Pre-service elementary teachers' attitudes towards components of physical science: Do they differ from other post-secondary students?

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Abstract

An early childhood education teacher's beliefs and attitudes about science will influence how he/she teaches science and will also have an impact on his/her own self-efficacy as well as on his/her students' attitudes toward science (Christidou, 2011; Lunn, 2002; Ramey-Gassert, Shrover, & Staver, 1996). It is, therefore, important to ascertain the attitudes and beliefs of preservice teachers towards specific areas of study since their attitudes and beliefs can be carried over into their future classrooms (Van Aalderen-Smeets, Walma Van Der Molen, & Asma, 2011). The current study examines attitudes towards elements of physical science that are held by preservice elementary education students, using the Colorado Learning Attitudes about Science Survey (CLASS), and compares these to the attitudes of their peers in other fields of study. The results show that while the preservice elementary education students have significantly less favorable attitudes than students in science, technology, engineering and mathematics (STEM) fields, their attitudes are very similar to students in non-STEM fields. Although a large gender gap exists in all groups of students, because males have more favorable attitudes than females, the gender gap in the preservice elementary education students is slightly smaller than that seen in the non-STEM students. This reduction in the gender gap for the preservice elementary education students was seen because the females had slightly more favorable attitudes than their non-STEM counterparts while the males had somewhat less favorable attitudes than their non-STEM male counterparts. Additionally, it was found that female preservice elementary education students carried more favorable attitudes about the connection of physics to the real-world than did their non-STEM female counterparts, suggesting that real-world connections should be a strong component of physical science courses offered to preservice elementary education students. In addition participation in science field-based experiences throughout the teacher preparation program may serve to foster positive attitudes towards science and science teaching.

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Background

In a major effort to help fuel the science, technology, engineering, and mathematics (STEM) pipeline in the United States, schools across the country have been given the charge to increase efforts in strengthening science literacy throughout the PreK-12 curriculum (National Research Council, 1996). If we are to be successful in building science literacy in our youth, thereby strengthening the future of our STEM professions, we must search for viable means to achieve this objective. Predicting a student's success in learning depends on several variables among which are the students' interest in the subject matter, motivation or will to take action to learn the subject matter, and background knowledge, or schema, about the subject (Borman & Levine, 1997). Teachers play a critical role in each of these areas as they work to maximize learning outcomes in their students by motivating and engaging them in science (Osborne, Simon, & Collins, 2003). An exploration of the role of the teacher in promoting science among students is therefore an important step towards building science literacy in our youth.

Attitudes

Cognitive psychologist Jerome Bruner (1966) examined theories of cognitive development for curriculum innovation. Building upon the work of previous learning theorists, Bruner proposed a theory of cognitive development that emphasizes the student's active role in the learning process. In identifying the significant aspects of effective teaching and learning, Burner attributes attitudes as a primary variable.

When examining the relationship between attitudes and learning, it is important to discuss what is meant by *attitudes*. There is a difference between *scientific attitudes* and *attitudes toward science*. The former is related to how much a person thinks like a scientist: critical thinking, curiosity, logic, etc. The latter is related to how an individual feels about science: interest level, enjoyment, opinion of its importance, etc. (Van Aalderen-Smeets, et al., 2011). Attitudes toward science are related to the affective domain whereas the scientific attitudes are more in the cognitive domain.

Since early childhood experiences in science influence a person's academic interest in science later in their schooling (Neathery, 1997), elementary teachers can contribute profoundly to their students' lifelong attitudes about science. One of the many expectations placed upon most elementary teachers is that they should be able to teach science. An enthusiastic teacher using true inquiry methods will usually succeed at stimulating the students' interests in science (Cuevas, Lee, Hart, & Deaktor, 2005; Kunter, Frenzel, Nagy, Baumert, & Pekrun, 2011; Skinner & Belmont, 1993). It is thus an important task of teacher training programs to inspire teachers to enjoy science, while also supplying them with a strong science content knowledge and the pedagogical skills for teaching science.

Unfortunately, by the time they graduate high school and reach the university level, most students prefer other subjects to science. Science is often perceived as difficult and many students thus avoid it (Osborne, et al., 2003). Regrettably, the experiences of preservice elementary teachers seem to be no different than those of many other college students selecting fields of study in non-STEM areas. Tosun (2000) showed that the descriptors used by preservice elementary teachers to describe previous science classes are predominantly negative, even if they did well in those courses.

Attitudes Toward Physical Science

In addition to their attitudes about science, teachers also carry attitudes about their own desires to teach science, as well as opinions of their self-efficacy as teachers of science. There have been several studies that have shown that preservice teachers are not comfortable with the prospect of teaching science, although comfort-level varies by scientific discipline: they generally feel more comfortable about their eventual teaching of the life sciences than the physical sciences (Brigido, Bermejo, & Mellado, 2012; Murphy, Neil, & Beggs, 2007; Yates & Goodrum, 1990; Yilmaz-Tuzun, 2008). This preference of preservice teachers for prospectively teaching the life sciences over the physical sciences, is a symptom of the overall trend that there is a general dislike for the physical sciences amongst most students. It is commonly known that within the sciences, the physical sciences (chemistry and physics) are the least popular (Osborne et al., 2003).

