Examining the Relationship Between Preservice Elementary Teachers' Attitudes Toward Mathematics and Professional Noticing Capacities

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The past 2 decades have seen a growing interest in research on teachers' attitudes about mathematics due to the potential influence they have on the way teachers enact classroom practices and understand mathematics (Grootenboer 2006; McLeod 1992, 1994; Pajares 1992; Philipp 2007; Wilkins 2008). Research on attitudes is critical because students and teachers often develop negative attitudes toward mathematics, which can

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later result in anxiety (Quinn 1997). Preservice elementary teachers (PSETs) have tended to view mathematics as a system of rules and procedures that must be transferred to students (Ball 1990; Foss and Kleinsasser 1996). Moreover, studies have reported that PSETs tend to view mathematics negatively or neutrally, but rarely positively (Ambrose 2004; Ball 1990; Bekdemir 2010; Quinn 1997). It is important to understand the attitudes PSETs hold because, these attitudes have the potential to influence the instructional practices they adopt. Ambrose (2004) suggested that mathematics educators focus on the range of strengths PSETs bring, such as the PSETs' view of teachers as nurturers of children. Jong and Hodges (2011) have also argued that mathematics educators take an asset-based approach to build on PSETs' prior knowledge and experiences. They found that it was possible for PSETs to experience positive changes in attitudes as a result of completing a mathematics methods course that connected past experiences with reform-oriented methods. We believe that our module on professional noticing within the mathematics methods courses could also positively affect PSETs' attitudes toward mathematics, because the module supports PSETs' development of strategies that might improve their own view of mathematics and teaching mathematics. Thus, our work focuses on PSETs and their potential changes in attitudes toward mathematics by engaging them in professional noticing of children's mathematical thinking in the context of an early numeracy progression.

This research is informed by the literature on teachers' attitudes toward mathematics (Grootenboer 2006; McLeod 1992; Philipp 2007), professional noticing (Jacobs et al. 2010), and the progression of early numeracy (Clements and Sarama 2009; Steffe 1992; Steffe et al. 1988; Steffe et al. 1983). Our previous analyses of the data from this project focused specifically on a learning experience using video vignettes to teach PSETs about professional noticing within the context of early numeracy. That analysis revealed significant gains in the professional noticing skills of the PSETs involved in this instructional module (Schack et al. 2013). Research has shown that positive correlations exist between PSETs' attitudes toward mathematics and their content knowledge (Matthews and Seaman 2007; Quinn 1997). Based on the literature and our previous analyses, we aimed to expand our analyses to examine whether similar relationships exist between our PSETs' attitudes toward mathematics and their professional noticing skills. Specifically, we investigated the following research questions: *Did PSETs who engaged in a professional noticing learning experience exhibit improvements in their attitudes toward mathematics*? *If so, what correlations exist between aspects of PSETs' professional noticing performance and attitudes toward mathematics*?

Theoretical Framework and Literature Review

Preservice Elementary Teachers' Attitudes Toward Mathematics

Research on attitudes toward mathematics has become an increasingly prominent area of study. Attitudes are often defined as a component of *affect* (Philipp 2007), which has various meanings in the field of psychology (Chamberlin 2010). Mathematics educators have attempted to differentiate attitudes from beliefs by characterizing beliefs as having true or false orientations (Philipp 2007), but the field still varies on its use of definitions of beliefs (Beswick 2005; Pajares 1992). We focus on attitudes because mathematics educators are more consistent in their definition of attitudes in contrast to beliefs. For the purpose of our study, we draw upon Philipp's (2007) definition of attitudes as "manners of acting, feeling, or thinking that show one's disposition or opinion…. Attitudes, like emotions, may involve positive or negative feelings" (p. 259).

In the context of teacher education, researchers have studied PSETs' attitudes toward mathematics through coursework and field experiences (Jong and Hodges 2011; Quinn 1997; Wilkins 2008). Several studies have shown positive changes and significant relationships between PSETs' attitudes toward mathematics and their content knowledge (Matthews and Seaman 2007; Quinn 1997; Young-Loveridge et al. 2012). It is not a surprise that PSETs with stronger content knowledge also develop a more positive attitude toward mathematics because they are more likely to show favor toward a subject in which they are more confident. Quinn (1997) used Aiken's Revised Mathematics Attitudes Scale to investigate attitudes and found that there were statistically significant positive changes in PSETs' attitudes toward mathematics, but no significant changes in attitudes toward mathematics of preservice secondary mathematics teachers, who entered with higher attitude measures. He argued, and we agree, that the methods course could play a critical role in the improvement of attitudes toward mathematics, especially for PSETs who have negative attitudes toward mathematics. Matthews and Seaman (2007) also used Aiken's Revised Mathematics Attitudes Scale to examine the mathematics attitudes of PSETs enrolled in a course that emphasized a conceptual understanding of mathematics. Their results indicated that the course had a significant positive influence on PSETs' attitudes toward mathematics, along with their content knowledge. Young-Loveridge et al. (2012) found that if PSETs were "good at mathematics [it] did not automatically mean that [they] liked mathematics" (p. 38). Their study challenged the notion that those who have strong mathematical content knowledge also have a positive attitude toward mathematics. While studies have examined the relationship between PSETs' attitudes and their mathematics content knowledge, there is an absence of studies that examine PSETs' attitudes and their professional noticing skills.

