for the comfort of her non-math status to diminish others' high expectations of her in this content area. Roxanne viewed mathematics as “a sore subject.” Having spent her lifetime trying to pass mathematics classes despite not understanding the content, Roxanne had few ideas about mathematics other than mathematics was a subject to be endured. In other words, all three women spoke of mathematics as a requirement in their academic and professional lives, but not as a rich discipline they looked forward to learning or teaching. Based on the patterns of findings over three semesters of data collection, PSTs who experience high levels of mathematics anxiety and low perceptions of self-efficacy can learn to gain an understanding of the content, but they often limit (self-handicap) their opportunities to expand their mathematics understanding.

Further, the PSTs' experiences with mathematics anxiety and self-efficacy shaped their views of the ideal mathematics teacher. For Estelle, the ideal mathematics teacher was one who would never embarrass students in front of the class, who would be truly interested in all students' mathematical thinking (not just the smart students), and who would hold high expectations for all students. In other words, the best mathematics teacher would not let students hide behind a “wall” of feigned understanding; nor would she make them wish they could. For Phoebe, the ideal mathematics teacher was one who would explain mathematics concepts and problem-solving methods in multiple ways and who would thus create a learning environment in which there were multiple ways to be a “math person.” For Roxanne, the ideal mathematics teacher was one who would provide opportunities for students to actively engage in mathematics, regardless

of their mathematics ability so their focus would not be on just “getting through” the content. Thus the findings indicate that experiences in learning mathematics and learning to teach mathematics influence how future teachers imagine the qualities of the ideal mathematics teacher.

Quantitative Findings

In general, PSTs rated their mathematics learning anxiety and mathematics teaching anxiety similarly ($h = .04$), with the average scores on both scales falling between “a little” and “a fair amount” of anxiety in response to items. On both scales, anxiety was highest for items set in an evaluative context. In contrast, efficacy beliefs were quite high for both learning and teaching, although PSTs felt higher efficacy for learning ($h = .16$). Item averages indicate that students tended to fall between “agree” and “strongly agree” with statements about their efficacy to learn (with the lowest efficacy for learning to inspire students in mathematics), while they fell somewhere between “uncertain” and “agree” on statements about their efficacy to teach.

Based on efficacy theory, it was hypothesized that mathematics anxiety and vicarious experience in the program would predict PST self-efficacy, which would in turn predict preference for teaching mathematics. A mediation model (using PROCESS 2.11; Hayes, 2013) was found to be significant; $R = .55, F(3, 48) = 7.33, p < .001$, with $R^2 = .31$, and CI 95% [.12, .50]. Results indicated that the mathematics anxiety ($b = -.33, p = .001$) and vicarious experience ($b = .12, p = .017$) significantly predict self-efficacy, self-efficacy significantly predicts subject area preference ($b = .83, p = .013$), but anxiety ($b = -.44, p = 0.059$) and vicarious experience ($b = .05, p = 0.658$) do not significantly predict the outcome with the mediator in the model. Thus, self-efficacy appears to mediate the relationship between anxiety, vicarious experience, and subject area preference. The indirect effect of mathematics anxiety on subject area preference is $-.27$ (Boot 95% CI [-.64, -.08]), and the indirect effect of vicarious experience on subject area preference through self-efficacy is $.10$ (Boot 95% CI [.02, .25]).

Discussion

Based on the literature, it was hypothesized that PSTs would respond with relatively high levels of anxiety and low levels of self-efficacy for teaching mathematics as has been demonstrated in other studies. While anxiety was high across the studies (especially around contexts of evaluation and failure), efficacy was higher in the quantitative study than expected and inconsistent with the ways PSTs talked about their future teaching in the qualitative study. However, the PSTs in the quantitative study felt most efficacious about their ability to learn, rather than teach, the content. Given the relatively low level of real classroom experience these PSTs had, uncertainty is probably a healthy response and is certainly consistent with self-efficacy theory, which asserts that the efficacy of novices remains fluid until such time as individuals have had successful (or unsuccessful) mastery experiences upon which to base their beliefs. It is further consistent with the qualitative findings that suggested the PSTs were greatly concerned about their abilities to become good mathematics teachers.

An interesting finding across both studies was that PSTs were concerned about their ability to inspire students in mathematics. In the quantitative work, PSTs reported lower self-efficacy for helping their students become interested in mathematics, motivating them when they lost interest, and helping build connections with families to improve student achievement in mathematics. In the qualitative work, the “ideal” teacher is clearly represented as one who can help even anxious students feel comfortable in learning mathematics. Clearly, PSTs need more support to develop skills and confidence in motivating and inspiring students to be comfortable and engaged in mathematics.

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