

Anxiety towards Teaching Mathematics and Science: Correlation, Prevalence, and Intensity

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This study sought to examine the correlation, prevalence, and intensity of preservice elementary teachers' anxiety towards teaching mathematics (ATTM) and anxiety towards teaching science (ATTS). In Experiment 1, 42 participants, most of whom were female, Caucasian, and in their 20s, completed Anxiety Towards Teaching Mathematics and Science Questionnaire. In Experiment 2, 29 similar participants were interviewed about the reasons for ATTM and ATTS, the intensity of anxiety as perceived by themselves, and the importance of not transferring anxiety to their own students. It was found that there is a strong correlation between participants' ATTM and ATTS, that a majority of them have ATTM or ATTS, and that their anxieties are rather intense. Moreover, participants are the most anxious about content knowledge and conceptual understanding and the least anxious about class activities and state standards. It is suggested that preservice elementary teachers' ATTM or ATTS be handled before their teaching career starts so that they will be able to teach all the basic subject areas equally well.

Keywords: anxiety towards teaching mathematics, anxiety towards teaching science, ATTM, ATTS, preservice elementary teachers.

Mathematics and science have been known to trouble many students. The title of an article, "I hate math! I couldn't learn it, and I can't teach it!" (Cornell, 1999), in *Childhood Education* offers a vivid glimpse of this problem. For the past several decades, researchers have tried to correlate students' feelings with their ability to understand these subjects, and the traits characteristic of adverse and negative feelings towards them have come to be referred to as mathematics anxiety (Tobias, 1978) and science anxiety (Mallow, 1978), respectively. More recently, there has been a renewed interest in these traits as researchers attempt to formulate theoretical models to explain the relationship between such anxieties and other variables and related issues (Hembree, 1990; Ma, 1999; Mallow, 2006; Udo, Ramsey, & Mallow, 2004). In addition, researchers have made observations on the physiology of sufferers of such anxieties. One researcher specified that the sufferer "has sweaty palms, is nauseous, has heart palpitations, and experiences paralysis of thought" (Krantz, 1999, p. 1).

But the importance of addressing mathematics anxiety and science anxiety has not been properly recognized. It has been reported that pre- and inservice elementary teachers have a high level of anxiety (Austin, Wadlington, & Bitner, 2001; Gresham, 2007; Udo et al., 2004). Moreover, mathematics or science anxious teachers can unwittingly transmit their anxieties to the student, thus perpetuating this process generation after generation (Bursal & Paznokas, 2006; Mallow et al., 2010; Udo, Ramsey, Reynolds-Alpert, & Mallow, 2001; Udo et al., 2004).

Generally, it is agreed that mathematics anxiety and science anxiety are common among students of all levels, directly affecting their learning of and achievement in mathematics and science (Mallow, 1994; Martinez & Martinez, 1996). Anxieties almost inevitably lead to avoidance, resulting in decreases of enrollment in mathematics and science classes at the university level (Hembree, 1990; Mallow et al., 2010; Udo et al., 2004). Such avoidance ultimately affects one's career choices and professional opportunities (Mallow, 2006; Trujillo & Hadfield, 1999). Furthermore, mathematics anxiety and science anxiety seem to affect females more than they affect males (Hembree, 1990; Mallow et al., 2010; Udo et al., 2001; Udo et al., 2004). Moreover, these anxieties know no cultural bounds and are an international phenomenon. Participants from studies cited in this article covered many countries such as Australia, Canada, China, Denmark, Egypt, Israel, Kuwait, New Zealand, Taiwan, and the United States, to name just a few.

For mathematics anxiety, much attention has been paid to its causes and relationship with other mediating factors. Ma (1999) found a significant, negative correlation between anxiety and achievement in mathematics in a meta-analysis of 26 studies. Uusimaki and Nason (2004) classified causes of mathematics anxiety into three categories: (a) environmental, such as negative experiences in the classroom, parental pressure, and mathematics taught as rote memorization; (b) intellectual, such as mathematics taught with mismatched learning styles, lack of confidence in mathematical ability, and lack of perceived usefulness of mathematics; and (c) personality factors, such as shyness, low self-esteem and, for females, viewing mathematics as a male domain. In addition to the relationship among mathematics anxiety, gender, and grade level (see Hembree, 1990), researchers have examined other factors as well. Mathematics anxiety was found to correlate with tactile-kinesthetic and auditory learners (Onwuegbuzie, 1998). Sloan, Daane and Giesen (2002) found a low but significant correlation between mathematics anxiety and learning styles. Recently, Beilock, Gunderson, Ramirez, and Levine (2010) found that female elementary school teachers who are mathematics anxious have a particularly negative impact on girls' mathematics achievement.

