# The Influence of Elementary Preservice Teachers' Mathematical Experiences on their Attitudes towards Teaching and Learning Mathematics

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This study examined how preservice elementary teachers' perceptions of past schooling experiences and their experience in a mathematics methods course influenced their attitudes about mathematics' teaching and learning. Pre- and post-surveys were administered to preservice teachers (n = 75) enrolled in a mathematics methods course at a university in the northeastern United States. The purpose of the surveys was to understand entering attitudes about mathematics, whether those attitudes changed, and why. Findings indicated that perceptions of prior schooling experiences influenced preservice teachers' initial attitudes about mathematics. Over the course of a semester, however, significant positive changes in preservice teachers' attitudes and confidence to teach mathematics suggest that experiences in the mathematics methods course were conducive to building on preservice teachers' prior experiences. We argue that regardless of the nature of preservice teachers' prior experiences in mathematics, those experiences can provide an effective backdrop for developing attitudes towards mathematics teaching and learning aligned with reform recommendations. Recommendations are made for mathematics teacher educators to build upon entering attitudes and experiences in their mathematics methods courses.

*Keywords: Mathematics Education; Preservice Teachers; Survey Research*

It has long been argued that teachers' affect is an important part of the way teachers understand mathematics (Ball, 1990; McLeod, 1994). At an international level, studies examining affect have influenced the field of mathematics education and how it has been conceptualized in teacher education (Leder & Grootenboer, 2005). In Philipp's (2007) review of literature on mathematics teachers' beliefs and affect, he argues that "for many students studying mathematics in school, the beliefs or feelings that they carry away *about* the subject are at least as important as the knowledge they learn *of* the subject" (p. 257). Philipp defines *affect* as "[a] disposition or tendency or an emotion or feeling attached to an idea or object," which is "comprised of emotions, attitudes, and beliefs" (p. 259). In this study we focus on one aspect of affect, namely the attitudes that preservice teachers (PTs) develop through their perceived experiences as K-12 learners of mathematics and their experiences in mathematics methods coursework. This article contributes to the literature on attitudes in mathematics education research by quantitatively examining the connections among preservice teachers' attitudes toward mathematics, perceived past schooling in mathematics, and the mathematics methods course experience. This study also extends beyond descriptive statistics to examine the factors that influence positive changes in attitudes along with a growth in PTs' confidence to teach mathematics. Ultimately, we argue that, regardless of the nature of prior experiences in mathematics and whether or not they are oriented toward a reform view, teacher educators

need to draw upon PTs' entering attitudes and experience as resources to inform the mathematics methods course instruction. This focus is significant because many students[1] develop negative attitudes towards mathematics, seeing it as a source of frustration and anxiety (Ignacio, Blanco Nieto, & Barona, 2006). These attitudes then become a part of the *apprenticeship of observation* (Lortie, 1975), beginning with the thousands of hours spent as a student in schools, which creates a "latent culture" that surfaces when one becomes a teacher.

Additional research has shown that this apprenticeship of observation is influential in shaping preservice teachers' ideas about teaching and learning (Ball & Cohen, 1999; Feiman-Nemser, 1983; Grossman, 1990; Wideen et al., 1998). The lenses through which preservice teachers make sense of these course and field experiences are shaped by prior knowledge and experiences (Ball, 1989; Grossman, 1990). Adopting an asset view of teacher education is an important step in building upon PTs prior experiences to understand the attitudes with which PTs enter mathematics education coursework, how those attitudes are a reflection of prior school experiences, and how attitudes change through participation in a mathematics education course. Regardless of the nature of preservice teachers' prior experiences in mathematics, those experiences can provide an effective backdrop for developing attitudes towards mathematics teaching and learning aligned with reform recommendations (Drake, 2006; National Council of Teachers of Mathematics (NCTM), 2000). Thus, the goal of this study was to examine preservice teachers' entering attitudes about mathematics teaching and learning, whether those attitudes change, and the factors that might contribute to any changes in attitudes. Correspondingly, our research question asked, *How do elementary preservice teachers' perceptions of their past schooling and their mathematics methods course influence their attitudes about the teaching and learning of mathematics?*

Feiman-Nemser (1983) asserted that teacher educators often underestimate the effects of past experiences on PTs and that these effects overshadow the role teacher education plays in forming PTs attitudes about mathematics teaching and learning. While some (e.g. Wideen et al., 1998) have argued that the prevailing aim in teacher education is to help PTs learn to teach in ways that are essentially different from the way they have been taught and from what they have observed, others (e.g. Ball, 1989) note that it is not necessary to completely change teachers beliefs about teaching and learning, but to support PTs development, since many enter the program with beliefs about mathematics teaching that can support student learning. Our study follows a line of research that has attempted to examine PTs' attitudes about the nature of mathematics and whether they adopt a more reformed view of teaching mathematics (Ebby, 2000; Eisenhart, Borko, Underhill, Brown, Jones, & Agard, 1993; McGinnis, Kramer, Roth-McDuffie, & Watanabe, 1998; and MacNab & Payne, 2003).

Mathematics methods courses that expose teachers to reform practices tend to positively influence PTs' attitudes towards mathematics teaching and learning. One approach teacher educators have taken to understand and build upon PTs' prior experiences is to examine their mathematics autobiographies (Ellsworth & Buss, 2000; Drake, 2006; Harkness, D'ambrosio, & Morrone, 2006). Ellsworth and Buss (2000) found that PTs' past teachers had the most

[1] We use *students* to refer specifically to K-12 pupils throughout this paper to avoid confusion with preservice teachers who are college students.

salient effect, be it positive or negative, on their attitudes towards mathematics and science. Harkness et al. (2006) found that PTs were highly motivated in methods courses that focused on mastery goals by engaging them in problem solving. Harkness et al. (2006) and Drake (2006) argued that mathematics autobiographies also provided a platform where PTs were given a voice. Consistent across the aforementioned studies is the perspective that pre-service teachers' attitudes towards mathematics can provide an effective stage for developing attitudes towards mathematics teaching and learning aligned with reform recommendations.

In addition to coursework, PTs often engage in multiple field experiences (e.g. observations, practica, internships, student teaching) that provide opportunities for the evolution of attitudes about mathematics teaching and learning. While universally seen as valuable, teacher educators and preservice teachers often face the dilemma of "bridging the cultures of the school and the university" (Wideen et al., 1998, p. 156). PTs can be overwhelmed with the practical demands of field experiences which may contribute to feelings of frustration related to inadequate preparation in their coursework. Despite these challenges, Feiman-Nemser and Remillard (1995) note that "powerful and innovative teacher preparation can affect the way teachers think about teaching and learning, students, and subject matter" (p. 65). While field experiences can contribute to PTs' attitudes about mathematics, we chose not to include this experience in our analysis for this paper. This was due to the varied field experiences that would be difficult to examine with a survey. Thus, we focus primarily on the mathematics methods course.

