Assessment of Korean Preservice Elementary Teachers' Science Teaching-anxiety and Science Teaching-efficacy

Choi, Sung-Youn · Kim, Sung-Won*

Ewha Womans University

Abstract: Science teaching-anxiety and science teaching-efficacy are influential factors in teachers' teaching practices and behaviors. In order to encourage elementary teachers to do better teaching practice, this study identified factors that have caused teachers' science teaching-anxiety, developed an instrument measuring science teaching-anxiety, and investigated the relationship between science teaching-anxiety and science teaching-efficacy. In addition, we attempted to suggest practical implications to enhance teachers' confidence in science teaching. The guiding research questions were 1) which factors affect science teaching-anxiety level of the preservice elementary teachers, and 2) how each factor of science teaching-anxiety is related to science teaching-efficacy. The subjects were 133 Korean preservice elementary teachers (57.1% were female) in a large city. The data sources included teachers' responses to three paper and pencil questionnaires: State-Trait Anxiety Inventory (STAI), Science Teaching-Anxiety Questionnaire (STAQ), and Science Teaching Efficacy Belief Instrument (STEBI-B). To clarify the science teaching-anxiety, we specified it into six factors: trait anxiety about nature of science and science teaching, state anxiety about instruction, science activities, student assessment, and professional responsibilities. The results indicated three significant aspects of science teaching anxiety and efficacy. First, their level of anxiety about professional responsibility and science teaching was relatively high among six factors. Second, there was a negative correlation between science teaching-anxiety and science teaching-efficacy. Third, trait anxiety about science teaching is the most influential factor for science teaching-efficacy while state anxiety about instruction and professional responsibilities were followed.

Key words: science teaching, teaching-anxiety, teaching-efficacy, preservice elementary teacher

I. Introduction

Recent research findings consistently point to the critical roles of teachers in helping students to learn and achieve (Darling-Hammond, 2000; Goldhaber, 2002; Wright et al., 1997). An affective, qualified teacher is the single most important factor affecting students' academic achievements (Hunt, 2003; Keegan, 2003). Becoming an effective science teacher is a continuous process that stretches from preservice experiences in undergraduate years to the end of a professional career (NRC, 1996). Therefore, improving teaching behaviors is one of the most important factors since what teachers do easily affect on students' behaviors, and participating in preservice teacher programs is the first step for improving teachers' effectiveness. Yet, according to nationwide profiles of science education, approximately only one-fourth of elementary teachers reported feeling well-qualified to teach science (Weiss et al., 2001). Moreover, most elementary teachers have relied heavily on textbooks and lecture modes of instruction, when they teach science at schools (Goodlad, 1984). Teaching behaviors, such as commitment to teaching (Coladarci, 1992), teachers' persistence in the teaching field (Glickman & Tamashiro, 1982), and teacher burnout (Brouwers & Tomic, 2000) have significant relations with teacher's self-efficacy. Thus, the difficulties of elementary teacher in science may contribute to their self-efficacy toward teaching science.

A teacher's sense of self-efficacy has been consistently recognized as an important attribute of effective teaching and has been positively correlated to teacher' and student' outcomes (Tschannen-Moran et al., 1998). Elementary teachers who have a low

*Corresponding author: Sung-Won Kim (sungwon@ewha.ac.kr)
**Received on 12 January 2008, Accepted on 11 November 2008

sense of efficacy tend to be anxious about teaching science and rely upon teacher-directed strategies (Czerniak & Schriver, 1994). In addition, low efficacy teachers spent less time teaching science and used less hands-on instruction and spend less time developing science concepts (Ramey-Gassert et al., 1996; Riggs, 1995). In brief, teaching-efficacy has been found to be one of the most important variables, consistently related to both of positive teaching behaviors and students' outcomes (Enochs et al., 1995; Gibson & Dembo, 1984; Henson, 2001; Woolfolk & Hoy, 1990). Since, teaching-efficacy encourages teachers to improve their teaching behaviors, understanding of preservice teachers' efficacy is an important step.

According to Bandura(1997)'s self-efficacy theory, teacher efficacy is influenced by mastery and vicarious experiences, verbal persuasion, and physical and affective states. Particularly, affective states have widely generalized effects on beliefs of personal efficacy in diverse spheres of functioning. In addition, it is an effective way for altering efficacy beliefs to enhance physical status, reduce stress levels and negative emotional proclivities, and correct misinterpretations of bodily states. While previous research literatures founded that science teaching-efficacy seems to be related to science teaching-anxiety (Britner & Pajares, 2006; Czerniak, 1989; Czerniak & Schriver, 1994; Riggs, 1995), there is little research on the influence of affective states on teacher efficacy. Therefore, concerning that science teaching-anxiety may represent the affective state about science teaching, the influence of science teaching-anxiety on teaching-efficacy needs to be explained. Furthermore, since teaching-efficacy is influenced by mastery and vicarious experiences (Bandura, 1997), we need to choose subjects who have no experiences on learning or teaching science.