Although the scope of studies on science anxiety is generally narrower than that on mathematics anxiety, from what is available in the literature, one can see many similarities between the two. Both are acquired traits, starting to appear as early as age nine or fourth grade (Chiarelott & Czerniak, 1987; Renga

& Dalla, 1993), and both are contagious, meaning that they can be transmitted to others (Austin et al., 2001; Udo et al., 2004). In both cases, unpleasant past experience in mathematics or science classes and exposure to teachers with mathematics or science anxiety are often cited as causes (Trujillo & Hadfield, 1999; Udo et al., 2004). For teachers with mathematics or science anxiety, lack of training in mathematics or science is often regarded as one of the reasons for developing their anxiety (Udo et al., 2004). Besides, both anxieties can be alleviated using a variety of techniques, such as resorting to mathematics or science anxiety reduction clinics or using components built into teacher education methods courses (Author, 2008; Foss & Hadfield, 1993; Levine, 1996; Vinson, 2001).

To measure mathematics anxiety and science anxiety, researchers, in their earliest effort, developed two instruments, the Mathematics Anxiety Rating Scale (Richardson & Suinn, 1972), and the Science Anxiety Questionnaire (Alvaro, 1978), respectively. These instruments grew very popular and would be frequently used in later years.

In another perspective, mathematics anxiety and science anxiety have been found to correlate with self-efficacy or teacher efficacy. Self-efficacy was described by Bandura (1986) as one's belief in his or her capabilities to execute a behavior successfully. Mathematics or science anxious preservice teachers may possess low self-efficacy or low teacher efficacy affecting their teaching in these subjects (Bates, Latham, & Kim, 2011, Gresham, 2008; Swars, Daane, & Giesen, 2006).

Despite the fruitfulness of the past research on mathematics and science anxiety, two important issues remain unclear. First, studies on mathematics anxiety and those on science anxiety have been conducted essentially separately, and we practically know nothing about the correlation between the two traits. This issue seems to be even more outstanding with regard to the alliance between mathematics and science (Louis & Mistele, 2012) and to the observation that anxiety in one subject area can easily be associated with that in the other (Bursal & Paznokas, 2006; Lewis, Alacaci, O'Brien, & Jiang, 2002; Tosun, 2000).

The second issue concerns anxiety associated with pre- and inservice elementary school teachers. Many authors have mentioned that mathematics anxiety and science anxiety are prevalent among such teachers and that their anxiety level is high (Harper & Daane, 1998; Hembree, 1990; Malinsky, Ross, Pannells, & McJunkin, 2006; Udo et al, 2004). This is legitimate cause for concern because teachers with mathematics anxiety or science anxiety can unwittingly transmit their anxieties to their students, thus perpetuating this vicious cycle. As preservice elementary teachers have not started teaching yet, what is manifest in inservice teachers as mathematics anxiety and science anxiety is actually anxiety towards teaching mathematics (ATTM) and anxiety towards teaching science (ATTS), respectively, for preservice teachers. Just as we know little about the correlation between mathematics anxiety and science

anxiety, neither do we know much about the correlation between ATTM and ATTS. A good understanding of the relationship between these two traits can help preservice elementary teachers, during their teacher training program, fight their anxiety and become confident teachers and also help inservice elementary teachers break the cycle of transmitting their anxieties to the student.

This study was driven by speculations of these issues. Specifically, it was designed to answer the following research questions:

1. What is the correlation between ATTM and ATTS among preservice elementary teachers?
2. How prevalent are ATTM and ATTS among preservice elementary teachers?
3. For those preservice elementary teachers identified as having ATTM or ATTS, how intense are their anxieties?
4. What do those preservice elementary teachers identified as having ATTM or ATTS worry about the most? What do they worry about the least?

Research questions 1 – 3 were to be addressed in Experiment 1 with the use of a questionnaire. Research question 4 was to be addressed in Experiment 2 with interviews.

Experiment 1

Method

Participants. Participating in this experiment were 42 preservice elementary teachers at a mid-western US university. As common requirements for all education majors, they had taken two years of general education classes before entering their teacher education program. During their training in the general education program, participants had to take, among other courses, a basic skills mathematics class, a statistics class, a life science class, and a natural science class of either geology or biology.