In the following sections, we describe our methods including the context of the study, survey instrument, research design, and data analysis. Then we present results from our data analysis. Lastly, we provide an interpretive summary of the findings and make recommendations for teacher education and future research.

## Methods

### Context and Participants

Research was conducted at Hillside College[2], a private university in the northeastern United States. The teacher education program offered both a traditional four-year undergraduate degree and a graduate degree that could be completed in a twelve-month period. As part of the teacher education program, PTs were required to take one mathematics methods course. This course was typically taken during the fall semester before student teaching.

All participants were undergraduate or graduate level preservice elementary school teachers enrolled in one of four sections of the mathematics methods course. Three professors taught the four sections of the elementary mathematics methods course. The mathematics methods courses at this university emphasized a reformed view of teaching mathematics (NCTM), 2000) where the professors thoughtfully used the NCTM process standards as a means for teaching the content standards. At least half of the class sessions used manipulative materials where the professors emphasized a link between concrete models and abstract mathematics concepts.

[2] Pseudonyms are used throughout this study to maintain anonymity.

Participating PTs completed both a pre-survey, which was administered the first week of the mathematics methods course, and a post-survey, administered during the last week of the course during the same semester. The pre-survey sought to capture participants' entering attitudes about mathematics and perceived experiences as K-12 students of mathematics. The purpose of the post-survey was to examine the exiting attitudes about mathematics, practicum experience, and mathematics methods course experience. The population size was 102 and the total sample size for those who completed both the pre- and post-surveys was 75, a 73.5% response rate.

## Instrumentation

To develop the pre-survey, we first searched educational research databases for existing surveys pertaining to the teaching and learning of mathematics, attitudes towards mathematics, and mathematics methods courses. We gathered 15 existing surveys that overlapped with the purpose of this study. Then, we examined the surveys, highlighted items that were possible candidates for the survey, and categorized the items. The pre-survey included the following four sections about mathematics: attitude and past experiences, teaching and learning, methods course expectations, and diverse learners. The post-survey included the following four sections about mathematics: attitudes and practicum experiences, teaching and learning, diverse learners, and future teaching. Five drafts of the pre-survey were constructed before the final version was drafted and agreed upon by the three participating mathematics methods professors. The survey items were on a four-point Likert scale including: SA = strongly agree, A = Agree, D = Disagree, and SD = strongly disagree. Thus, some of the figures and tables include the abbreviations of the item responses, such as SD for "strongly disagree." In addition, a fifth option, "not applicable," was included for those who were not enrolled in a practicum or truly had no idea how to response to a particular item. The fourth and fifth drafts were given to a group of mathematics educators to pilot, examine, and provide feedback regarding the wording of items and item order. The post-survey, constructed similarly to the pre-survey, was adapted once the pre-survey was administered, and a factor analysis was completed. The post-survey included 31 items identical to those in the pre-survey, except for changes in the stems of the items (see Appendix for surveys). For example, questions pertaining to topics and strategies taught in the mathematics methods course on the pre-survey were phrased in terms of what preservice teachers expected and viewed as "important for [them] to learn." The same items were rephrased for the post-survey to ask whether "the methods course taught…" preservice teachers a particular strategy such as "how to assess student learning in mathematics." The questions about PTs' perceived past experiences were replaced with questions about practicum experiences. For example, item 3 on the pre-survey stated, "I had several positive experiences with mathematics as a K-8 student." The majority of PTs enrolled in a mathematics methods course also has a field experience during that semester which consisted of a weekly school visit for a 10 week period. One of the goals of the post-survey was to capture these experiences. For example, item 5 on the post-survey stated, "My cooperating teacher used a conceptual method (i.e., problem-solving, open-ended Qs) to teach math."

The overall factor analysis of the pre-survey accounted for 79.3% of the total variance among responses. Conceptually, the items fit into seven factors. When the instrument was forced into seven factors, the analysis accounted for 66.8% of the variance. The rotated component matrix and conceptual understanding were used to divide the items into seven factors: 1. Attitude toward mathematics; 2. Negative experiences; 3. Procedural mathematics; 4. Conceptual mathematics; 5. Course expectations; 6. Confidence to teach; and 7. Social justice. Next, reliability tests for the pre-survey were completed to examine the scales as indicated by Cronbach's alpha, which examines the internal consistency of the scales within an instrument. The alpha level for each factor is as follows: 1. attitude toward mathematics ($\alpha$ = .912); 2. negative experiences ($\alpha$ = .780); 3. procedural mathematics ($\alpha$ = .612); 4. conceptual mathematics ($\alpha$ = .626); 5. course expectations ($\alpha$ = .921); 6. confidence to teach ($\alpha$ = .879); and 7. social justice ($\alpha$ = .648).

The *attitudes toward mathematics* factor included attitudinal items such as "I look forward to teaching math" along with positively worded past experience items. The *negative experiences* factor included items that were negatively worded about past experiences such as "I have struggled with math in K-8" along with negatively worded attitude items. The *procedural* and *conceptual mathematics* factors included items about the nature of mathematics such as "Memorizing facts and formulas is essential," to get a sense of PTs' agreement with reform recommendations. The factor on *course expectations* included items about what PTs viewed as important to address in the mathematics methods course, such as "how students learn math developmentally." The *confidence to teach* factor included items related to teaching mathematics to different types of learning such as being "confident to teach mathematics to English language learners." The factor on *social justice* include items about addressing equity in the mathematics classroom such as "math can help students critically analyze the world."

The overall psychometric properties of the instrument were sound. All seven factors had adequate to high reliability levels (Nunnally, 1978). Two items did not load well onto the factors where they fit conceptually; thus, we removed them from all analyses. Due to this, more precise language was used in the post-survey, which defined terms and directly asked participants whether they planned to teach mathematics in a traditional or conceptual manner. For example, item 14 stated, "I plan on teaching math in a procedural way (facts, skills, etc…)." . The post-survey instrument was divided into five factors and had similarly reliable scales: 1. attitude toward mathematics ($\alpha$ = .709); 2. teaching practices ($\alpha$ = .751); 3. practicum experiences ($\alpha$ = .696); 4. methods course experiences ($\alpha$ = .893); and 5. confidence to teach ($\alpha$ = .888). The *attitudes toward mathematics* factor included all attitudinal items as the pre-survey. The *teaching practices* factor included all the nature of mathematics items, similar to the procedural and conceptual mathematics factors. The *practicum* and *methods course experiences* factors included items related to field and course experiences such as "I had a positive practicum experience" and "my mathematics methods course focused on how to assess student learning." The *confidence to teach* factor included the same items as the pre-survey to get a sense of any changes.