This aversion for the physical sciences amongst students may be the reason that several studies of preservice elementary teachers have found that they have negative attitudes and lack confidence towards their potential teaching of this material (Brigido et al., 2012; Johnston & Ahtee, 2006; Tosun, 2000; Wenner, 1993; Yilmaz-Tuzun, 2008). Some suggest that this may stem from a lack of understanding of the scientific ideas or prior negative experiences in school (Ahtee & Johnston, 2006; Harlen, 1997; Johnston & Ahtee, 2006). This link between understanding and confidence in preservice teachers carries over into their teaching careers. A study of in-service teachers found that a teacher's understanding of the material is strongly linked to the teacher's confidence (Harlen & Holroyd, 1997). Additionally, they found that other factors such as gender, years since accreditation and age of pupils also play a role. Amongst these other factors, gender is critical: when the teachers in that study were given a set of science topics, the male teachers were more confident than female teachers in addressing them.

While gender is correlated to a teacher's confidence, it also correlated to a person's attitudes about science. In fact, studies have shown that the most significant factor affecting a student's attitudes about science is his or her gender: females tend to have more negative attitudes than males. In particular, there is "a substantial bias against physical sciences held by girls" (Osborne et al., 2003, p.1064). Since most preservice elementary teachers are female, physical science content area instructors in teacher training programs may face several hurdles in the form of elementary preservice teachers' negative attitudes towards this subject.

Negative attitudes toward the physical sciences are discouraging for many reasons, not least of which is that in the sciences, as in other disciplines, there is a relationship between attitude and learning. Most research shows that there is a moderate correlation between attitudes about science and abilities in science, and it is generally believed that the student's attitudes influence abilities (Osborne et al., 2003). For physics students, beliefs when they start a course influence their conceptual learning, and students with more expert-like conceptual understanding of the nature of physics have higher learning gains (Perkins, Adams, Pollock, Finkelstein, &

Wieman, 2005). For preservice teachers this relationship between attitudes and achievement can carry over from their schooling into their career as teachers. For instance, one study concluded that there are correlations between an elementary level teacher's attitudes about science and his or her self-efficacy for science teaching (Ramey-Gassert, et al., 1996). Thus, effort needs to be focused on improving the attitudes of preservice elementary teachers so that they will have better attitudes about physical science in their careers as teachers.

Physical Science

In developing the National Science Education Standards, the National Research Council (2001) divided science content into three main divisions: the life sciences, the physical sciences, and earth and space sciences. For K-4 levels, the physical science standards target three main concepts: (a) the properties of objects and materials, (b) the position and motion of objects, and (c) light, heat, electricity and magnetism (National Research Council, 2001). At the university level and in the world of higher education, the first of these concepts is frequently covered in introductory chemistry courses while the latter two are discussed in physics courses. There have been numerous physics and physical science courses designed by science faculty in attempts to better serve preservice teachers (Lilly & Sirochman, 2000; Loverude, Gonzalez, & Nanes, 2011; McDermott, Shaffer, & Constantinou, 2000; Ukens, Hein, Johnson, & Layman, 2004). Given that the physical sciences are not relished by many students, the attitudes of preservice elementary education students towards these classes needs to be addressed.

Method

Participants

All students were enrolled at the same small, liberal arts, regional public university campus. The survey was administered during the first week of class. Two hundred sixty-six students were surveyed (Table 1). Of the students surveyed, 101 were early childhood PreK-4 (elementary) education majors who were surveyed at the beginning of a physical science course for preservice teachers. The surveys were given over the course of three years to five different sections of the class.

Table 1

Student Populations Surveyed

	Preservice elementary education students	STEM majors	Non-STEM majors
Total number of students	101	91	74
Number of male students	23	63	26
Number of female students	78	28	48

In addition, 91 students enrolled in first-year regular introductory physics courses were surveyed: the surveys were given over the course of two years to two sections of the class. These students had selected fields of study in a variety of STEM (science, technology, engineering and mathematics) areas but were predominantly engineering, mathematics, and chemistry majors. They will be referred to as the STEM group, although it should be noted that they include very few biology majors, no physics majors, and few technology or computer science majors. The surveys were given to two different classes during the same semester.

Finally, 74 students enrolled in two sections, during subsequent years, of a survey natural science course designed to meet general education requirements were also surveyed. These students had selected fields of study in non-STEM areas such as communication, psychology, business and management, and they were fulfilling a general science requirement with the course. The surveys were given to two different classes during the same semester. For the purpose of this article, this group of students is denoted as the non-STEM students.

Survey Instrument

The Colorado Learning Attitudes about Science Survey (CLASS) addresses both attitudes toward science and scientific attitudes (Adams, Perkins, Dubson, Finkelstein, & Wieman, 2005; Adams et al., 2006). The survey contains 42 statements that probe an individual's interest level, problem solving erudition, and conceptual understanding about the nature of physics (see Appendix). A respondent's answers are deemed favorable if they correspond to the answers of *experts*, physicists with wide-ranging teaching experience (Adams et al., 2006). The 42 statements on the survey are answered on a 5-point Likert scale from 'strongly agree' to 'strongly disagree' where 3 is considered neutral, indicating that a respondent neither agrees nor disagrees with the experts. When scored, answers of *disagree* or *strongly disagree* are condensed into a *disagree* group and answers of *agree* or *strongly agree* are condensed into an *agree* group to make the survey more accurate across various populations (Adams et al., 2006). There is one statement that asks students to choose the number 4 on the Likert scale, to preserve their answers. This question is included as a means to viably discard surveys from students who did not read the statements.