As part of their program requirement, all participants had to observe 10 hours in a designated elementary school classroom during their first core semester and teach a minimum of nine lessons for each of the next two semesters. At the end of their program training, they would be licensed to teach K – 6 mathematics, science, language arts, and social studies.

This experiment occurred during the participants' third core semester when they were taking Elementary Mathematics Methods and Elementary Language Arts Methods, with this author being their instructor of the former course. Participants met two times a week for the first 10 weeks of the semester for their course work before they would do their 5-week pre-student teaching practicum. It was at the end of their course work that they participated in this experiment. Six others did not participate. The majority of the participants were female, Caucasian, and in their 20s (mean age = 28.5 years, $SD = 10.0$. See Table 1).

Table 1
Participants' Demographic Data

Category	Experiment 1 (<i>n</i> = 42)		Experiment 2 (<i>n</i> = 29)	
	<i>f</i>	%	<i>f</i>	%
Age Group				
21-25	26	61.9	18	62.1
31-35	5	11.9	3	10.3
36-40	2	4.8	2	6.9
41-62	6	14.3	2	6.9
Gender				
Female	39	92.9	28	96.6
Male	3	7.1	1	3.4
Ethnicity				
Caucasian	39	92.9	28	96.6
Other	3	7.1	1	3.4

Instrument and procedure. An Anxiety Towards Teaching Mathematics and Science Questionnaire was developed for this study. First, items from Author's (2008) Anxiety Towards Teaching Mathematics Questionnaire were consulted, with the sentence structure "I will worry about..." decided on for each item in the new questionnaire. Then items concerning ATTM were created under five constructs: content knowledge, class activities, conceptual understanding, perceptions of one's teaching mathematics, and state or district requirements, with each construct consisting of three or four items. These constructs were mostly derived from National Council of Teachers of Mathematics (2000) and National Research Council (1996). Then, the word *mathematics* in each item was changed into *science*, transforming into a corresponding section about ATTS. Four additional items were composed centering on specific characteristics of teaching mathematics such as problem solving and logical reasoning, referred to as mathematics-specific items. A science instructor from another institution was consulted, who composed four science-specific items on such issues as designing a scientific experiment and the scientific method.

To ensure the content validity of the instrument, this author conducted an expert review. Five persons were invited: a mathematics education professor and a mathematics professor from the same institution as this author's, two elementary mathematics and science teaching specialists from the area school district, and the science instructor who composed the science-specific items. The mathematics education professors and the two mathematics and science teaching specialists had extensive experiences teaching or working at the elementary school level. The five experts were asked to add or delete any items where appropriate and suggest any changes needed. No deletions were made, but addition of a few items was suggested to make the number of items under each construct uniform. The final questionnaire was composed of a

mathematics section and a science section, with each section consisting of 20 common items and 4 content-specific items (see Appendix).

The order of the 24 items for each of the two sections was randomized to avoid possible systematic effects. Then two versions were created. One version had the mathematics section first followed by the science section whereas the order for the other version was reversed, again for avoiding systematic effects. Participants from each class were randomly divided into two groups of about the same size, with one group taking the mathematics-science version and the other taking the science-mathematics version. Five choices were provided for each item, ranging from 1 through 5 (*strongly disagree*, *disagree*, *neutral*, *agree*, and *strongly agree*), with higher scores indicating higher levels of anxiety.

Criterion for identifying participants with and measuring the intensity of ATTM and ATTS. To identify participants with ATTM or ATTS, a criterion used by Udo et al. (2004) was adopted but with modifications. In Udo et al.'s study, anyone was categorized as having "acute science anxiety" who gave one or more responses of "much" or "very much" to the 22 science anxiety-causing scenarios, based on the general direction of describing how much a participant was frightened by such a scenario. For the current study, participants with any number of response of 4s (*agree*) were classified as having moderate ATTM or moderate ATTS. Of all participants identified as having moderate ATTM or moderate ATTS, those with any number of response of 5s (*strongly agree*) were classified as having acute ATTM or acute ATTS. The intensity of ATTM or ATTS was gauged by the number of items a participant with ATTM or ATTS felt anxious about. The larger the number, the more areas described in the questionnaire the participant felt anxious about, and hence the more intense their anxiety. The rationale for this classification was for a more sensitive description of a participant's anxiety level.