We also know that stronger content knowledge alone does not lead to effective teaching (Hill and Ball 2004). In fact, Wilkins (2008) found that strong content knowledge was negatively related to beliefs about effective mathematics instruction that aligns with practices recommended by the National Council of Teachers of Mathematics (2000). That is to say, teachers who had stronger content knowledge did not necessarily agree with more reform-oriented practices in mathematics. Wilkins (2008) also found that beliefs about mathematics have a strong influence on teachers' practices, although teachers with more positive attitudes toward mathematics were more likely to have an orientation toward inquiry-based practices. For example, teachers who believe that mathematics is primarily a system of rules and procedures that must be transferred to students will instruct in a manner that reflects this belief whether or not they have a positive attitude. However, those with a positive attitude are more likely to hold beliefs that reflect inquiry-based practices. This suggests that building positive attitudes toward mathematics in PSETs could lead to their adoption of more inquiry-based practices. Unlike the aforementioned studies, Wilkins used a combination of items to measure attitudes to include items about the enjoyment of teaching mathematics along with liking mathematics as a subject. Schackow (2005) used the Attitudes Toward Mathematics Inventory (ATMI) (Tapia and Marsh 2005), which was not originally designed for use with preservice teachers; however, by changing two questions to make it more suitable for preservice teachers, she found significant gains in PSETs' attitudes toward mathematics. In our study, we used Schackow's revised version of the ATMI, since it was edited for use with preservice teachers, and the ATMI (Tapia and Marsh 2005) also measures multiple factors of attitudes rather than a single factor. While many mathematics education researchers have attempted to examine changes in PSETs' attitudes, there is still more work needed in the field on identifying conditions to support PSETs in developing positive attitudes (Grootenboer 2006; Jong and Hodges 2011; Quinn 1997; Wilkins 2008). Thus, we have established an instructional module to aid in increasing PSETs' professional noticing skills, and subsequently, supporting PSETs' attitudinal improvement.

Our instructional module situates the professional noticing of children's mathematics in the context of mathematics progressions, specifically an early numeracy progression, illustrated through video representations of children's work. The focus on children's mathematical work capitalizes on PSETs' nurturing attitudes about teaching (Ambrose 2004) and also reveals to them the complexities of the mathematics content. The content of early numeracy, on the surface, seems simple for PSETs to understand, because it encompasses such skills as forward and backward counting, skip counting, and addition and subtraction of numbers within 100. As PSETs view video vignettes of children engaged in mathematical thinking along the early numeracy progression, they are exposed to the idea that counting, for example, is not an "all or nothing" skill. The children in the videos used during our instructional module display nuanced understandings and skills that demonstrate the incremental but important steps through which children progress. Providing meaningful and focused experiences in both coursework and clinical or field activities, as the aforementioned studies show, can potentially relate to a positive shift in PSETs' attitudes toward mathematics. Our intent is to investigate whether engaging PSETs in a focused experience that integrates representations of practice with coursework and is specifically aimed to develop professional noticing of children's mathematical thinking results in a positive shift in PSETs' attitudes toward mathematics. If PSETs' attitudes shift positively in relation to developing professional noticing skills, the improved attitudes could result in PSET adoption of more reform-oriented instructional practices. And, incorporation of professional noticing skill development in preservice coursework would be one tool for improving PSETs' attitudes toward mathematics.

Research on attitudes toward mathematics and noticing skills of teachers, individually, is not new; however, there is no previous research comparing the professional noticing capacities with attitudes toward mathematics, within the same study. Due to the importance of both of those constructs, and supported by the evidence by Wilkins (2008) in which attitudes were found to have an influence on teachers' practices, we think a better understanding of this relationship seems warranted.