In addition to the pre- and post-surveys, which were administered during the first and last weeks of the semester course, observations of one section of the mathematics methods course were conducted and course artifacts (e.g. syllabi, assignments, and assessments) were

collected to provide contextual information related to survey and observation data associated with the mathematics methods courses. However, this paper solely focuses on the survey data.

### Data Analysis

Survey data analyses were carried out with SPSS, a software package used for organizing data, conducting statistical analyses, and generating tables and graphs that summarize data. Our data analysis involved several steps. First, descriptive statistics were applied to analyze overall item response percentages and note any possible trends in responses. Then, we used correlations to examine the relationships among perceived past experiences, field experiences, the mathematics methods course, attitudes about mathematics education, and confidence to teach. Paired t-tests were then completed to compare the differences in preservice teachers' attitudes and perceived level of preparation between the pre- and post-surveys. Lastly, a multiple regression model was created to examine how perceived past schooling experiences and the mathematics methods course accounted for preservice teachers' a) attitude towards mathematics and b) perceived level of preparation to teach mathematics.

## Results

Considering the influence past experiences have on PTs conceptions of teaching and the desire of teacher education programs to help shape these conceptions (Ball, 1990; Cady, Meier, & Lubinski, 2006; Lortie, 1975; Scott, 2005), we became interested in responses on three unique items on the post-survey that directly asked preservice teachers about the perceived impact of their past K-8 schooling, practicum, and mathematics methods course on their future teaching practices (see Figure 1). The results across all three were similar, suggesting that PTs perceptions of the role past schooling played in their future instructional practices aligned with findings from prior research (Ellsworth & Buss, 2000; Drake, 2006; Harkness, D'ambrosio, & Morrone, 2006). The percentages were based on the total *n* of 75 to avoid an inflated percent due to missing data. The stem for the three items stated, "The following will have a major impact on the way I teach math in the future." The PTs were then asked to respond to this statement specifically about their past K-8 schooling, practicum, and mathematics methods course experiences on a four-point Likert scale, from strongly agree (SA) to strongly disagree (SD).

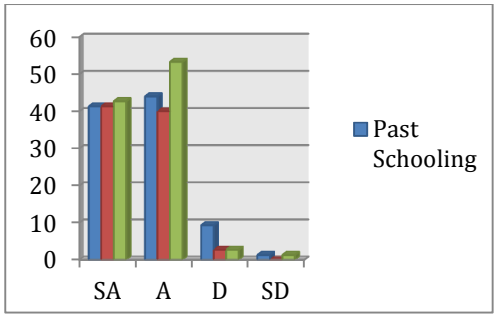


*Figure 1.* Elements influencing preservice teachers' anticipated practices by percentages

To further examine the relationship between PTs attitudes and items related to prior schooling experiences, bivariate two-tailed Pearson's correlations were run at the 0.05 and 0.01 alpha levels. Table 1 displays results from the analyses among items pertaining to these topics on the pre-survey. All correlations were significant at the 0.01 alpha level, indicating very strong linear relationships between attitudes towards mathematics, experiences in mathematics, and confidence in their ability to teach mathematics.

Table 1
*Relationships among attitudes and prior schooling experiences in mathematics*

| Pre-Survey Items | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| 1. Positive math attitude | .599** | .719** | .713** | .661** | .553** |
| 2. Positive K-8 math | | .539** | .526** | .455** | .368** |
| 3. Positive 9-12 math | | | .599** | .508** | .440** |
| 4. Perceived Proficiency in math | | | | .563** | .585** |
| 5. Looking forward to teaching math | | | | | .504** |
| 6. Confidence in ability | | | | | |

** Correlation is significant at the $p < 0.01$ level (2-tailed)

To examine the relationships among preservice teachers' experiences in the mathematics methods course, attitudes about mathematics, anticipated approaches to teaching mathematics, and perceived preparation, bivariate two-tailed Pearson's correlations were run at the .05 alpha level. Table 2 displays results from the analyses among items pertaining to these topics on the post-survey. Results indicated a moderate positive relationship between participants who had a more positive attitude towards mathematics and whether they learned a variety of strategies in the mathematics methods course ($r = .273$, $p < .05$), planned to teach mathematics in a conceptual manner ($r = .326$, $p < .01$), planned to require their students to memorize facts ($r = .274$, $p < .05$), and agreed that the mathematics methods course would have a major impact on their future teaching ($r = .268$, $p < .05$). Preservice teachers who indicated that they learned a variety of strategies in the methods course showed an increased: desire to teach mathematics ($r = .371$, $p < .01$), confidence ($r = .277$, $p < .05$), and belief that the course would have an impact on their teaching practice ($r = .440$, $p < .01$). An increased agreement that the mathematics methods course would have an impact on teaching practices was also significantly related to an increase in looking forward to teaching mathematics ($r = .360$, $p < .01$) and confidence ($r = .291$, $p < .05$). Participants' level of confidence was also associated with whether they would encourage students to use multiple strategies ($r = .279$, $p < .05$), a characteristic of teaching with a conceptual focus.

Table 2
*Relationships among attitudes and the mathematics methods course experiences*

| Post-Survey Items | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| 1. Positive math attitude | .273* | .306** | .794** | .566** | .326** | .168 | .066 | .274* | .268* |
| 2. Learned a variety of strategies | | .192 | .371** | .277* | .149 | .043 | .142 | -.013 | .440** |
| 3. Prepared to teach math | | | .397** | .438** | .139 | -.149 | .227* | .047 | .210 |
| 4. Looking forward to teaching math | | | | .711** | .311** | .011 | .140 | .061 | .360** |
| 5. Confident in ability | | | | | .412** | 0.031 | .279* | .137 | .291* |
| 6. Teach conceptual Math | | | | | | .275* | .382** | .155 | .014 |
| 7. Teach procedural Math | | | | | | | .051 | .601** | -.083 |
| 8. Encourage multiple strategies | | | | | | | | .016 | .119 |
| 9. Require students to memorize facts | | | | | | | | | -.109 |
| 10. Methods course, major impact | | | | | | | | | |

* Correlation is significant at the $p < 0.05$ level (2-tailed)
** Correlation is significant at the $p < 0.01$ level (2-tailed)

Results showed that whether PTs planned to teach in a conceptual manner related to whether they would encourage students to use multiple strategies ($r = .382$, $p < .01$). This positive relationship was stronger for those who planned to teach mathematics in a procedural manner and planned to require their students to memorize facts ($r = .601$, $p < .01$). These findings suggest that preservice teachers were familiar with characteristics commonly associated with both approaches to teaching mathematics. A relationship between preservice teachers' plans to teach with both approaches was not surprising; there can be overlap among strategies to teach mathematics where both conceptual and procedural knowledge are valued. While examining relationships among items is interesting, it is also important to extend analyses beyond correlations to further examine preservice teachers' attitudes.