The responses from the survey can be analyzed by examining the responses to individual statements, or by examining eight categories that the survey addresses. The categories of attitudes that the survey examines were empirically determined by finding groupings of statements for which answers were typically correlated and are shown in Table 2 (Adams et al., 2006). Several of the categories probe an individual's attitudes towards science while others evaluate an individual's scientific attitudes. While most of the categories are self-explanatory, several of them require further explanation. The *Sense Making/Effort* category explores an individual's attitudes about putting in an effort to make sense of the physics. The *Conceptual Understanding* category reflects an individual's strength in recognizing that physics is not about memorizing and that there are underlying concepts, whereas the *Applied Conceptual Understanding* category reflects the individual's attitudes about applying the underlying conceptual framework and using the appropriate reasoning, not memorization, for problem solving.

Table 2
CLASS Survey Categories

Attitude Types	Categories	Items
Attitudes Toward Science	Personal Interest	3, 11, 14, 25, 28, 30
	Real World Connections	28, 30, 35, 37
Scientific Attitudes	General Problem Solving	13, 15, 16, 25, 26, 34, 40, 42
	Problem Solving Confidence	15, 16, 34, 40
	Problem Solving Sophistication	5, 21, 22, 25, 34, 40
	Sense Making/Effort	11, 23, 24, 32, 36, 39, 42
	Conceptual Understanding	1, 5, 6, 13, 21, 32
	Applied Conceptual Understanding	1, 5, 6, 8, 21, 22, 40

Twenty six of the statements on the survey are used in various combinations of four to eight questions to determine the category results. These 26 statements have consistent expert-like responses and the students' responses are compared to the experts as either favorable (agreeing with the experts) or unfavorable (disagreeing with the experts). An *Overall* favorable (or unfavorable) attitude is also determined by the responses to all of the statements that have consistent expert-like responses and is reported as an average percentage of statements for which the students agree (or disagree) with the experts.

Data Analysis

Several comparisons were made amongst the different student populations. The different groups were compared to one another, accounting for gender (male vs. male and female vs. female), and as a whole (all students vs. all students). Additionally, the males and females within each group were compared to one another. For all comparisons, responses to the individual statements on the survey were evaluated, as were favorability scores for the various categories that the survey examines.

When comparisons were made between sets of students on individual statements, chi-square tests were performed. Comparisons between sets of students on the category results were made through independent t-tests. Responses for both tests were considered statistically different from one another when the test yielded a p-value ≤ 0.05.

Results and Discussion

Between Class Comparisons

Table 3 shows the categorical results for the three different groups of students. The average percentage of questions answered favorably (or unfavorably) is shown for each class, in each category, and is also broken down by gender. The average percentage of students who had a neutral response is not shown, but is the remainder of the students.

The preservice elementary education students held their most favorable attitudes in the *Sense Making/Effort* and *Real World Connections* categories: their responses in the *Sense Making/Effort* category were consistent with those of experts for approximately 61% of the questions, and their responses in the *Real World Connections* category were consistent with those of experts for approximately 53% of the questions. The preservice elementary education students' attitudes that were least like the experts were in the *Problem Solving Sophistication* and *Applied Conceptual Understanding* categories. These were the least expert-like categories for the non-STEM majors and STEM majors as well.