Professional Noticing

The construct of professional noticing, as defined by Jacobs et al. (2010), is "a set of three interrelated skills: attending to children's strategies, interpreting children's understandings, and deciding how to respond on the basis of children's understandings" (p. 172). The first skill, attending, contains physical evidences observed from the student and teacher, such as eye movements, finger counting, and touching objects to count. The second skill, interpreting, is determining how those observations in the attending category can inform the observer on the mathematical abilities of the students. Finally, deciding involves the next steps in the process, which can include diagnostic or instructional decision making. Jacobs et al. (2010) found that teaching experience alone does not contribute to an increase in professional noticing skills; professional development in the area of professional noticing is needed to adequately develop these skills, especially in the deciding component. Several studies have found that closer attention to children's mathematical thinking can significantly impact student learning (Carpenter et al. 1999; Kersting et al. 2010); however, attention to the three interrelated components of professional noticing is missing from much of the previous research.

Numeracy and Counting

The term *numeracy,* a portmanteau of "numerical literacy," is typically invoked to describe an understanding of number and arithmetic operations. This area of mathematical learning has been the subject of considerable study over the past four decades (Gelman and Gallistel 1978; Siegler and Robinson 1982; von Glasersfeld 1982; Steffe et al. 1983; Fuson 1988; Steffe 1992; Wright et al. 2006; Clements and Sarama 2009; Thomas and Harkness 2013). In the USA, young children's initial numeracy experiences typically involve counting (Steffe et al. 1983, 1988; Wright 1994). Depending upon the context, counting can describe several different activities. For example, the term might be used to describe the production of a specified verbal sequence (e.g., "four, five, six, seven"). Similarly, counting might also refer to verbal utterances when presented with a sequence of numerals. These descriptions of counting, however, fail to capture the potentially quantitative aspect of the activity. To capture this aspect, Steffe et al. (1983) investigated children's counting activity in the face of problematic situations dealing explicitly with quantities. Wright and his colleagues describe this type of *quantitative counting* as "the coordination of each uttered number word with the conceptual production of a unit item" (Wright et al. 2006, p. 52).

To further define early numeracy progression, Steffe and his colleagues (Olive 2001; Steffe et al. 1983, 1988; Steffe 1992) put forward a framework, ultimately termed the *Stages of Early Arithmetic Learning* (SEAL), that is an extremely descriptive progression constructed from highly authentic research methods. This progression was used in our previous research (Schack et al. 2013) to further investigate the interpretations of mathematical thinking within the professional noticing context. We hypothesized that combining the early numeracy progression of SEAL into a learning experience focused on professional noticing and then using representations of practice in an authentic diagnostic setting would improve PSETs' attitudes toward mathematics.

Methodology

Instructional Module Description

The instructional module was a component of the methods or blended course at each institution. The module consisted of multiple in-class sessions in which professional noticing was developed in the context of early numeracy, specifically, SEAL, and organized around multiple video cases of children engaged in early numeracy experiences. The decomposition of professional noticing into three interrelated skills allowed for the skills to be progressively nested (Boerst et al. 2011) throughout the module sessions. The instructional module embedded video vignettes throughout the lessons to provide examples of one-on-one interviews with children for PSETs to practice their newfound professional noticing skills. The first two sessions focused solely on the development of attending. Subsequent sessions further developed attending with interpreting and deciding. SEAL was nested within the development of professional noticing and integrated through the video cases as representations of practice. Additional assignments throughout the instructional module included assigned readings on SEAL and video-based assessments and other activities, such as role-playing, small group discussions, whole-class discussions, and another activity entitled "World Café," where PSETs rotate around the room discussing their observations from a selected video clip and creating Venn diagrams of their findings. The culminating experience was an assignment that required the PSETs to conduct and record (on video) at least one diagnostic interview with a child during their field experience—an approximation of practice, one of the three pedagogies of practice proposed by Grossman et al. (2009), where they addressed the three stages of professional noticing within their written analyses of their interview. Schack et al. (2013) provides further information about the individual modules, rationale for the selection of early numeracy as the mathematics focus, and measures taken to ensure fidelity across multiple sites.

Participants

All 270 PSETs enrolled in the participating researchers' 11 mathematics education course sections over a two-year period participated in the module. They were predominantly women, enrolled in an elementary mathematics method or a blended content and methods course at one of the five participating public universities in a south central state. The five institutions' populations, taken as a whole, represent varying regions of the state because of their locations in central, northern, western, and eastern parts of the state. The populations also represent rural, suburban, and urban areas. Notably, two of the regional universities draw much of their population from central Appalachia, a traditionally underrepresented population in science, technology, engineering, and mathematics (STEM) fields. The majority of the participants were traditional university students, while some were second-career students.

Data Sources and Analyses

Data analyzed for this study include that which was collected from the 123 PSETs who provided consent and responded to all questions on both the pre- and post-assessments of professional noticing and the pre- and post-assessment of the ATMI (Tapia and Marsh 2005). The number of PSETs who did not complete all pre- and post-assessments and those who completed them yet left items blank, particularly on the ATMI, affected the response rate. One can only speculate as to the reasons for leaving items blank.