To measure the internal reliability of the instrument, a histogram for the distribution of the mathematics and science data set was generated. Except for one bar at the low end of the ATTS graph being high instead of tapering off, the distribution of the data set appeared normal. Thus, Cronbach's *alpha* was conducted on the data by construct. The coefficient *alpha* indices for content knowledge, class activities, conceptual understanding, perceptions of one's teaching mathematics, state or district requirements, and mathematics-specific items for the mathematics section were 0.91, 0.87, 0.93, 0.91, 0.46, and 0.84, respectively, and those for the corresponding constructs of the science section were 0.87, 0.85, 0.88, 0.84, 0.83, and 0.87, respectively. The majority of these indices indicated a high estimated internal reliability.

For each participant, all responses in the two sections were averaged into a mean overall ATTM score and a mean overall ATTS score, respectively. Furthermore, participants' responses were partitioned into a mean subscore for each construct, for the two sections. A scatterplot depicting the correlation between ATTM and ATTS, in their overall measures, revealed a highly

consistent association in all but three participants. While the high correlation between ATTM and ATTS shouldn't come as a surprise given the alliance between mathematics and science (Louis & Mistele, 2012), there was still sufficient distinction between the two traits, as evidenced by the three participants, all being female, who showed a very high level of ATTM and at the same time a very low level of ATTS. These three outliers were removed from further analyses for statistical reasons.

Results and Discussion

To address research question 1 concerning the correlation between ATTM and ATTS among preservice elementary teachers, a Pearson's product-moment correlation was conducted on the mean overall scores of ATTM and ATTS. It was found to be statistically significant, $r(38) = .81, p = .000$, indicating that there is a strong, positive correlation between these two variables. Such a relationship suggests that preservice elementary teachers who are anxious about teaching mathematics are also anxious about teaching science. A close look at the mean subscores for each construct revealed a striking pattern: The rank of the mean subscores for the six ATTM constructs was the same with that of the mean subscores for the six ATTS constructs. Ordered from highest to lowest, they were: content knowledge, conceptual understanding, perceptions of one's teaching, section specific, district requirements, and class activities. Because of this similarity, a separate Pearson's product-moment correlation coefficient was calculated for each pair of constructs between the two types of anxieties. Each correlation was found to be statistically significant. Table 2 presents the mean subscores of ATTM and ATTS for each construct as well as for the overall mean score and their corresponding correlation coefficients.

Table 2
Means, Standard Deviations, and Correlation Coefficients for Mean Scores of Constructs of ATTM and ATTS in Experiment 1

Construct (n = 42)	ATTM		ATTS		
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>r</i>
Content knowledge	2.92	1.04	2.90	0.98	.67*
Conceptual understanding	2.81	1.02	2.86	0.98	.79*
Perceptions of teaching	2.79	0.95	2.61	0.91	.75*
Section specific	2.76	0.93	2.58	0.93	.76*
District requirements	2.76	0.69	2.55	0.83	.68*
Class activities	2.39	0.82	2.48	0.85	.81*
Overall	2.74	0.80	2.66	0.84	.81*

Note. ATTM = anxiety towards teaching mathematics; ATTS = anxiety towards teaching science.

* $p < .01$.

To address research question 2 regarding the prevalence of ATTM and ATTS among preservice elementary teachers, participants' responses indicative of their anxiety were tabulated. ATTM and ATTS were found to be prevalent among preservice elementary teachers. A startling majority had moderate ATTM (85.7%) and moderate ATTS (76.2%), and some of them displayed acute ATTM and acute ATTS. Except for one case, those displaying acute forms of anxiety were among the ones displaying moderate forms of anxiety, resulting in the frequency at the combined level roughly the same as that at the moderate anxiety level. The frequencies and percentages at different levels of ATTM and ATTS are shown in Table 3.

Table 3
Frequencies and Percentages of Participants with ATTM and ATTS by Level of Anxiety in Experiment 1 (n = 42)

Level of Anxiety	ATTM		ATTS	
	<i>f</i>	%	<i>f</i>	%
Moderate	36	85.7	32	76.2
Acute	13	31.0	8	19.0
Combined	37	88.1	32	76.2

Note. ATTM = anxiety towards teaching mathematics; ATTS = anxiety towards teaching science.