Science anxiety is defined as feelings of tension and stress that interfere with the construction of science knowledge, the development of science skills and abilities, and the use of science knowledge, skills, and abilities in life and in academic situations (Mallow, 1981). Studies in this field generally utilize the State-Trait Anxiety Inventory (STAI) to measure anxiety (Westerback, 1984). However, there are some uncertainties about the definition or the specification of the concepts in the science teaching anxiety. Thus, it is better to specify the factors of science teaching-anxiety and to develop the instruments based on these factors.

As we have seen, the purpose of this study was to understand Korean preservice elementary teachers' anxiety and efficacy about teaching science. For this purpose, firstly, we defined factors of science teaching-anxiety and developed instrument to measure science teaching-anxiety. Secondly, we explored (1) which factors affect science teaching-anxiety level of the preservice elementary teachers, and (2) how each factor of science teaching-anxiety is related to science teaching-efficacy. Finally, we attempted to suggest practical implications to enhance preservice elementary teachers' confidence in science teaching.

Ⅱ. Methods

1. Subjects

In this study, 133 preservice elementary teachers in Korea (57.1% were female and 12.8% were science major) who were enrolled in college of education were chosen and answered three questionnaires. They were beginning the first or second year of their four-year programs and most of them have never taken any science course or science-related in-school internship before. The majority (83.0%) of subjects showed a good willingness to teach science at school while over half of subjects (52.6%) felt confident in becoming proficient science teachers in elementary schools. They completed background information, the STAI, the STAQ, and the STEBI-B.

2. Data sources

This study was implemented during the second semester of 2006. Data has been obtained through three-kinds of questionnaires; STAI, STAQ, and STEBI-B. The STAI (Spielberger, 1991) was used for concurrent validity of STAQ, which was developed to measure science teaching-anxiety. The STEBI-B (Enochs & Riggs, 1990) was used for measuring science teaching-efficacy. The background information such as gender, and level of willingness to teach

science at school and confident in becoming a proficient science teacher in elementary schools also gathered. The willingness and confident were presented using five-point Likert items.

1) State-Trait Anxiety Inventory (STAI)

The STAI (Spielberger, 1991) is a forty-item self-report Likert-type Inventory. The STAI consists of two scales: state anxiety and trait anxiety scale. Twenty items out of forty measure state anxiety, a transitory emotional state which can be influenced by training while other twenty items measure trait anxiety, relatively stable individual differences in anxiety proneness. The items on both scales were never altered, but the headings on the STAI state anxiety forms and the directions were changed for use in measuring anxiety about teaching other domain. The STAI was translated into Korean and used for assessing by correlating with the STAQ for concurrent validity of STAQ. In this study, the STAI has a Cronbach's alpha coefficient of 0.800.

2) Science Teaching-Anxiety Questionnaire (STAQ)

Even though STAI generally has been utilized to measure anxiety, it has some uncertainties in measuring specific factors. Therefore, we defined factors of science teaching-anxiety and developed a instrument, STAQ, for measuring it. As shown in Table 1, the framework of science teaching was classified into six factors by Danielson's framework for teaching (Danielson, 2007) and requirement of effective science teachers (Chiappetta & Koballa, 2005; Turner & DiMarco, 1998), which was concerned for balancing of teaching activities. First two factors are related with trait anxiety based on the Spielberger's definition of anxiety (Spielberger, 1966) and previous literature (Westerback, 1984; Mallow, 1981). Thus the trait anxiety is interpreted as measuring stable individual differences in an unitary, relatively permanent personality characteristics (Spielberger, 1966). We defined trait anxiety in science teaching is a kind of emotion based on science knowledge and pedagogy. In details, we specified Spielberger's trait anxiety into two factors, the nature of science and science teaching. While state anxiety is based on a pattern of variables that covered over occasions of measurement, defining a transitory state or condition of the organism which fluctuated over time (Spielberger, 1966). State anxiety in science teaching is defined as a kind of emotion that arises when someone experiences teaching science lessons and laboratory activities, designing assessments, and reflecting on teaching. In detail, we specified Spielberger's state anxiety into four factors: instruction, science activities, student assessment, and professional responsibilities.