Table 3

Categorical Results For All Groups

Category	Gender	Status	%Preservice elementary education students ±SErr*	%Non-STEM students ±SErr*	%STEM students ±SErr*
Overall	Male	Favorable	47.1 ± 2.6	50.1 ± 3.6	57.9 ± 2.0
		Unfavorable	23.6 ± 1.6	22.0 ± 3.1	17.7 ± 1.2
	Female	Favorable	41.7 ± 1.5	39.1 ± 2.2	50.5 ± 3.4
		Unfavorable	28.2 ± 1.6	28.9 ± 1.9	23.3 ± 2.4
	All	Favorable	42.9 ± 1.3	42.9 ± 2.0	55.6 ± 1.8
		Unfavorable	27.1 ± 1.3	26.5 ± 1.7	19.4 ± 1.1
Personal Interest	Male	Favorable	38.4 ± 4.6	47.7 ± 4.8	64.6 ± 3.2
		Unfavorable	29.0 ± 3.7	22.7 ± 5.0	7.7 ± 2.0
	Female	Favorable	35.9 ± 2.3	31.1 ± 4.1	48.2 ± 6.3
		Unfavorable	35.3 ± 3.1	41.0 ± 3.6	28.6 ± 5.4
	All	Favorable	36.5 ± 2.0	36.9 ± 3.3	59.5 ± 3.0
		Unfavorable	33.8 ± 2.5	34.5 ± 3.1	14.1 ± 2.4
Real World Connections	Male	Favorable	57.6 ± 4.8	59.6 ± 6.2	66.7 ± 3.3
		Unfavorable	8.7 ± 2.5	12.5 ± 4.6	12.3 ± 2.3
	Female	Favorable	51.3 ± 3.1	38.5 ± 5.1	53.6 ± 6.9
		Unfavorable	19.6 ± 2.9	25.5 ± 4.1	18.8 ± 4.4
	All	Favorable	52.7 ± 2.6	45.9 ± 4.1	62.6 ± 3.2
		Unfavorable	17.1 ± 2.4	20.9 ± 3.2	14.3 ± 2.1
Problem Solving General	Male	Favorable	51.1 ± 4.4	55.9 ± 4.9	67.5 ± 2.9
		Unfavorable	18.5 ± 2.7	16.5 ± 3.9	7.5 ± 1.7
	Female	Favorable	43.1 ± 2.7	42.2 ± 3.5	60.3 ± 5.1
		Unfavorable	22.3 ± 2.4	24.6 ± 3.5	13.4 ± 2.8
	All	Favorable	44.9 ± 2.3	47.2 ± 2.9	65.2 ± 2.6
		Unfavorable	21.4 ± 2.0	21.7 ± 2.2	9.3 ± 1.5
Problem Solving Confidence	Male	Favorable	57.6 ± 6.0	65.1 ± 5.5	69.4 ± 3.8
		Unfavorable	13.0 ± 3.8	10.6 ± 4.0	7.5 ± 2.0
	Female	Favorable	47.1 ± 3.4	44.8 ± 4.3	63.4 ± 4.9
		Unfavorable	19.9 ± 3.1	22.9 ± 3.8	11.6 ± 3.0

	All	Favorable	49.5 ± 3.0	51.9 ± 3.5	67.6 ± 3.0
		Unfavorable	18.3 ± 2.5	18.6 ± 2.9	8.8 ± 1.7
Problem Solving Sophistication	Male	Favorable	31.9 ± 4.8	44.0 ± 5.7	45.8 ± 3.4
		Unfavorable	39.1 ± 4.4	27.2 ± 4.6	23.5 ± 2.9
	Female	Favorable	21.8 ± 2.3	18.2 ± 3.0	36.9 ± 5.1
		Unfavorable	41.7 ± 3.1	50.6 ± 4.4	29.8 ± 4.9
	All	Favorable	24.1 ± 2.1	27.3 ± 3.1	43 ± 2.8
		Unfavorable	41.1 ± 2.6	42.3 ± 3.5	25.5 ± 2.5
Sense Making/Effort	Male	Favorable	65.2 ± 3.7	60.4 ± 4.5	65.8 ± 2.9
		Unfavorable	9.3 ± 2.3	12.6 ± 3.5	8.6 ± 1.6
	Female	Favorable	59.7 ± 2.2	63.5 ± 3.3	64.3 ± 4.8
		Unfavorable	14.3 ± 1.7	7.8 ± 1.8	13.8 ± 2.9
	All	Favorable	61.0 ± 1.9	62.5 ± 2.7	65.3 ± 2.5
		Unfavorable	13.2 ± 1.4	9.5 ± 1.7	10.2 ± 1.4
Conceptual Understanding	Male	Favorable	45.7 ± 4.7	44.0 ± 6.0	50.3 ± 3.3
		Unfavorable	27.5 ± 3.7	26.8 ± 5.3	23.3 ± 2.5
	Female	Favorable	32.7 ± 2.8	31.0 ± 3.7	51.2 ± 5.8
		Unfavorable	33.1 ± 2.5	35.9 ± 3.7	19.6 ± 3.8
	All	Favorable	35.6 ± 2.4	35.6 ± 3.2	50.5 ± 2.9
		Unfavorable	31.8 ± 2.1	32.7 ± 3.1	22.2 ± 2.1
Applied Conceptual Understanding	Male	Favorable	32.9 ± 4.1	36.9 ± 4.6	38.5 ± 2.9
		Unfavorable	38.5 ± 3.3	33.6 ± 4.0	36.3 ± 2.7
	Female	Favorable	22.2 ± 2.2	18.2 ± 2.9	38.3 ± 4.8
		Unfavorable	45.8 ± 2.5	48.7 ± 3.7	33.2 ± 3.9
	All	Favorable	24.6 ± 1.9	24.7 ± 2.7	38.5 ± 2.5
		Unfavorable	44.1 ± 2.1	43.4 ± 2.9	35.3 ± 2.2

*The uncertainty in the percentages is the standard error of the mean.

Preservice Elementary Education vs. Non-STEM

The results for the non-STEM majors and the preservice elementary education students were very similar which is not surprising since both of these groups have chosen fields of study that are not STEM-intensive. When independent sample t-tests were performed between these two groups, there were no statistically significant differences between the categorical results. This is true when comparing all of the non-STEM students to all of the preservice elementary education students, and when just comparing males to males or females to females.

When chi-square tests were performed on the responses to the individual statements on the survey, it was found that of the 42 statements there was only one statement (#35) for which there was a statistical difference in the responses between the two groups when gender is not taken into account. However, when looking at the responses to this statement as a function of gender, it appears that this difference was due to a dissimilarity in the attitudes of the women in the two groups, not the men (see Table 4). The preservice elementary education women responded to this statement with far more positive attitudes than did the non-STEM women. Although statement #35 is used in calculating the favorability percentages of the *Real World Connections* category, it is not the only statement related to this category, and the difference in the two groups of women's answers for this one question was not enough to affect their categorical results.