To address research question 3 regarding the intensity of ATTM and ATTS among preservice elementary teachers, the combined responses of moderate and acute ATTM and ATTS from those participants who made such responses were tabulated. Results indicate that on average, a participant felt anxious about over one third of either set of the 24 ATTM items ($M = 8.6$, $SD = 6.3$) or the set of 24 ATTS items ($M = 8.1$, $SD = 5.6$), suggesting that for those preservice elementary teachers identified as having ATTM or ATTS, their anxieties are rather intense.

To gain insight into what preservice elementary teachers are the most and the least anxious about, all items from the questionnaire were rank ordered, for each section, by the percentage of combined form of anxiety (response of 4s and 5s). It is interesting to note that two of the four highest (items 3 and 19) and two of the four lowest (items 5 and 7) percentages were the same for both the mathematics and science sections (see Table 4). Half of the items that generated the highest level of anxiety concerned content knowledge and conceptual understanding. Even though it is natural that preservice teachers will worry about teaching lessons that they do not know well enough, still it is doubtful that they would worry as much if the subjects were other than mathematics or science. In contrast, items concerning class activities and state/district requirements generated the lowest anxiety.

Table 4

Items That Generated the Highest and Lowest Percentages of Anxious Responses in Experiment 1 (4s and 5s Combined, in Descending Order)

(n = 42)		Highest		Lowest	
Item*	("I will worry about...")	%	Item*	("I will worry about...")	%
Mathematics					
3.	teaching lessons I don't know well	61.9	18.	following sequencing guide	21.4
19.	finishing content within time	54.7	17.	meeting state standards	16.7
4.	making mistakes	42.9	7.	modifying activities	14.3
16.	giving wrong answers	40.5	5.	choosing appropriate activities	7.2
Science					
3.	teaching lessons I don't know well	52.4	23.	teaching inquiries	11.9
19.	finishing content within time	42.8	7.	modifying activities	11.9
10.	identifying misconceptions	38.1	20.	teaching sci. more than other subj.	9.5
22.	understanding newest discoveries	38.1	5.	choosing appropriate activities	7.2

Note: The wording has been simplified. See Appendix for original items.

Experiment 2

Experiment 1 provided some intuitive results concerning the correlation, prevalence, and intensity of ATTM and ATTS. Yet, a few issues had yet to be further probed, particularly those that are unlikely to be captured in quantitative analysis. This concern was addressed in Experiment 2, which was conducted in the form of semistructured interviews designed to implement an in-depth exploration of such issues as reasons for ATTM and ATTS, the intensity of anxiety as perceived by participants themselves, and the importance of not transferring anxiety to their own students. .

Method

Participants. As Experiment 1 was conducted at the end of the participants' course work and access to them soon became unlikely, new participants were recruited for Experiment 2. Participants in Experiment 2 were 29 preservice elementary teachers taking a required course, offered during the summer, from the same university as described in Experiment 1. In many ways they had similar characteristics to those participating in that experiment, with the majority being female, Caucasian, and in their 20s (mean age = 26.5 years, $SD = 7.4$). See Table 1).

The summer course these participants were taking was Mathematical Investigations, a prerequisite course for their mathematics methods later in the program. They met for about 2 hours on every weekday for three consecutive weeks. Extra credit equivalent to one assignment grade was offered for participation. One person did not participate.

Interview protocol, procedure, and analysis. Five questions were constructed for the interviews. To prevent participants from picking up cues from questions about mathematics anxiety and science anxiety and forming preconceived ideas about mathematics and science being at a different level from other school subjects, the purpose of the study was communicated as for

investigating preferences and dislikes for different subjects taught at elementary schools. This would also allow those who would not worry about teaching mathematics or science a chance to express their opinions. The mention of *mathematics anxiety* and *science anxiety* was not made until after questions about their general dislikes and preferences were asked (see below), although for better organization the discussion of the correlation was presented first.

The first two questioned concerned participants' general feelings over the core subject areas. Questions 1 stated, "When you start teaching as an elementary school teacher, out of the four basic subject areas of language arts, mathematics, science, and social studies, which one do you feel you will worry about teaching the most? Why do you feel that way?" Question 2 approached the issue from the opposite direction, with the words *prefer* used in place of *worry about*. Question 3 focused on the correlation between mathematics anxiety and ATTM and between science anxiety and ATTS, respectively. It stated, "Some people suffer from what researchers refer to as mathematics anxiety. If a preservice elementary teacher suffers from mathematics anxiety, do you think he or she will tend to worry about teaching mathematics as well? Why do you think that way? Similarly...[the science counterpart is omitted here]." Question 4 involved participants' own mathematics anxiety: "Do you have mathematics anxiety? If you do, how intense is your anxiety?" Question 5 was worded similarly for science anxiety.