Professional Noticing Assessment A pre- and post-assessment was used to measure the changes in professional noticing at the beginning of the semester and again at the end of the semester. A video of a diagnostic interview with a child completing a comparison, difference unknown task (Carpenter et al. 1999) was used, and both pre- and post-assessments were identical in prompts and video. The brief 25-sec video shows an interviewer presenting a first-grade student with a partially screened task that extends beyond finger range. The screened component consists of 11 seashells hidden by the interviewer's hand and the visible component is seven red counting bears in a row. The student is asked to determine how many more shells there are than bears. Counting the bears from one and continuing the count on his fingers until he reaches 11, the student then glances at his raised fingers and correctly responds, "I'm gonna have four left over."

After the PSETs watched the video, they were asked to respond to the following prompts and questions: (1) *Please describe in detail what this child did in response to this problem,* (2) *Please explain what you learned about this child's understanding of mathematics, and* (3) *Pretend that you are the teacher of this child. What problems or questions might you pose next*? *Provide a rationale for your answer.* These prompts were drawn from the work of Jacobs et al. (2010) and each prompt addresses one of the components of professional noticing.

The researchers, individually and as a group, examined the clip to reach a consensus on the key response details for each professional noticing prompt to develop scoring benchmarks along the continuum for each of the prompts. A sample set of data was examined to extract qualitatively different response types for each prompt and the response types were subsequently examined for emergent themes (Glaser and Strauss 1967). The emergent themes were coupled with the researchers' key response details to define the benchmarks or rankings. This process was used for each prompt and resulted in four potential rankings for attending, three for interpreting, and three for deciding. The high rank of four for attending represents an emergent theme from PSET responses that represented an elaboration beyond the salient attending features. A similar elaborating theme did not emerge for the remaining two professional noticing components.

Teams of two scorers ranked the data, and ranks by different scorers were compared. Discrepancies in ranks were resolved through discussion and/or a third scorer if a consensus was not met. The desire to better standardize rankings by multiple scorers and to make the ranking process more efficient led to the development of a decision tree-scoring device with multiple levels of questions to guide the scorers' rankings. Interrater reliability across six scorers using the decision trees averaged 83 % (Schack et al. 2013).

Attitudes Toward Mathematics Inventory The ATMI was administered as a pre- and post-assessment at approximately the same time as the professional noticing assessment. The ATMI is an instrument consisting of 40 Likert-scale items with five response choices ranging from *strongly disagree* to *strongly agree*. Eleven items are reverse scored. We selected the ATMI over Aiken's (1963) Revised Mathematics Attitudes Scale, because the ATMI included more factors about mathematics. Factor analysis on the ATMI resulted in four factors associated with attitudes toward mathematics: value, enjoyment, self-confidence, and motivation (Tapia and Marsh 2005), whereas Aiken's instrument considered only enjoyment and value. Table 1 illustrates sample items by factor with reverse-scored sample items noted. The total number of items per factor is also included. Scores are determined by summing all items and items within factors. Maximum possible scores for each factor vary because of the differing number of items per factor.

The ATMI was determined by Tapia and Marsh (2004) to be a reliable instrument with a Cronbach alpha coefficient of 0.97. Cronbach alpha coefficients for each of the four factors range from 0.88 (motivation) to 0.95 (self-confidence). Test–retest reliability was established with a Pearson correlation coefficient of 0.89 for the total scale. Coefficients of the subscales ranged from 0.70 (value) to 0.88 (self-confidence) (Tapia and Marsh 2004). The ATMI was initially used with secondary students but has since been used with postsecondary students (Schackow 2005; Tapia 2012). Schackow (2005) modified two items for use with a sample of PSETs. She determined a Cronbach alpha coefficient of 0.98 for this sample, indicating internal consistency of the modified instrument. Our study used the instrument modified by Schackow for use with preservice teachers.

Table 1 Sample Attitudes Toward Mathematics Inventory items by factor

Factor	Sample attitudes
Value (10 items)	Mathematics is a very worthwhile and necessary subject. Mathematics courses would be very helpful no matter what grade level I teach.
Enjoyment (10 items)	I really like mathematics. I have usually enjoyed studying mathematics in school.
Self-confidence (15 items)	Mathematics does not scare me at all. Studying mathematics makes me feel nervous. (reverse scored)
Motivation (5 items)	The challenge of mathematics appeals to me. I would like to avoid teaching mathematics. (reverse scored)

Table 2 Pre- and post-assessment results of paired *t*-tests

	N	*t*	*p*-value
Value	123	−1.543	0.125
Enjoyment	123	−3.070	0.003
Self-confidence	123	−5.057	<0.001
Motivation	123	−2.733	0.007

Analyses Paired *t*-tests were used to examine the relationships between the pre- and post-assessment scores for the ATMI. However, due to the ordinal nature of the data for the professional noticing scores, similar parametric tests could not be used to test for significance for professional noticing measures or the correlation between attitudes and professional noticing. A statistical test using Spearman's rho was used to determine, if a correlation exists between the change scores of the two assessments, and further investigation by quartile on the ATMI was also conducted.