Table 4

Statement Responses Differing Between Preservice Elementary Education Students and Non-STEM Students

Gender	Students	Attitudes	Statement						
			#35	**#25**	**#26**	**#27**	**#3**†	**#5**†	**#30**†
Male	Preservice elementary education students	Favorable	74%	9%	65%	26%	13%	35%	48%
		Unfavorable	9%	57%	4%	35%	70%	48%	4%
	Non-STEM students	Favorable	62%	15%	58%	31%	31%	65%	81%
		Unfavorable	12%	50%	4%	42%	35%	12%	4%
			#35†	**#25**†	**#26**†	**#27**†	**#3**	**#5**	**#30**
Female	Preservice elementary education students	Favorable	58%	9%	55%	35%	17%	27%	60%
		Unfavorable	15%	51%	9%	31%	68%	33%	12%
	Non-STEM students	Favorable	31%	9%	42%	13%	13%	23%	46%
		Unfavorable	33%	77%	2%	47%	77%	43%	19%
			#35†	**#25**	**#26**	**#27**	**#3**	**#5**	**#30**
All	Preservice elementary education students	Favorable	61%	9%	57%	33%	16%	29%	57%
		Unfavorable	14%	52%	8%	32%	68%	37%	10%
	Non-STEM students	Favorable	42%	11%	47%	19%	19%	38%	58%
		Unfavorable	26%	67%	3%	45%	62%	32%	14%

†The differences between the two classes are considered statistically significant, $p \leq 0.05$.

Although there were no statistical differences in the categorical results, there were several individual statements that were different between the two groups when the classes are compared, while taking into account gender. In addition to #35, the preservice elementary education women also had more favorable responses to statements #26 and #27 and were statistically less unfavorable about #25 than the non-STEM women (Table 4). The responses of the men for these statements were not statistically different between the two classes. However, there were differences in the responses of the men between the two groups for statements #3, #5 and #30. Whereas the preservice elementary education women tended to be more favorable when they differed with their non-STEM counterparts, the opposite is true of the preservice elementary education men. For all statements in which the preservice elementary education men's responses statistically differed from the non-STEM men, the preservice elementary education men had much less favorable responses.

Preservice Elementary Education vs. STEM

Although their responses only differed slightly from the non-STEM majors, the preservice elementary education students did show many differences in attitudes with the STEM majors. Their responses for the survey were different enough that it affected the categorical results.

The independent sample t-tests showed that there were categories with significantly different results between the preservice elementary education students and the STEM students. Categories in which the differences between the male STEM majors' and the male preservice elementary education students' favorable and unfavorable attitudes were statistically significant are shown in Table 5. The corresponding results for the female students are also shown.

Table 5

Within Gender Comparison Between Preservice Elementary Education Students and STEM Majors[a]

Category	**Male Preservice elementary education *vs* Male STEM**	**Female Preservice elementary education *vs* Female STEM**
Overall	X	X
Personal Interest	X	
Real World Connections		
General Problem Solving	X	X
Problem Solving Confidence		X
Problem Solving Sophistication	X	X
Sense Making/Effort		
Conceptual Understanding		X
Applied Conceptual Understanding		X

[a] The table indicates the categories in which the differences in the students' responses between the preservice elementary education and STEM classes were found to be statistically significant, $p \leq 0.05$.

The preservice elementary education students were most similar to their STEM peers in the *Sense Making/Effort* and *Real World Connection* categories. In these two categories, there was no statistically significant difference between the responses of the groups. These two categories were also where the preservice elementary education students held the most expert-like beliefs.

In all cases that were statistically significant, the attitudes of the preservice elementary education students were more negative than those of their peers in STEM majors. The categories in which the attitudes of the two groups were significantly different showed some variation by gender (Table 5). While male preservice elementary education students had significantly less favorable attitudes regarding their personal interest in physics than did the male STEM majors, this was not true of the corresponding female students. There was no statistical difference in the attitudes regarding their personal interest in physics between the female STEM majors and the female preservice elementary education students.

The female preservice elementary education students were more negative in their attitudes that corresponded to *Problem Solving Confidence*, *Conceptual Understanding*, and *Applied Conceptual Understanding* than were their female STEM counterparts. These three categories were not, however, significantly different between the two male groups. The *Applied Conceptual Understanding* category showed some of the least expert-like attitudes for students in any major, and of either sex. The gender specific results in Table 5 show that the preservice elementary education males were no more negative in this category than the STEM males, whereas the female preservice elementary education students were, unfortunately, even more negative than the female STEM majors.

Within Class Comparisons

Previous studies using the CLASS survey have found that women's personal interest in physics is typically less than men's, and in general their answers tend to be less expert-like than men's (Adams et al., 2006). It is thus important to compare the women to the men within each course. Table 6 shows the categories examined by the survey that were statistically significant ($p \leq 0.05$) between the men and women within each class.