Participants were randomly divided into three groups of about the same size, and each group was interviewed separately in a conference room on campus, with the author conducting each interview session. The author's assistant and two others transcribed the recorded interviews. Then Atlas.ti was used to aid in the analysis.

Results and Discussion

Correlation of mathematics anxiety and science anxiety with ATTM and ATTS. Generally, many participants regarded mathematics anxiety and science anxiety as closely correlated with ATTM and ATTS, respectively. One participant said without a doubt, "I definitely think there is a connection between anxiety and discouragement of teaching it because there'll be questions from children and you don't want to answer them incorrectly. You want to have a high confidence in whatever you're teaching." Another participant described her disposition when teaching mathematics: "I do have anxiety for math. When I'm trying to do math in front of someone or when I'm working with a kid, I do second-guess myself and I think that's going to be hard for me to overcome." Still another participant related this anxiety to the possible uncertainty displayed in teaching those subjects. She said,

I think it definitely affects the way that you approach the subject because if you are thinking that you aren't the most confident in it then you're constantly going to be like "Am I doing this right?" "Am I teaching them the right things?" "Are they going to get the correct information?"

This comment found support in another participant, who said, "If it's your weakest subject, you're going to have anxiety of teaching it, because if you aren't as interested you aren't going to study it as much or want to learn as much about it to extend your knowledge." Perhaps the comment from yet another participant summed it all: "Anxieties will harm your abilities in all those areas."

Reasons for ATTM and ATTS. The reasons that participants would worry about their future teaching of mathematics and science were generally expressed in three categories: personal feelings, content material, and their own teachers' lack of understanding. Typically, the few male participants were not among those expressly describing their ATTM and ATTS and the reasons for them.

Some participants were straightforward about their adverse feelings towards these subjects. "I hated science growing up so it's going to be hard to want to teach it," one participant said. Another agreed, "Science is the one I'm not so excited about teaching since it's a subject I've never liked and I don't have a very strong background in it." Such a feeling was echoed by yet another participant who said that mathematics was her weakest subject. "I don't find it as interesting as everything else," she said.

When it came to specifics related with content material, several components, notably formulas, multiple ways of solving the same mathematics problem, and the interconnections within a subject were often cited as reasons for worrying about teaching these subjects. One participant said, "I don't remember formulas [well] and I have a hard time remembering what is supposed to go where." Another participant said, "I worry most about teaching math, because when kids don't get it I have a hard time of coming up with a different way of explaining it." Still another participant expressed this mindset: "I think [science] can be a fun subject for kids but I have a hard time drawing the connections for the littler kids for science. It just seems so complicated to me."

The importance of having a competent mathematics or science teacher was frequently brought up by some participants. One said, "I'd worry about math because if you have a bad teacher at a really critically time it can ruin it for a kid. I'd hate to be that teacher because I had that one when I was a kid." This comment found echo in another participant, who shared her experience about middle school science: "I didn't have much science background in my schools, and I just really didn't feel like my middle school teachers knew what they were doing at all." Still another participant offered a similar experience: "I think that it would be hard for me to teach an older grade fractions and stuff when I'm still trying... I don't know, because some of my math teachers weren't very consistent with how they taught in school."

Importance of not transferring anxiety to students. Earlier in this article it was mentioned that mathematics anxiety and science anxiety are contagious and can be easily transmitted from teachers to their students. This

theme actually surfaced during the interviews. Quite a few participants stressed the importance of not passing anxiety to their students. One participant said,

The No. 1 thing to remember is that kids will pick up on any anxiety or any kind of lack of confidence in a teacher and that's going to put your kids at a disadvantage for that particular subject. If you don't act like you enjoy it or you don't know what you need to know about that subject, you're not going to give your kids the best that they need for that subject.

Another participant provided support for the above comment: "If you do have fears about math you have to make sure that that doesn't spill over into your classroom. You just have to kind of watch that." Still another participant agreed, saying, "I think that as teachers we have to be good actors to not give the students our anxiety because it's so easily transferable."