## Paired t-tests

Paired t-tests were conducted to determine significant differences in the mathematics attitude and confidence to teach over the course of the semester (see Table 3). The paired t-test was carried out with a two-tailed 95% confidence interval. Results indicated that PTs in

the mathematics methods courses had statistically significant positive changes in their attitudes towards mathematics. They also became significantly more confident in their overall ability to teach mathematics.

Table 3
*Overall statistically significant differences on pre- and post-survey results*

| Item | Mean (pre to post) | Test Results |
|---|---|---|
| Positive attitude towards math | 2.076 to 2.280 | t= 3.401, $p < .01$ |
| Confident in ability to be a good math teacher | 1.932 to 2.139 | t= 3.110, $p < .01$ |

To examine preservice teachers' anticipated teaching practices, we analyzed responses to two items on the post-survey: "I plan on teaching math in a conceptual way (for understanding, problem-solving)"and "I plan on teaching math in a procedural way (facts, skills, etc…)." Figure 2 shows participants' responses to these two items by percentages. Results indicated that 100% of PTs teachers strongly agreed or agreed that they planned to teach mathematics in a conceptual way. In contrast, only about 70% strongly agreed or agreed that they planned to teach mathematics in a procedural way. Paired t-tests showed a statistically significant difference (p <.001) between PTs' responses to the two items in favor of a conceptual teaching method.

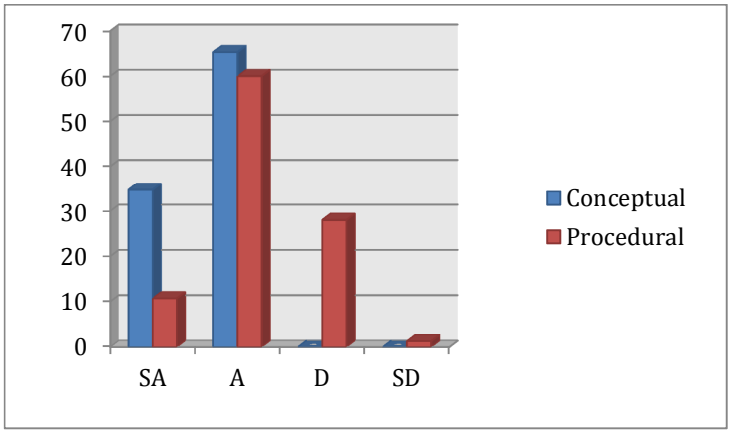


*Figure 2.* Participants' planned approaches to teaching mathematics by percentages

Another finding showed that approximately 80% of preservice teachers strongly agreed or agreed that: "As a K-8 student, I mostly learned mathematics in a traditional manner (i.e., textbooks, worksheets, rules, lectures)." However, the majority also disagreed or strongly disagreed with the following statement: "I want to teach mathematics the same way I learned it." There was a statistically significant difference in responses to the two items (p <.0001), indicating that preservice teachers wanted to teach mathematics in a way that was different from the way they learned it.

**Regression Analyses**

Ordinary least squares (OLS) hierarchical regression was completed to investigate the extent to which past schooling experiences and the mathematics methods courses accounted

for preservice teachers' attitudes about teaching mathematics and their perceived preparation to teach mathematics. The *prep_lookforward* served as the outcome variable. This variable was computed by taking the mean of responses from items "I am prepared to teach" and "I look forward to teaching." The two items were selected because they provided a sense of preservice teachers' attitude and preparation to teach mathematics. The responses from the two items were divided by two so the outcome variable was on 4-point scale, consistent with the predictor variables. For the multiple regression model, the predictor variables were entered as follows: *positive K-8 math* as the first predictor and *math course strategies* next. First we entered *positive K-8 math* into the model; research suggests that perceptions on prior schooling can have a strong influence on teachers due to their countless hours spent as students observing their own teachers (Ball, 1989; Ellsworth & Buss, 2000; Lortie, 1975). Participants also spent more time as K-8 students than as student teachers. Next *math course strategies* was entered because the mathematics methods course was specifically designed to prepare preservice teachers to teach mathematics, whereas teaching mathematics may not be a focus of the practicum (Ebby, 2000). Following a confirmatory approach, we hypothesized that the variation found in preservice teachers' perceptions of preparation and anticipation to teach mathematics after being in the mathematics methods course for one semester could be explained in terms of the aforementioned variables. In statistical terms, the hypotheses were expressed as:

$$H_0 = \beta_{positiveK8math} = 0 \qquad H_0 = \beta_{mathcoursestrats} = 0$$
$$H_a = \beta_{positiveK8math} \neq 0 \qquad H_a = \beta_{mathcoursestrats} \neq 0 .$$

The significance level was set at the 0.05 two-tailed level. Prior to running this model, the individual influence each predictor variable had on its own was examined, as described next.

**Single Predictors**

Before constructing the multiple regression models, two simple regression models were carried out to examine the amount of variance of each predictor variable accounted for in *prep_lookforward*. Table 4 shows a summary of each of the regression statistics and its significance. The two predictors accounted for a significant portion of the *prep_lookforward* on their own ($p < .01$). *Positive K-8 math* alone accounted for 12.5% of the variance in the outcome variable ($R^2 = .125$, $F = 10.45$, $p < .01$); the predictor variable *math course strategies* alone explained 12.3% of the variance in *prep_lookforward* ($R^2 = .123$, $F = 10.23$, $p < .01$).