Table 6

Within Class Comparison Between Genders[a]

Category	**Preservice Elementary Education Women vs Men**	**non-STEM Women vs Men**	**STEM Women vs Men**
Overall	X	X	X
Personal Interest		X	X
Real World Connections	X	X	
General Problem Solving		X	
Problem Solving Confidence		X	
Problem Solving Sophistication		X	
Sense Making/Effort			
Conceptual Understanding	X	X	
Applied Conceptual Understanding	X	X	

[a] Male and female results for the categories were compared within each class. The table indicates the categories in which the differences in the students' responses were found to be statistically significant, $p \leq 0.05$.

In all three groups, any of the differences in attitudes that were seen between the genders occurred because the men had more expert-like opinions than the women. Overall, there seemed to be less division between the attitudes of the male and female preservice elementary education students than was seen between the attitudes of the male and female non-STEM students. However, the differences in the attitudes between the genders in the preservice elementary education class were still greater than the differences in the attitudes between the genders in the STEM class.

For all three groups, the men's and women's attitudes were closest to each other in the *Sense Making/Effort* category and there was no statistical difference between genders for any of the three groups. For the non-STEM students, this was the only category where there was not a difference between the genders.

While the responses of the non-STEM students were different, gender-wise, on all categories but one, the STEM students showed much more similarity in the attitude differences between the genders and only had statistically significant differences in two of the categories examined. As with the non-STEM students, the STEM students differed by gender on the attitudes that correlate to personal interest: the male STEM students and the male non-STEM students had much more positive attitudes in this category when compared to their female counterparts. This is not, however, true for the preservice elementary education students. For this group, the men and women had similar attitudes corresponding to their personal interest.

The results for the preservice elementary education students also differed from the results for the non-STEM students in the three categories related to problem solving. The preservice elementary education genders did not share the differences in attitudes corresponding to *General Problem Solving*, *Problem Solving Confidence* and *Problem Solving Sophistication* that were seen between the non-STEM genders. The men and women in the preservice elementary education classes were more similar to one another than the men and women in the non-STEM courses. This could be due to more favorable attitudes by the preservice elementary education women, less favorable attitudes by the preservice elementary education men, or both, all of which would reduce the gap in attitudes between the genders.

An analysis of the responses by gender for the individual statements allows for further comparison between the male and female preservice elementary education students, and begins to explain the decrease in the disparity of attitudes between the preservice elementary education genders. While the non-STEM students showed significant gender gaps on approximately 25% of the questions, there was only a significant gender gap in the preservice elementary education students for about 7% of the questions. Table 7 shows the statements for which there was a statistical difference between the responses of men and women in the non-STEM groups. The average percentage of these same statements responded to favorably and unfavorably in the preservice elementary education courses are also shown, although the differences between genders for preservice elementary education students were not found to be statistically significant. Additionally, Table 7 shows the statements in the preservice elementary education courses for which there was a statistical difference in the responses of men and women, and also includes the results from the non-STEM course even though the latter results were not statistically significant between genders. There were 10 statements for which the men and women non-STEM students had statistically significant differences in their responses, and only three statements for which the men and women preservice elementary education students had statistically significant differences in their responses. This indicates that the different genders in the preservice elementary education courses had fewer disparities in their responses on the survey than did the different genders in the non-STEM courses.

Table 7

Statement Responses Differing Between Male and Female Students Within Groups

Class	**Gender**	**Attitudes**	**Question**												
			#1[†]	**#3[†]**	**#5[†]**	**#10[†]**	**#12[†]**	**#22[†]**	**#30[†]**	**#32[†]**	**#34[†]**	**#35[†]**	**#11**	**#16**	**#21**
Non-STEM	Male	Favorable	15%	31%	65%	54%	15%	31%	81%	58%	48%	62%	65%	64%	35%
		Unfavorable	35%	35%	12%	31%	73%	31%	4%	23%	8%	12%	12%	16%	46%
	Female	Favorable	10%	13%	23%	44%	4%	2%	46%	67%	17%	31%	70%	46%	13%
		Unfavorable	67%	77%	43%	10%	94%	56%	19%	13%	42%	33%	9%	15%	54%
			#1	**#3**	**#5**	**#10**	**#12**	**#22**	**#30**	**#32**	**#34**	**#35**	**#11[†]**	**#16[†]**	**#21[†]**
Preservice Elementary Education	Male	Favorable	9%	13%	35%	65%	4%	22%	48%	78%	30%	74%	70%	83%	43%
		Unfavorable	39%	70%	48%	13%	83%	39%	4%	4%	22%	9%	0%	4%	48%
	Female	Favorable	12%	17%	27%	51%	1%	8%	60%	67%	22%	58%	58%	51%	14%
		Unfavorable	63%	68%	33%	18%	94%	55%	12%	8%	35%	15%	22%	14%	55%

[†]Indicates that the differences in responses between these male and female students were statistically significant, $p \leq 0.05$.