Results

Attitudes Toward Mathematics Inventory

Paired *t*-tests were applied to ATMI data to examine PSET change in attitudes toward mathematics from pre- to post-assessment. There were statistically significant increases in the enjoyment, self-confidence, and motivation factors. Table 2 summarizes the paired *t*-test results for the 123 cases. There was not a statistically significant change in the fourth factor, value, when all 123 cases were included. However, when the 15 cases that achieved the maximum possible score on the value factor on the pre-assessment were removed, there was a statistically significant increase in this factor from pre- to post-assessment ($t=2.181$, $p=0.031$).

The significance of the change in the value factor, after removing the data for maximum possible scores on the pre-assessment, indicated a need to further examine the change scores of all factors more closely. For example, if a PSET started at

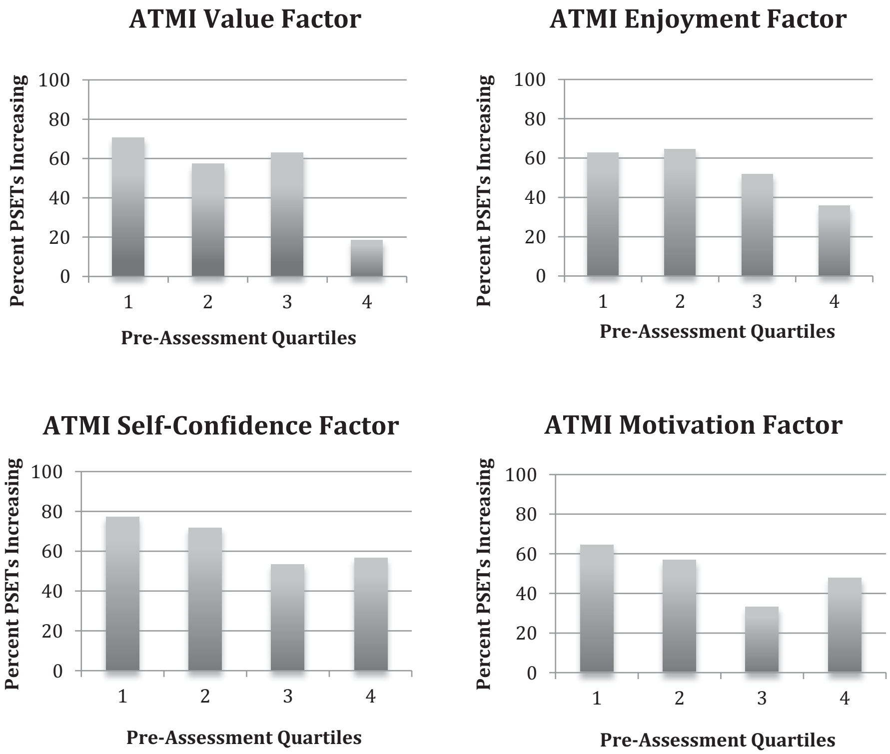


Fig. 1 Percent PSET increase within factors by pre-assessment quartiles

a lower score for a factor, the potential range of increase was much greater than, for example, a PSET with a pre-assessment score at or near the maximum. Hence, the ATMI data were examined within pre-assessment quartiles. Figure 1 shows the percent of PSETs increasing for each factor by pre-assessment quartile. The percent of PSETs with a pre-assessment score in the lowest quartile showing an increase on the post-assessment ranged from 63 to 77 % for the four factors. Remarkably, even those PSETs in the highest pre-assessment quartile for motivation and self-confidence showed that 48 and 57 % of the PSETs increased their scores, respectively.

Overall, more than 50 % of the PSETs increased from pre- to post-assessment for each of the four factors. The self-confidence factor had the greatest percent of PSETs increasing with 65 %. The 95 % confidence interval for the "improvement" rate for this factor was 55.9–73.4 %. The value that scored the lowest percentage of increase was motivation, with 51 % of PSETs demonstrating an increase. Value and enjoyment revealed increases at 54 and 55 %, respectively. Regrettably, approximately 30 % of PSETs decreased in each category except self-confidence, where the percentage of decrease was 21 %; thus, the remaining PSETs remained unchanged in their scores on those factors.