Anxiety towards a subject considered as anxiety towards teaching in general. It is interesting to note that even though participants were not asked about their opinions on any possible relationship between anxiety towards mathematics or science and anxiety towards teaching in general, this thesis was repeatedly touched upon. Several participants foresaw their first year of teaching as anxiety-provoking. One of them commented, "I think no matter what, we're all going to be stressed out the first year teaching any [subject], no matter if we have anxiety or not. I just think it's how you overcome and get better at teaching those [subjects]."

Another participant agreed and followed up with this comment:

You try to overcompensate [for the fact that you don't have confidence in the subject] enough that you try to make sure you know the information, so you're stressing yourself out trying to make those lesson plans and plan for those questions and in the end you can't. I mean for first and second graders you never know what kind of questions you're going to get from them, so trying to overcompensate for that could be hard and stressful on us too.

Still another participant showed some optimism that would follow after the first few years:

I feel like at first you might feel a little bit like, you know, scared about teaching it or anxiety about teaching it, but once you get the hang of it after a couple of years, like the second, third, or fourth year teaching, you're going to feel more comfortable and maybe not have that anxiety anymore. And that will help your teaching styles as well.

Intensity of anxiety as perceived by participants themselves. At the question of whether any participant had mathematics anxiety or science anxiety and how intense it was, quite a few participants not only bluntly admitted that they had it, but also revealed that it was intense. One participant said, "I had *terrible* math anxiety so I just don't like math at all...I don't get it. You know, it just never...I just don't get the depths of math and I just never will." Another participant used a similar word, *extreme*, in describing her anxiety: "I have extreme math anxiety. I always have...I never got taught fractions in school."

Still another participant gave a little more detail about how her anxiety towards mathematics had developed. She said,

I do [have anxiety], big time, because I've just always struggled with math and when I was younger I remember my teachers more or less like moving on with the class because they understood it and I didn't and I wasn't one of those ones that would raise my hand and was like "oh, I don't understand" and hold everybody else behind.

Interestingly, when it came to science anxiety, it was not as much about science content as about dealing with equipment, supplies, and so on. One participant said, "Yes and very intense. I'm very clumsy and it can be broken or completely messed up...especially with hands-on activities. I've been in situations where...I've completely screwed up a lab." For another participant, bugs were what caused her anxiety:

I think the only thing that might be an anxiety thing for me is I keep having issues with bugs and I'm afraid one of my students is going to bring me a spider or something and I'm going to run screaming and yelling.

Also, a few participants actually treated science anxiety and mathematics anxiety as being one thing and made a connection between the two. As one participant put it, "My science anxiety stems from the math part." Another participant said,

I don't really have science anxiety because to me math and science are kind of interlinked. There is a process behind what happens in science, there is a process behind what happens in math, and you just have to learn the different processes. So I don't really get the anxiety because I see the two subjects as being almost interlinked.

Still another participant related mathematics anxiety and science anxiety to test anxiety. She commented,

I feel like a lot of both anxieties is testing, like state testing. I think that's probably what the most of math and science and all subjects is, getting the kids to be up to par on the testing, because you want them to do well and the schools drill it and like that. So that'd be like my only worry for science and math.

General Discussion

The findings concerning the first two research questions, that ATTM and ATTS are prevalent among preservice elementary teachers and that there is a strong correlation between their ATTM and ATTS, indicate that most preservice elementary teachers have anxiety towards their future teaching of mathematics and science and, moreover, if they have anxiety towards teaching one of these subjects, they will likely have anxiety towards teaching the other.

It is interesting to note that, of the four basic subject areas taught at the elementary school level, we do not hear "reading anxiety" or "social studies

anxiety." Rather, not only do we hear "mathematics anxiety" and "science anxiety" very often, but also there is a strong correlation between them. Such results suggest that before preservice elementary teachers start their teaching career, their ATTM or ATTS should be given dedicated instructional attention so that they will be able to teach all the four basic subject areas with a similar level of confidence. Naturally, this needs to occur at the time when they are going through teacher education training, but currently this topic is not covered in teacher education curriculum. Prior research has indicated that different components of teacher training programs (Author, 2008; Levine, 1996; Vinson, 2001) or teacher preparation programs in themselves (Marso & Pigge, 1998) have some effect in reducing anxiety. If so, a streamlined effort, then, could be even more effective. To begin with, a small component may be built into mathematics and science methods courses, addressing such issues as how anxiety appears, develops and gets transmitted, the conditions under which it is spread and intensified, and ways to fight it when one gets it, and so on. As ATTM and ATTS are prevalent, such an instructional component should be directed to all preservice teachers. This small component can even be further divided between the two methods courses so as not to significantly increase the load of either one of them.