Table 4
*Simple regression statistics* (*Prep_lookforward as outcome variable*)

| Predictor Variable | R Square | Adjusted R Square | Unstnd. Coefficient | Standardized Coefficient | F-value | Sig. |
|---|---|---|---|---|---|---|
| Positive K-8 Math | .125 | .113 | .457 | .354 | 10.45 | .002 |
| Math Course Strategies | .123 | .111 | .789 | .351 | 10.23 | .002 |

**Multiple Regression Model with Two Predictors**

The overall regression of *prep_lookforward* on positive *K-8 math* and *math course strategies* was statistically significant [$R^2$ = .208, F (2, 75) = 9.441, p< .001]. Overall, the variance explained by the two predictors differed significantly from zero; thus, we rejected the null. Table 5 shows the overall model summary and significance levels. This model had a higher F-value and was statistically significant. The *positive K-8 math* variable accounted for approximately 12.5% of the variance in *prep_lookforward*, while *math course strategies* accounted for an additional 8.3% of the variance. Taken together, the predictor variables could explain approximately 20.8% of the variance of *prep_lookforward*. Although the model was significant, nearly 80% of the variance was unaccounted for in *prep_lookforward*, which supports the argument that a multitude of variables influence preservice teachers' attitudes and preparation to teach mathematics. The unstandardized coefficients of the model were .192 for *positive K-8 math* and .330 for *math course strategies*. The regression solution for this model was:

$$\hat{Y}_{preplookfwd} = 0.942 + 0.192X_{positiveK8math} + 0.330X_{mathcoursestrats}.$$

Similar to the first model, this means that if both predictor variables had a value of 0, there would be a predicted *prep_lookforward* score of 0.942. However, a value of 0 is not possible.

Table 5
*Model summary and significance of two predictors*

| Predictors | $R^2$ | $\Delta R^2$ | *F* | *P* | *DW* |
|---|---|---|---|---|---|
| 1. Positive K-8 Math | .125 | .125 | 10.447 | .002 | |
| 2. Positive K-8 Math<br>Math Course<br>Strategies | .208 | .083 | 9.441 | .000 | 2.164 |

**Note:** Dependent Variable (constant): Prep_lookforward to teach Math

The values indicated that with every increased rating in *positive K-8 math* there was almost a 0.192 increase (i.e. 1= .192, 2= .384) in *prep_lookforward* and approximately a .330 increase with increased ratings in *math course strategies*. Using the same example as the first model, a participant who "agreed" to the two items on the survey would have a predicted *prep_lookforward* score of 2.508 = .942 + (.192 x 3) + (.330 x 3). One who "agreed" to the two items would yield an approximate score of 2.51 on *prep_lookforward*, indicating greater feelings of preparation and anticipation to teach mathematics than one without positive experiences and with a response of "disagree," or a baseline outcome score of one out of four.

The Durbin-Watson statistic for this model was 2.164. The DW obtained was higher than the upper limit of 1.68; therefore, we failed to reject the null or to accept $H_0$ and conclude that there was no statistically significant autocorrelation in our regression model. Results indicated that multicollinearity was at a minimum because the tolerance was a .962 when the second predictor variable was added. Similarly, the Variance Inflation Factor (VIF) was 1.039 with two predictors, indicating a small amount of multicollinearity. Multicollinearity occurs when two variables are related; thus, it is important to keep it at a minimum when

creating regression models. To evaluate the effect size of the regression model, we computed a post-hoc power analysis. The model with two predictors (see Table 5) had a very high level of power ($1 - \beta = 0.97$) with a medium effect size ($f^2 = 0.26$) at the alpha level of .05. The next section situates survey results within the literature to consider implications.

## Discussion

Our research question stated, *How do preservice elementary teachers' perceptions of their past schooling and their mathematics methods course influence their attitudes about the teaching and learning of mathematics?* Results from the survey showed several statistically significant positive relationships among preservice teachers' attitudes towards mathematics, confidence to teach mathematics, and the two predicting variables: perceived past schooling and the mathematics methods course. While the paired t-tests showed a significant difference in favor of participants planning to teach mathematics with a conceptual approach, there were significant correlations between conceptual and procedural approaches, implying some overlap in the way in which participants responded to the two approaches. Regression models confirmed that past schooling experiences and the mathematics methods course were influential in predicting a significant portion of preservice teachers' preparation and attitude toward teaching mathematics.

Descriptive statistics from the post-survey showed that more than 80% of participants perceived their prior schooling and the mathematics methods course experiences as having a major impact on their anticipated teaching practices. The multiple regression model confirmed that the two variables accounted for a significant proportion of preservice teachers' perceived level of preparation and their attitude towards teaching mathematics. Nevertheless, the two factors combined accounted for only 20.8% of the desired outcome variable including preservice teachers' looking forward to teaching mathematics and viewing themselves as prepared. Thus, other factors beyond those in our model account for almost 80% of PTs' preparation to teach mathematics and attitudes about teaching mathematics. In this section we present an interpretive summary of the two main themes from our data.

### Evolution of Attitudes

Findings indicated a strong relationship between PTs' attitudes about mathematics and their prior schooling experiences. A positive increase in participants' attitudes towards mathematics was related to positive perceptions of experiences in K-8 prior schooling ($r = .599$, $p < .01$) and to high school ($r = .719$, $p < .01$). Although both experiences had positive relationships with PTs' attitudes, their high school experiences in mathematics had a greater shared variance with their attitudes, suggesting that high school experiences in mathematics may have a stronger influence on PTs' attitudes. We conjecture that at the high school level, mathematical content becomes more challenging and those with a more positive experience were more likely to have experienced success in mathematics courses. Similarly, an increased response to perceived proficiency in mathematics had a strong positive relationship with attitude towards mathematics ($r = .713$, $p < .01$). In addition, participants' perceived proficiency was related to both their perceived prior K-8 ($r = .526$, $p < .01$) and high school ($r = .599$, $p < .01$) experiences in mathematics. Thus, correlation results indicated that those

with more positive prior schooling experiences had more positive attitudes towards mathematics and considered themselves as more proficient. These findings are consistent with findings from a qualitative study conducted by Ellsworth and Buss (2000), who examined preservice teachers' attitudes towards mathematics by analyzing their autobiographies. They found that past teaching models was the most salient theme because preservice teachers' commonly reported that their interest in or attitude towards mathematics was positively or negatively affected by past teachers. However, elsewhere we have reported PTs with relatively negative experiences in K-12 mathematics demonstrate significant gains in attitudes over the duration of mathematics methods coursework (Hodges, Jong, & Royal, 2013). Consequently, by bringing past experiences to the surface, preservice teachers may be more cognizant of how their own attitudes about mathematics are affected.