For statements #3, #5, and #30, there was a gender gap in the responses by the non-STEM group (see Table 7). Whereas the responses of the non-STEM women were statistically different from the non-STEM men on these statements, the responses of the non-STEM women were not statistically different from those of the preservice elementary education women (Table 4). Additionally, the preservice elementary education women's responses did not differ from the male preservice elementary education responses (Table 7). However, the responses of the preservice elementary education men did differ from the responses of the non-STEM men to these statements (Table 4). Overall, this seems to indicate that the preservice elementary education men are more like the preservice elementary education women and non-STEM women, and differ from the non-STEM men on their responses to these statements. Unfortunately, this is because the preservice elementary education men were more negative than the non-STEM men in regards to these particular statements. Statements #3 and #30 are employed in the *Personal Interest* category and likely account for the finding that the preservice elementary education men and women did not differ in that category: the decrease in favorable attitudes by the male preservice elementary education men decreased the gap in the attitudes between the preservice elementary education genders.

There was one statement, #11, 'I am not satisfied until I understand why something works the way it does,' to which all of the male preservice elementary education students agreed. It is interesting that they can agree with this statement and yet still have more negative attitudes towards physics than their non-STEM and STEM male peers.

One statement that is not used for calculation of the categories, #12, 'I cannot learn physics if the teacher does not explain things well in class' does have a consistent expert-like response (disagree). Analysis of this question showed a variation between the sexes in both the non-STEM and STEM classes, but not in preservice elementary education classes. The responses by the students for this particular question are summarized in Table 8. In all classes the women answered this more unfavorably (i.e. they agreed with the statement) than the men, and in the STEM and non-STEM classes the difference was statistically significant between the genders. In the preservice elementary education classes, however, there was not a statistically significant difference between the men and women. Once again, there was no typical gap between the male and female preservice elementary education because the men had more unfavorable responses, thus decreasing the size of the gender gap. Overall, the students' unfavorable responses to this statement indicate that they rely upon their instructors for all of their learning, as has been seen in other studies (Young & Kellogg, 1993).

Table 8

Student Responses to Statement #12

Gender	**Attitudes**	**Preservice Elementary Education**	**†Non-STEM**	**†STEM**
Male	Favorable	4%	15%	14%
	Unfavorable	83%	73%	73%
Female	Favorable	1%	4%	0%
	Unfavorable	94%	94%	86%

†Indicates that for a comparison of these male and female students, the differences in responses were statistically significant, $p \leq 0.05$.

Concluding Remarks

A gender gap in attitudes was found to exist for all of the classes surveyed: the males had more favorable attitudes towards physics than the females. However, the size of this gap and the aspects of physics attitudes with which it correlates depended upon the student population. The smallest gap existed between the men and women in STEM fields while the largest gap existed between the men and women in non-STEM fields. The gap in the preservice elementary education students was slightly smaller than that for the non-STEM students, but it was still significantly larger than that for the STEM students.

Overall, the preservice elementary education students surveyed in this study did not have attitudes as favorable as students in STEM fields. It should be noted that the STEM majors surveyed here had slightly less expert-like beliefs than is typically seen with this type of student (Perkins, Gratny, Adams, Finkelstein, & Weiman, 2006). Whether there was a corresponding decrease in the attitudes of the preservice elementary education students needs to be further explored.

When the preservice elementary education students were compared to other non-STEM students there were only slight differences in their responses to the survey. For several survey statements, the preservice elementary education women had attitudes that were more favorable than other non-STEM women, but on other questions the preservice elementary education men tended to be less favorable than their male peers. These two trends resulted in a slightly smaller gender gap in attitudes for the preservice elementary education students than for the non-STEM students.

The preservice elementary education women were much more positive than were their non-STEM female counterparts in their response to a statement that probed attitudes about how physics is related to experiences in the real world. A previous study by Perkins et al. (2006) found that students have more favorable attitudes about physics, and an increased interest in it, if they see a link between physics and the real world. Well-designed content specific courses that provide meaningful and relevant learning experiences by making real world connections in science are needed. It would then be reasonable to suggest that to improve the preservice elementary teacher's attitudes about physics, college level courses could emphasize the connection between physics and the real world. Since this is already an attitude that is positive amongst the female preservice elementary education students, a nurturing of this attitude in their courses could improve their overall attitude towards physics. One possible way to do this would be to design physical science courses that deal with the relationship between physics and how the everyday world works. A study by Gonzalez-Espada (2009) found that non-STEM undergraduates would prefer physical science courses that show applications of physics, i.e. courses about *how things work*. Courses that explore the importance of physical science in regards to how things work (e.g. roller coasters, x-rays, musical instruments, etc.) would clearly utilize students' positive attitudes about the connection between physics and the real world.

Additionally, courses designed for preservice elementary education students need to address the negative attitudes that they do carry. Particularly, these students fail to understand that topics in physics are interconnected and not discrete, and that memorizing is not a means to understanding the material. Their attitudes also indicate that they lack the insight to view formulas for anything other than plugging-and-chugging. These unfavorable opinions cannot be ignored. Several studies have suggested that unless courses overtly address the attitudes students carry about the nature of science and the nature of knowledge (their epistemological beliefs), their attitudes will not improve (Akerson, Abd-El-Khalick, & Lederman, 1999; Elby, 2001). Thus, if we want preservice elementary education students to have opinions more consistent with the favorable opinions of scientists, we must explicitly address their attitudes. An example of a course that successfully implemented such a strategy was discussed by Otero and Gray (Otero & Gray, 2008). The course they describe (Physical Science and Everyday Thinking, PSET) includes activities throughout the semester in which the students are "*explicitly* asked to reflect on their own learning, to reflect on the learning of other students, and to reflect on the learning of scientists" (Otero & Gray, 2008, p. 020104-2). The students are asked to consider how their thinking has evolved and why their answers to questions change as they gain more knowledge. Students in the PSET course, who were given the CLASS survey at the beginning of the semester and at the end of the semester, showed an improvement in their attitudes and had more expert-like responses after completing the course.