That preservice elementary teachers' ATTM and ATTS are rather intense is also disturbing. Data collected from this study suggest that participants' highest level of anxiety, for both mathematics and science, resides in the constructs of content knowledge and conceptual understanding. This has important implications for teacher training programs. The mathematics and science courses required of preservice elementary teachers, in addition to addressing instructional strategies, assessment, and management, should also promote conceptual understanding in mathematics and science. This is consistent with findings by prior research demonstrating that preservice elementary teachers with a higher level of anxiety show a significantly lower level of conceptual understanding of certain mathematics topics (Rayner, Pitsolantis, & Osana, 2009).

As anxiety is contagious and often passed down from teachers to students (Austin et al., 2001; Udo et al., 2004), preservice teachers should be taught the importance of presenting a subject they are not particularly fond of as something enjoyable and not as something fearful. They should be specifically instructed how not to show off their anxiety in front of their students even if they have it. This point is best reflected in the comment a preservice elementary teacher made in a previous study (Author, 2008): "Fake it until we get it." Also, it was laudable that quite some participants were aware of their own teachers' weaknesses in their teaching. This may be a very positive step towards handling their anxieties more effectively and becoming better teachers themselves.

Lastly, the well-documented correlation between gender and mathematics and science anxiety (Hembree, 1990; Udo et al., 2004, for instance)

has important implications for teacher education because anxiety, as mentioned earlier, is contagious and can be passed from teachers to students. Furthermore, anxiety seems to interact with gender in its transmission process. Beilock et al. (2010) reported that, because children generally emulate the behavior and attitudes of same-gender adults, female elementary school teachers who are mathematics anxious negatively affects girls' mathematics achievement but not boys'. But here lies the difficulty: It is a very difficult task to investigate this gender-anxiety correlation with preservice elementary teachers, as their makeup, in most countries, is predominantly female. In the current study, for example, only 4 of 71 participants were male and would not form a reasonable sample size for looking into this correlation. Nevertheless, even though these male participants did not expressly describe their anxieties and thus were not isolated for a special examination of the gender factor, it coincided with a previous observation that men can cover up their emotions and do not reveal any weaknesses easily (Author, 2008). Future research is therefore suggested for samples in countries where there is a higher percentage of male preservice elementary teachers.

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Appendix

Anxiety Towards Teaching Mathematics and Science Questionnaire

Mathematics Section

Content Knowledge

1. I will worry about my mathematics knowledge being incomplete.
2. I will worry about not having a sound knowledge base of mathematics.
3. I will worry about having to teach a mathematics lesson that I don't know well.
4. I will worry about making mistakes while teaching mathematics.

Class Activities

5. I will worry about being able to choose appropriate mathematics activities for my students.
6. I will worry that a mathematics activity will not work.
7. I will worry about how to modify mathematics activities for my students.
8. I will worry about being able to change the difficulty level of a mathematics problem.

Conceptual Understanding

9. I will worry about my understanding of mathematical concepts.
10. I will worry about how to identify misconceptions in mathematics.
11. I will worry about how to correct misconceptions in mathematics.
12. I will worry that I don't quite understand some of the mathematical concepts that I teach.

Perceptions of One's Teaching of Mathematics

13. I will worry if someone comes to my classroom to observe a mathematics lesson.
14. I will worry about being as good as my peers in teaching mathematics lessons.
15. I will worry about being wrong when teaching mathematics.
16. I will worry about giving a wrong answer to students' questions about mathematics.

State or District Requirements

17. I will worry about meeting the state standards in mathematics.
18. I will worry about following the school district's sequencing guide in teaching mathematics.
19. I will worry about being able to finish the mathematics content within the required timeframe.
20. I will worry about teaching mathematics more than I will worry about teaching other subjects.

Mathematics-Specific

21. I will worry about teaching students how to design a mathematics problem solving procedure.
22. I will worry about understanding new theories in mathematics.
23. I will worry about teaching inquiry in mathematics.
24. I will worry about teaching logical reasoning in mathematics.

Science Section

1 – 20. (Same as above, with the word *science* used in place of *mathematics*.)

Science-Specific

21. I will worry about teaching students how to design a science experiment.
22. I will worry about understanding the newest discoveries in science.
23. I will worry about teaching inquiry in science.
24. I will worry about teaching the scientific method.

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