Attitudes about mathematics can also influence preservice teachers' own confidence to teach mathematics. Bursal and Paznokas (2006) suggest that PTs with more positive attitudes towards mathematics also had greater confidence in their own ability to teach mathematics. In addition, findings from paired t-tests indicated that preservice teachers had a significant increase in both their attitude towards mathematics and confidence to teach mathematics over the course of the semester. These results suggest that positive changes in PTs' attitudes and confidence can begin to grow over a semester long mathematics methods course. The findings differed from those of Vinson, Haynes, Brasher, Sloan, & Gresham (1997), who compared PTs' mathematics anxiety before and after taking methods courses emphasizing the use of manipulative materials. Pre- and multiple post-survey results indicated no significant difference in the mathematics anxiety scale after the first quarter of classes in the fall; however, significant differences showing a reduction of mathematics anxiety were evident after the winter, spring, and summer quarter classes. Thus, although immediate changes cannot always be detected, attitudes might be affected over time by learning opportunities in the mathematics methods course.

Data suggested that preservice teachers who learned mathematics in a traditional manner would like to teach it differently than the way in which they were taught. However, the desire to teach in a reformed manner can be difficult to put into practice. Rasmussen and Marrongelle (2006) argue that teaching in a manner consistent with NCTM reform recommendations may be overwhelming for teachers, because part of the challenge includes the ability to understand students' thinking and use it to develop mathematical ideas. This can be a struggle for beginning teachers, who in most cases already have feelings of uncertainty about their teaching, due to their limited classroom experience. In addition, prior to teaching in a reformed manner, a teacher must value the classroom characteristics of reformed teaching and have explicit reformed goals as a part of their classroom practice (Remillard & Bryans, 2004).

## Influential Factors

It is particularly important to acknowledge that preservice teachers enter teacher education programs with a wealth of knowledge from their prior schooling. Although in some cases, the goal of a course is to change or challenge entering assumptions about the role of teaching, PTs can also have positive perspectives about teaching upon which complementary ideas can

be built. Mathematics methods courses could be built upon PTs entering attitudes, which could be more positive and fertile than expected. While the mathematics methods courses observed in this study did not appear to have an overt agenda or strategy to build upon PTs' past experiences, questions were raised about their view of the teaching and learning of mathematics. As the instructors taught methods for different mathematics topics such as multi-digit subtraction, PTs would use the standard algorithms in many cases and connect their prior knowledge about the procedure with concrete materials. It would have been interesting for PTs to explicitly compare different strategies and discuss the benefits of alternative algorithms.

While the two experiences we focused on, perceived prior schooling experiences and the mathematics methods course, can be of great importance in preparing elementary teachers to teach mathematics, our study found that the two only accounted for 20% of the variance of preparation to teach mathematics. This suggests that past experiences that we often try to work with may not account for as much as we thought. While past experiences are important, they might play a smaller part than we expect. We suggest that explicit efforts still be made in the mathematics methods courses to connect to PTs' prior knowledge, in the same way that teacher educators encourage PTs to build upon students' prior knowledge. Many scholars have made a strong case for the importance of adopting an asset model by using students' prior experiences as resources (Cochran-Smith, 1999, 2004; Darling-Hammond, French, & Garcia-Lopez, 2002; Ladson-Billings, 1995). In addition, there are many factors that need to be explored over time, such as field experiences, student teaching, mentors, family members who are educators, peers, mathematics methods course designs, and mathematics content courses, which could potentially influence changes in participants' attitudes and confidence.

Our survey results suggest that PTs had an ideological stance in favor of conceptual approaches to teaching mathematics. If the goal is for teachers to adopt practices that emphasize a conceptual understanding of mathematics, meaningful teacher learning experiences need to foster such attitudes along with exposing teachers multiple strategies that can be implemented in the classroom. Harkness et al. (2006) suggested that mathematics methods courses should provide opportunities for PTs to engage in meaningful problem solving tasks to make sense of the mathematics and make connections to improve upon their future practices.

## Recommendations for Future Research

Preservice teachers' prior schooling experiences influence their attitudes towards mathematics and perceptions of the teaching and learning of mathematics. Thus, it is important that teacher educators learn about PTs' entering attitudes and perceptions in order to create learning experiences that connect their prior knowledge to new ideas. Although several scholars have argued that beginning teachers' socialization into teaching takes place when they are students (Ball, 1989; Grossman, 1990; Peker & Mirasyedioglu, 2008; Scott, 2005; Wideen et al., 1998), more empirical work that explores the *extent to which* past experiences influence preservice teachers is needed. This study explored that issue as it pertains to mathematics teacher education and showed that perceived past experiences only accounted for 12.5% of the explained variance in PTs' attitudes and confidence to teach

mathematics. We believe that this could actually be a very encouraging finding. While past schooling experiences are a significant factor and need to be taking into consideration, there are many additional factors that account for and influence teachers' attitudes. Thus, providing teachers with meaningful mathematics experiences in methods courses, supportive field experiences, and continued professional development may have the potential to account for a greater portion of teachers' attitudes and confidence to teach mathematics.

Given that much of the influence on teachers' attitudes toward mathematics teaching and learning lie beyond prior experiences and methods courses, research is needed on other possible contributing factors in the attitudes and practices that PTs develop over time. Future research should follow PTs longitudinally across teacher education programs and their entry into the profession. In this study, the pre- and post-surveys were confined to one semester-long mathematics methods courses in one university. Based on the factor analysis, the instrument also had room for improvement, as surveys do not fully capture the variables of interest due to self-reporting and restricted Likert-scales. Multiple data sites over time and across institutions would allow for stronger comparisons. In addition to survey results, qualitative interviews that elaborate on these experiences would help us further investigate preservice teachers' attitudes.

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## APPENDIX A - Mathematics Education Pre-Survey

Using the scale 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree, or 5=Not Applicable (if you absolutely do not know or the item does not apply to you), please respond to the following statements about mathematics.