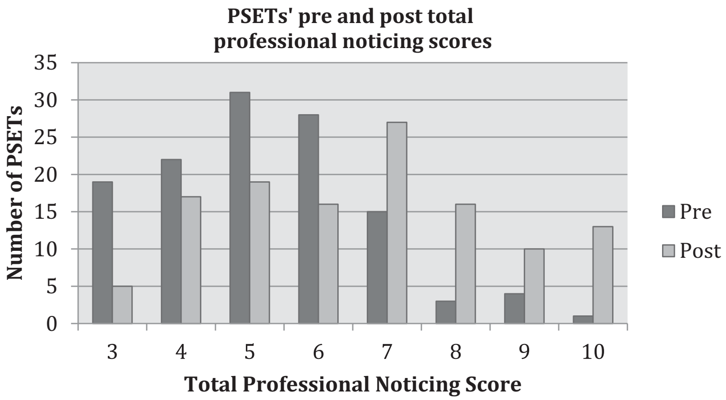


Fig. 2 Professional noticing total score frequencies

Professional Noticing Assessment

Our research questions sought to determine the correlation of changes between PSETs' professional noticing and attitudes toward mathematics. Figure 2 shows the overall trend of improved PSET professional noticing total scores. Ten is the maximum possible score, while a score of three is the minimum.

Professional noticing is a complex construct (Jacobs et al. 2010) with the potential for the three components—attending, interpreting, and deciding—to be interdependent. Spearman's rho correlations were performed to determine correlations between the professional noticing components on the pre- and post-assessments as well as on the interrelationships of the changes in the components. Interestingly, the results indicated no significant correlation between any two components on the pre-assessment and no significant correlations between changes in components from pre- to post-assessment, yet there were significant positive correlations between components on the post-assessment. Tables 3 and 4 show the results of the Spearman's rho correlations.

The professional noticing data were analyzed using nonparametric statistics because of the ordinal nature of the rankings. Wilcoxon signed-rank tests were employed to determine if there was growth in each component of PSETs' professional noticing. The results, indicating statistically significant increases in all three components, are displayed in Table 5. The larger z-score in deciding can be attributed to that component receiving the largest overall growth, relative to attending and interpreting. This growth is illustrated by comparing the top section of bars from pre to post for each component in Fig. 3.

At first examination, the lack of correlations among components on the pre-assessment and on changes from pre- to post-assessment, along with the significant correlations among the professional noticing components on the post-assessment, is a bit confounding. However, consideration of the trends we observed in the data

Table 3 Spearman's rho correlations between professional noticing components on pre- and post-assessments

			Pre-assessment		Post-assessment	
Variable 1	Variable 2	*N*	Spearman	*p*-value	Spearman	*p*-value
Attending	Deciding	123	0.117	0.196	0.270*	0.003
Attending	Interpreting	123	0.108	0.234	0.339*	<0.001
Deciding	Interpreting	123	0.169	0.061	0.235*	0.009

* Significant at $p = .01$.

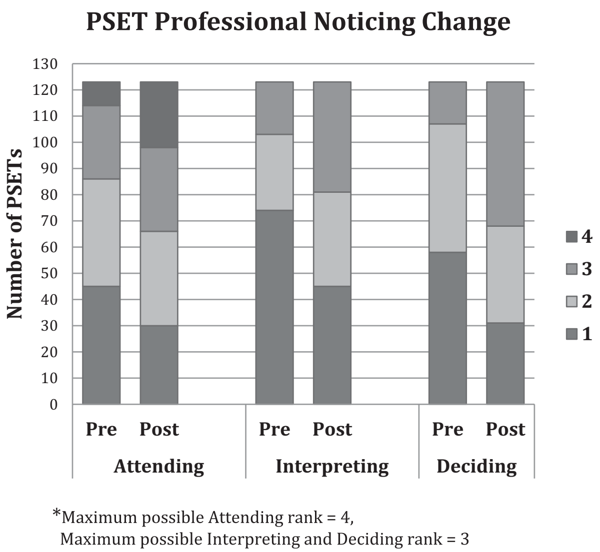
Table 4 Spearman's rho correlations between professional noticing components on pre/post changes

			Pre/Post change	
Variable 1	Variable 2	*N*	Spearman	*p*-value
Change in attending	Change in deciding	123	0.134	0.139
Change in attending	Change in interpreting	123	0.146	0.108
Change in deciding	Change in interpreting	123	0.124	0.173

Table 5 Results of Wilcoxon signed-rank tests on professional noticing components from pre- to post-assessment

	Scale	*N*	*z*	*p*-value
Attending	1–4	123	−3.466	<0.001
Interpreting	1–3	123	−3.841	<0.001
Deciding	1–3	123	−5.378	<0.001