Instructors of physics and physical science courses need not necessarily design an entirely new course and could begin to address the attitudes of students by making modifications to current courses. As illustrated by Elby (2001), epistemological-based class discussions, homework questions and test questions could be integrated into almost any physical science course in a manner such that students are required to think about how their understanding has evolved and how they are most successful at making sense of the material. Cognitive theories of motivation focus not only on thoughts, beliefs and expectations, but also on attitudes and how they can increase or decrease motivation to learn (Schunk & Ertmer, 2000). A strong motivation for preservice elementary education teachers would be to see science taught by master teachers in the elementary classroom. Preservice elementary education teachers need the opportunity to observe science learning in progress within our elementary schools in order to foster their own interest and motivation (Mosely, Ramsey, & Ruff, 2004). Authentic and practical science field-based opportunities within the elementary schools will build the preservice elementary education teachers' confidence and self-efficacy in teaching science as they apply first-hand the elements of best practice relative to science teaching. Moseley et al. (2004) found that participation in such field experiences cultivated positive attitudes towards science and science teaching.

While the CLASS survey that was used in this study specified *physics*, it would be of use to see how attitudes vary by scientific discipline. Thus, future work should examine the attitudes that these students carry about the physical sciences and science in general. Elucidating the attitudes that preservice teachers carry towards science is the first step in addressing science literacy in our youth.

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Appendix

CLASS Survey.

1. A significant problem in learning physics is being able to memorize all the information I need to know. (D)
2. When I am solving a physics problem, I try to decide what would be a reasonable value for the answer. (A)
3. I think about the physics I experience in everyday life. (A)
4. It is useful for me to do lots and lots of problems when learning physics. (N)
5. After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic. (D)
6. Knowledge in physics consists of many disconnected topics. (D)
7. As physicists learn more, most physics ideas we use today are likely to be proven wrong. (N)
8. When I solve a physics problem, I locate an equation that uses the variables given in the problem and plug in the values. (D)
9. I find that reading the text in detail is a good way for me to learn physics. (N)
10. There is usually only one correct approach to solving a physics problem. (D)
11. I am not satisfied until I understand why something works the way it does. (A)
12. I cannot learn physics if the teacher does not explain things well in class. (D)
13. I do not expect physics equations to help my understanding of the ideas; they are just for doing calculations. (D)
14. I study physics to learn knowledge that will be useful in my life outside of school. (A)
15. If I get stuck on a physics problem on my first try, I usually try to figure out a different way that works. (A)
16. Nearly everyone is capable of understanding physics if they work at it. (A)
17. Understanding physics basically means being able to recall something you've read or been shown. (D)
18. There could be two different correct values for the answer to a physics problem if I use two different approaches. (D)
19. To understand physics I discuss it with friends and other students. (A)
20. I do not spend more than five minutes stuck on a physics problem before giving up or seeking help from someone else. (D)
21. If I don't remember a particular equation needed to solve a problem on an exam, there's nothing much I can do (legally!) to come up with it. (D)
22. If I want to apply a method used for solving one physics problem to another problem, the problems must involve very similar situations. (D)
23. In doing a physics problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem. (D)
24. In physics, it is important for me to make sense out of formulas before I can use them. (A)
25. I enjoy solving physics problems. (A)
26. In physics, mathematical formulas express meaningful relationships among measurable quantities. (A)
27. It is important for the government to approve new scientific ideas before they can be widely accepted. (D)
28. Learning physics changes my ideas about how the world works. (A)
29. To learn physics, I only need to memorize solutions to sample problems. (D)

30. Reasoning skills used to understand physics can be helpful to me in my everyday life. (A)
31. We use this statement to discard the survey of people who are not reading the questions. Please select agree (4) for this question to preserve your answers.
32. Spending a lot of time understanding where formulas come from is a waste of time. (D)
33. I find carefully analyzing only a few problems in detail is a good way for me to learn physics. (N)
34. I can usually figure out a way to solve physics problems. (A)
35. The subject of physics has little relation to what I experience in the real world. (D)
36. There are times I solve a physics problem more than one way to help my understanding. (A)
37. To understand physics, I sometimes think about my personal experiences and relate them to the topic being analyzed. (A)
38. It is possible to explain physics ideas without mathematical formulas. (A)
39. When I solve a physics problem, I explicitly think about which physics ideas apply to the problem. (A)
40. If I get stuck on a physics problem, there is no chance I'll figure it out on my own. (D)
41. It is possible for physicists to carefully perform the same experiment and get two very different results that are both correct. (N)
42. When studying physics, I relate the important information to what I already know rather than just memorizing it the way it is presented. (A)

Note. For statements that have a consensus expert-like response, it is noted with either an A (experts agree) or D (experts disagree) at the end of the question. The statements that do not have a consensus expert-like response are followed by an N (no consensus amongst experts).