### Attitude and Past Experiences

| | S A | A | D | S D | NA |
|---|---|---|---|---|---|
| 1. I like mathematics. | 1 | 2 | 3 | 4 | 5 |
| 2. I enjoy solving mathematical problems that challenge me to think. | 1 | 2 | 3 | 4 | 5 |
| 3. I had several positive experiences with mathematics as a K-8 student. | 1 | 2 | 3 | 4 | 5 |
| 4. I had several positive experiences with mathematics as a 9-12 student. | 1 | 2 | 3 | 4 | 5 |
| 5. I am proficient in mathematics. | 1 | 2 | 3 | 4 | 5 |
| 6. Mathematics is one of my favorite subjects. | 1 | 2 | 3 | 4 | 5 |
| 7. I think mathematics is boring. | 1 | 2 | 3 | 4 | 5 |
| 8. I have struggled with mathematics as a K-8 student. | 1 | 2 | 3 | 4 | 5 |
| 9. I have struggled with mathematics as a 9-12 student. | 1 | 2 | 3 | 4 | 5 |
| 10. I used hands-on materials to learn mathematics in either elementary, middle school, or high school. | 1 | 2 | 3 | 4 | 5 |
| 11. The way mathematics is taught today is different from the way I learned it as a K-8 student. | 1 | 2 | 3 | 4 | 5 |
| 12. The way mathematics is taught today is different from the way I learned it as a 9-12 student. | 1 | 2 | 3 | 4 | 5 |
| 13. As a K-8 student, I mostly learned mathematics in a traditional manner (i.e. textbooks, worksheets, rules, lectures). | 1 | 2 | 3 | 4 | 5 |
| 14. As a 9-12 student, I mostly learned mathematics in a traditional manner (i.e. textbooks, worksheets, rules, lectures). | 1 | 2 | 3 | 4 | 5 |

## Teaching and Learning

| | SA | A | D | SD | N/A |
|---|---|---|---|---|---|
| 15. I am looking forward to teaching mathematics. | 1 | 2 | 3 | 4 | 5 |
| 16. It is important to incorporate the use of technologies (e.g. calculators, computers) when teaching mathematics. | 1 | 2 | 3 | 4 | 5 |
| 17. Using mathematics is essential to the every day life of K-12 students. | 1 | 2 | 3 | 4 | 5 |
| 18. I want to teach mathematics the same way I learned it. | 1 | 2 | 3 | 4 | 5 |
| 19. I am confident in my ability to be a good mathematics teacher. | 1 | 2 | 3 | 4 | 5 |
| 20. I plan to use hands-on materials to help my students learn mathematics and solve problems. | 1 | 2 | 3 | 4 | 5 |
| 21. Memorizing facts and formulas is essential to learn mathematics. | 1 | 2 | 3 | 4 | 5 |
| 22. I will allow and encourage students to solve mathematical problems in more than one way. | 1 | 2 | 3 | 4 | 5 |
| 23. I plan on integrating mathematics with different subjects (i.e. science, literature, social studies). | 1 | 2 | 3 | 4 | 5 |
| 24. I am scared of teaching mathematics. | 1 | 2 | 3 | 4 | 5 |

## Methods Course Expectations

| ***It is important for me to learn…*** | SA | A | D | SD | NA |
|---|---|---|---|---|---|
| 25. a variety of instructional strategies. | 1 | 2 | 3 | 4 | 5 |
| 26. how to use technologies (i.e. calculators, computers) in mathematics classrooms. | 1 | 2 | 3 | 4 | 5 |
| 27. how students learn mathematics developmentally (i.e. age, grade level). | 1 | 2 | 3 | 4 | 5 |
| 28. how to use hands-on materials to teach mathematical concepts. | 1 | 2 | 3 | 4 | 5 |
| 29. about national mathematics standards and state frameworks. | 1 | 2 | 3 | 4 | 5 |
| 30. how to teach mathematics to a diverse student population. | 1 | 2 | 3 | 4 | 5 |
| 31. how to assess student learning in mathematics. | 1 | 2 | 3 | 4 | 5 |
| 32. about the role of standardized tests in mathematics. | 1 | 2 | 3 | 4 | 5 |
| 33. about different mathematics curriculums used by districts across the nation. | 1 | 2 | 3 | 4 | 5 |
| 34. how to manage the mathematics classroom effectively (i.e. behaviors, grouping, transitions). | 1 | 2 | 3 | 4 | 5 |
| 35. how to integrate mathematics with science. | 1 | 2 | 3 | 4 | 5 |
| 36. how to integrate mathematics with literature. | 1 | 2 | 3 | 4 | 5 |
| 37. about a variety of mathematics games that can be used in the classroom. | 1 | 2 | 3 | 4 | 5 |

**Diverse Learners**

| | SA | A | D | SD | NA |
|---|---|---|---|---|---|
| 38. I am confident in teaching mathematics to high achievers. | 1 | 2 | 3 | 4 | 5 |
| 39. I am confident in teaching to students who do not have English as their primary language. | 1 | 2 | 3 | 4 | 5 |
| 40. I am confident in teaching mathematics to students with special needs. | 1 | 2 | 3 | 4 | 5 |
| 41. I am confident in teaching mathematics to students of different ethnic/racial/cultural backgrounds. | 1 | 2 | 3 | 4 | 5 |
| 42. Social justice plays an important role in the teaching and learning of mathematics. | 1 | 2 | 3 | 4 | 5 |
| 43. Most students (who do not have severe special needs) can be successful at learning mathematics. | 1 | 2 | 3 | 4 | 5 |
| 44. I am confident in teaching mathematics to students in an Urban school. | 1 | 2 | 3 | 4 | 5 |
| 45. I am confident in teaching mathematics to students in a Suburban school. | 1 | 2 | 3 | 4 | 5 |
| 46. I am confident in teaching mathematics to students in a Rural school. | 1 | 2 | 3 | 4 | 5 |
| 47. Mathematics can help students critically analyze the world. | 1 | 2 | 3 | 4 | 5 |
| 48. Issues about equity should be addressed in the mathematics classroom. | 1 | 2 | 3 | 4 | 5 |

**Background Information**

1. Gender: Male_____ Female_____
2. Degree: _____ 3. Current Year:_____
4. Major: _____ Minor: _____
5. If you are a Graduate Student, Undergraduate Major:_____
6. Course Professor:_____ Time: _____
7. Number of Math Content Courses Taken at the College Level: _____
8. Future Teaching Plans (check all that apply):
   Suburban_____ Urban_____ Rural_____
   Public_____ Private_____ Religious_____
   Grade(s): _____ Subject(s): _____
9. Describe your ethnicity. _____

_____

10. How long have you (and your family) been in the U.S.A.?
    Generation: 1st_____ 2nd _____ 3rd _____ 4+ _____
11. Mother's highest level of Education: _____
    Occupation: _____
12. Father's highest level of Education: _____
    Occupation: _____
13. Describe your previous teaching experience (if any).

_____

_____

## APPENDIX B - Mathematics Education Post-Survey

Using the scale 1=Strongly Agree, 2=Agree, 3=Disagree, 4=Strongly Disagree, or 5=Not Applicable (if you absolutely do not know or the item does not apply to you), please respond to the following statements about mathematics.