Fig. 3 Number of PSETs scoring each rank (by component) at pre- and post-assessment



enlightens this result. Figure 3 illustrates the relative changes in the number of PSETs scoring each rank on pre- and post-assessment for each professional noticing component. On the pre-assessment, PSETs' attending scores were spread fairly evenly across ranks of 1, 2, and 3 or greater, while their pre-assessment scores in interpreting and deciding tended to cluster in the lowest rank of 1, resulting in a lack of correlations among components but greater room for growth in interpreting and deciding. Growth in these two components, particularly deciding, was greater than attending, resulting in a lack of correlation among components on growth. The encouraging outcome is on the post-assessment, where the spread across ranks was more similar on all three components (Fig. 3), especially when comparing attending and deciding, resulting in significant correlations among components. One might interpret this to mean that many PSETs enter methods with an ability to observe the details of children's mathematics, but with less skill in interpreting and deciding. This is consistent with Jacobs et al.'s (2010) conclusion that learning to professionally notice requires deliberate professional development in each of the components of professional noticing. Furthermore, the ability to attend to children's mathematics that many PSETs bring to a methods course lends support to the perspective of Ambrose (2004) and Jong and Hodges (2011) to take an asset-based approach to PSET education, building upon their view of teachers as nurturers of children.

Correlation Between Professional Noticing Assessment and Attitudes Toward Mathematics Inventory (ATMI)

Spearman's rho correlations were employed to examine the correlation between the change in professional noticing and the change in attitudes toward mathematics. For reasons described earlier, the individual components of professional noticing and the factors of ATMI were analyzed for significant growth. While significant PSET growth was found in all three professional noticing components and in three of four factors of the ATMI, there was no statistically significant correlation between changes in professional noticing and changes in attitudes toward mathematics at the component/factor level or when overall scores of both professional noticing and ATMI were analyzed ($r_s = -0.020$, $p = 0.828$). The results of the correlation of changes in each professional noticing component and ATMI factor are found in Table 6.

Discussion and Implications

In this study, we hypothesized that developing PSETs' professional noticing skills in the context of children's early numeracy would relate to the improvement of PSETs' attitudes toward mathematics. Our hypothesis included the expectation that viewing children doing mathematics might capitalize on an oft-reported reason PSETs give for entering the teaching profession—their view of teachers as nurturers of children

Table 6 Spearman's rho correlations between changes in professional noticing components and attitudes factors

		Change in value	Change in enjoyment	Change in self-confidence	Change in motivation
Change in attending	Correlation coefficient	0.127	0.045	0.136	−0.009
	p-value	0.163	0.621	0.134	0.924
Change in interpreting	Correlation coefficient	−0.151	−0.081	−0.127	−0.052
	p-value	0.097	0.376	0.161	0.566
Change in deciding	Correlation coefficient	0.023	0.102	0.033	0.091
	p-value	0.799	0.261	0.715	0.316

(Ambrose 2004)—by motivating them to think mathematically themselves in order to better assist children in learning mathematics. Furthermore, the context of SEAL provides details of the common progression of early numeracy and children's mathematics (Steffe 2013), encouraging PSETs to see mathematics through the lens of a child, focusing on what children can do conceptually rather than on the procedures of mathematics that children cannot yet do, procedures that characterize what many PSETs believe mathematics to be. Our intention of this research is to push PSETs beyond their adult-level "first-order mathematical knowledge," as described by Steffe (2013), and to better understand the "second-order" knowledge, also known as the "mathematics of children." It is "frequently necessary to construct new ways of thinking mathematically to make adequate interpretations" (Steffe 2013, p. 368). By enhancing PSETs' understanding of children's mathematical thinking, they can, in turn, increase their own understanding of mathematics by constructing new ways of thinking, both pedagogically and mathematically, leading to greater self-confidence and, in general, more positive attitudes toward mathematics, and can contribute to closing the gap between research and practice.

The significant increase by PSETs in this study on three of the four factors of the ATMI (enjoyment, self-confidence, and motivation), and in the fourth factor (value) when maximum possible pre-scores are removed, is encouraging. This finding revealed the possibility that components of PSETs' attitudes can improve when experiencing a course where professional noticing skills are explicitly taught, modeled, and reinforced. Building on Wilkins' (2008) finding that positive attitudes toward mathematics resulted in beliefs aligned with reform-oriented practices, the positive shift of PSETs' attitudes in this study has the potential to result in the PSETs' adopting more reform-oriented instructional practices in mathematics. We are cautious with this claim as attitudes have many influences, including parents, peers, and past teachers (Tapia and Marsh 2004).

While we are encouraged by the growth in both professional noticing skills and in attitudes toward mathematics, the lack of correlation between the two presents the question as to why. There are several possible reasons why the lack of correlation occurs in this study. We will address two of these possible reasons. One possible reason for this lack of correlation could be due to the unmatched ordinal and interval scales of the professional noticing and ATMI assessments. The strength to draw more conclusions from parametric tests was not possible, with the professional noticing data scored as ordinal data and the ATMI measure calculated as interval data. Thus, the correlations had to be computed using a more simplistic nonparametric measure. At this time, other research studies that attempt to correlate attitudes about mathematics with professional noticing skills do not exist; thus, there is no prior literature with which to compare these results.

Another possible reason for a lack of correlation relates to the nature of the ATMI instrument. The ATMI primarily focuses on attitudes toward mathematics as a discipline, rather than attitudes toward teaching and learning mathematics, which could very well be more closely connected to gaining pedagogical skills, such as professional noticing. Further investigation on the lack of correlation between changes in attitudes and changes in professional noticing will be conducted in future studies to better understand this result, and we hypothesize that future use of the Mathematics Experiences and Conceptions Surveys (MECS), developed by Hodges and Jong (2012), to measure attitudes, beliefs, and dispositions will more closely correlate with attitudes toward teaching and learning of mathematics and not primarily on attitudes toward the discipline of mathematics.

Next Steps

PSETs experience a plethora of mathematical experiences throughout the duration of a methods semester, including field placements, in-class experiences, and other educational activities. The variety of influences makes it difficult to directly attribute PSETs' attitude change solely to their participation in the professional noticing instructional module. Nonetheless, PSET attitudes did improve, and a look at the results of the factors of the ATMI in this context is encouraging. Most notable is that more than 50 % of the PSETs increased in all four factors from pre- to post-assessment. The largest increase, 65 %, was exhibited in the self-confidence factor. We are hopeful that the increase in self-confidence is built upon an increase in Mathematical Knowledge for Teaching (MKT) (Hill and Ball 2004). The researchers have collected data on MKT (via the Learning Mathematics for Teaching Assessment) that will be examined independently and in relation to PSET changes in attitudes toward mathematics, as well as in relation to changes in professional noticing. More broadly, inquiries into the relationships among teaching practices (e.g., professional noticing), knowledge (e.g., MKT), and attitudes have the potential to shed increasing light on the mechanisms of change in each of these areas.

It is also interesting to note that 15 of the 123 PSETs entered the study with the highest possible rating on value of mathematics, indicating that at least some PSETs come to their teacher education courses valuing mathematics, despite the frequently reported fragile mathematical understanding harbored by PSETs (Ball

1990; Foss and Kleinsasser 1996; Quinn 1997). For those PSETs who already value mathematics, additional investigation of the processes by which these individuals developed such attitudes could aid in the refinement of the professional noticing module. Indeed, if one of the aims of the module is to positively affect PSETs' attitudes toward mathematics, a greater understanding of such change *with respect to our local contexts,* such as prerequisite courses, field placement requirements, and previous student experiences in education, holds the potential for increasing the effectiveness of the PSET learning experience.

Finally, the examination by quartile indicated that a large percentage of the PSETs scoring within the lowest quartile increased in all four attitudes toward mathematics factors. There seems to be a positive influence on these PSETs' attitudes toward mathematics in the methods and blended methods courses of this project, despite the lack of significant correlation to change in PSETs' professional noticing capacities. It is likely that incorporating a mid-semester measure of attitudes immediately following the professional noticing module would further illuminate the impact of the module on PSET attitudes. The data indicate that attitudinal growth is somewhat decoupled from growth in professional noticing capacities. However, a mid-semester measure may indicate a significant attitudinal growth linked to experiences within the professional noticing module.

Our primary research focus of PSET professional noticing has yielded positive results (Fisher et al. 2012; Schack et al. 2013). Collecting comparison data with similar groups of PSETs in their mathematics methods courses, where the professional noticing instructional module was not implemented, would help provide a picture of the effectiveness of the module (with respect to attitudinal change) in comparison with other teacher education activities. This could aid in determining whether other influences contributed to the growth in both professional noticing skills and attitudes toward mathematics.

Conclusion

We remain optimistic that professional noticing (i.e., attending, interpreting, deciding) is a *teachable* skill (Schack et al. 2013) and that research refinements can lead to more robust conclusions regarding the relationship between professional noticing and attitudes toward mathematics. Given the highly complex nature of both professional noticing and attitudes toward mathematics, it is, perhaps, expected that initial attempts to determine a relationship have proven elusive; however, there is much cause to continue such lines of inquiry. Returning to the notion that productive attitudes toward mathematics are crucial for the development of effective teaching practice, a firm understanding of mechanisms that promote such attitudinal change in conjunction with responsive teaching practices is essential.

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