### Attitude and Practicum Experiences

| | S A | A | D | S D | NA |
|---|---|---|---|---|---|
| 1. I like mathematics. | 1 | 2 | 3 | 4 | n/a |
| 2. I had a positive practicum experience. | 1 | 2 | 3 | 4 | n/a |
| 3. My cooperating teacher contributed greatly to my knowledge about the teaching and learning of mathematics. | 1 | 2 | 3 | 4 | n/a |
| 4. My cooperating teacher used a traditional method (i.e. textbooks, lectures, worksheets, rules) to teach math. | 1 | 2 | 3 | 4 | n/a |
| 5. My cooperating teacher used a conceptual method (i.e. problem-solving, open-ended Qs) to teach math. | 1 | 2 | 3 | 4 | n/a |
| 6. The math curriculum used in my practicum focused on teaching math in a conceptual manner. | 1 | 2 | 3 | 4 | n/a |
| 7. The math curriculum used in my practicum focused on teaching math in a traditional manner. | 1 | 2 | 3 | 4 | n/a |
| 8. My practicum experience connected to my math methods course. | 1 | 2 | 3 | 4 | n/a |
| 9. My practicum experience reinforced what I learned in my math methods course. | 1 | 2 | 3 | 4 | n/a |
| 10. My practicum placement had a diverse student population. | 1 | 2 | 3 | 4 | n/a |
| 11. I think math is boring. | 1 | 2 | 3 | 4 | n/a |

### Teaching and Learning

| | SA | A | D | SD | NA |
|---|---|---|---|---|---|
| 12. I am looking forward to teaching mathematics. | 1 | 2 | 3 | 4 | n/a |
| 13. I plan on incorporating the use of technologies (e.g. calculators, computers, software) when teaching mathematics. | 1 | 2 | 3 | 4 | n/a |
| 14. I plan on teaching math in a procedural way (facts, skills, etc…). | 1 | 2 | 3 | 4 | n/a |
| 15. I plan on teaching math in a conceptual way (for understanding, problem-solving). | 1 | 2 | 3 | 4 | n/a |
| 16. I am confident in my ability to be a good mathematics teacher. | 1 | 2 | 3 | 4 | n/a |
| 17. I plan to use manipulatives (hands-on materials) to help my students learn mathematics and solve problems. | 1 | 2 | 3 | 4 | n/a |
| 18. I will require my students to memorize mathematical facts and formulas. | 1 | 2 | 3 | 4 | n/a |
| 19. I will allow and encourage students to solve math problems in more than one way. | 1 | 2 | 3 | 4 | n/a |
| 20. I plan on integrating mathematics with different subjects (i.e. science, literature, social studies). | 1 | 2 | 3 | 4 | n/a |
| 21. I am scared of teaching mathematics. | 1 | 2 | 3 | 4 | n/a |
| 22. I am prepared to teach mathematics. | 1 | 2 | 3 | 4 | n/a |

## Methods Course Evaluation

| *The math methods course taught me…* | SA | A | D | SD | NA |
|---|---|---|---|---|---|
| 23. a variety of instructional strategies. | 1 | 2 | 3 | 4 | n/a |
| 24. how to use technologies (i.e. calculators, computers) in mathematics classrooms. | 1 | 2 | 3 | 4 | n/a |
| 25. how students learn mathematics developmentally (i.e. age, grade level). | 1 | 2 | 3 | 4 | n/a |
| 26. how to use manipulatives (hands-on materials) to teach mathematical concepts. | 1 | 2 | 3 | 4 | n/a |
| 27. about national mathematics standards and state frameworks. | 1 | 2 | 3 | 4 | n/a |
| 28. how to teach mathematics to a diverse student population. | 1 | 2 | 3 | 4 | n/a |
| 29. how to assess student learning in mathematics. | 1 | 2 | 3 | 4 | n/a |
| 30. about the role of standardized tests in mathematics. | 1 | 2 | 3 | 4 | n/a |
| 31. about different mathematics curriculums used by districts across the nation. | 1 | 2 | 3 | 4 | n/a |
| 32. how to manage the mathematics classroom effectively (i.e. behaviors, grouping, transitions). | 1 | 2 | 3 | 4 | n/a |
| 33. how to integrate mathematics with science. | 1 | 2 | 3 | 4 | n/a |
| 34. how to integrate mathematics with literature. | 1 | 2 | 3 | 4 | n/a |
| 35. about a variety of mathematics games that can be used in the classroom. | 1 | 2 | 3 | 4 | n/a |
| 36. theories about the teaching and learning of mathematics. | 1 | 2 | 3 | 4 | n/a |

## Diverse Learners

| | SA | A | D | SD | NA |
|---|---|---|---|---|---|
| 37. I am confident in teaching mathematics to high achievers. | 1 | 2 | 3 | 4 | n/a |
| 38. I am confident in teaching to students who do not have English as their primary language. | 1 | 2 | 3 | 4 | n/a |
| 39. I am confident in teaching mathematics to students with special needs. | 1 | 2 | 3 | 4 | n/a |
| 40. I am confident in teaching mathematics to students of different ethnic/racial/cultural backgrounds. | 1 | 2 | 3 | 4 | n/a |
| 41. I think social justice plays an important role in the teaching and learning of mathematics. | 1 | 2 | 3 | 4 | n/a |
| 42. I am confident in teaching mathematics to students in an Urban school. | 1 | 2 | 3 | 4 | n/a |
| 43. I am confident in teaching mathematics to students in a Suburban school. | 1 | 2 | 3 | 4 | n/a |
| 44. I think issues about equity should be addressed in the mathematics classroom. | 1 | 2 | 3 | 4 | n/a |

## Future Teaching

| ***The following will have a major impact on the way I teach mathematics in the future:*** | SA | A | D | SD | NA |
|---|---|---|---|---|---|
| 45. My past K-8 school experiences | 1 | 2 | 3 | 4 | n/a |
| 46. My past 9-12 school experiences | 1 | 2 | 3 | 4 | n/a |
| 47. Practicum experiences | 1 | 2 | 3 | 4 | n/a |
| 48. Math methods course | 1 | 2 | 3 | 4 | n/a |

## Background Information

*Practicum*

1. Grade level:_____
   Secondary, please specify content area(s)_____
2. Setting: Urban_____ Suburban_____
3. Public _____ Private (religious)_____ Private (nonreligious)_____
4. Math Curriculum used by Cooperating Teacher
   _____