A total of forty items was initially developed based on six science teaching-anxiety factors. Overall, the expression of anxiety symptoms was associated with the psychiatric symptoms expressive of anxiety (Cattell & Scheier, 1961) and Zuckerman's affect adjective checklist (Zuckerman & Lubin, 1965). The validity of this new questionnaire, STAQ, was confirmed in terms of its content, construct, and concurrent validity. The content validity was ascertained by responses during the progress of developing the STAQ, from four experts who have more than five-years of science teaching experience and master degree. They discussed about individual components of the framework and theoretical and practical aspects of science teaching. Some items were revised according to their suggestions. Additionally, exploratory principal-components factor analyses with Varimax rotations were performed on the STAQ. The seven items which were not loaded in the expected factor were removed. However, one-item which was not loaded in an expected factor, was included by the necessity for estimating, as shown in Table 2. Checking reliability of factors using Cronbach's alpha, items lowering the reliability of each factor were also removed (α=.886). Concurrent validity of the STAQ was confirmed by the investigation of correlations with the STAI (r=.633, p<.001). In detail, trait anxiety of STAQ has more stronger relationship with trait anxiety (r=.562, p<.001) than state anxiety (r=.491, p<.001) of STAI and similar to state anxiety (see Table 3). This result revealed that trait anxiety items of STAQ measured Spielberger's trait anxiety with effect and similar to state anxiety.

The final version of STAQ composed of thirty three items scored on a Likert-scale ranging from 1 (low level of anxiety) to 5 (high level of anxiety) and consisted of two scales with six factors (see Appendix).

Table 1

The framework of science teaching and science teaching-anxiety

Previous researches			Factors of science teaching		Factors of science teaching-anxiety
Framework of teaching (Danielson, 2007)	Framework of science teaching activities (Chiappetta & Koballa, 2005)	Requirement of effective science teachers (Tuner & DiMarco, 1998)			
· Knowledge of content	· Nature of science as background knowledge	· Subject knowledge	Knowledge about nature of science	· Knowledge of science · Attitude toward scientist · Scientific inquiry · Science-technology-society · Scientific literacy	· Trait anxiety about nature of science : Anxiety about nature of science is a kind of emotion based on science knowledge, inquiry, scientist, and scientific literacy.
· Knowledge of pedagogy	· Teaching strategies as background knowledge	· Subject curriculum knowledge · Subject application · Teaching strategies	Knowledge about science teaching	· Attitude toward science teaching · Content knowledge · Understanding curriculum · Pedagogical knowledge · Instructional materials and resources	· Trait anxiety about science teaching : Anxiety about science teaching is a kind of emotion based on teaching attitude and knowledge of content and pedagogy.
· Engaging students in learning · Setting instructional outcomes · Communicating with students · Managing student behavior · The classroom environment	· Planning for instruction · Lecture, discussion, and demonstration · Classroom management	· Pupils' learning · Communication skills · Class management	Instruction	· Managing students' learning · Planning for science lessons · Teaching strategies · Communication skills · Engaging students in learning · Teacher interaction with students	· State anxiety about instruction : Anxiety about instruction is a kind of emotion that arises when someone experiences preparing and teaching science lessons, managing classroom, and communicating with students.
	· Laboratory and field work		Science activities	· Safety in the laboratory activities · Planning for science activities · Managing laboratory activities · Technical skills · Accuracy of laboratory activities · Managing science activities class	· State anxiety about science activities : Anxiety about science activities is a kind of emotion that arises when someone experiences teaching laboratory and outdoor activities.
· Designing student assessments · Maintaining accurate records	· Assessing learning outcomes	· Assessment · Recording · Reporting	Students assessment	· Designing assignments · Assessment process · Designing criteria and standards · Making assessment · Designing of performance assessments · Preparing reports	· State anxiety about student assessment : Anxiety about student assessment is a kind of emotion that arises when someone experiences designing criteria and standards for student assessments.
· Reflecting on teaching · Growing and developing Professionally · Showing professionalism	· Growing professionally and evaluating teaching	· Professional development	Professional responsi-bilities	· Reflecting on teaching · Communication with families · Showing professionalism · Participating in a professional community · Growing and developing professionally	· State anxiety about professional responsibilities : Anxiety about professional responsibilities is a kind of emotion that arises when someone experiences reflecting on teaching and developing professionalism.

Table 2

Factor analysis for validation of STAQ

Science teaching-anxiety		Item No.	Factor loading						Communality
			1	2	3	4	5	6	
Trait anxiety	SA1. Nature of science	1			0.718				0.628
		2			0.580				0.499
		3			0.627				0.676
		4			0.662				0.534
		5			0.777				0.629
	SA2. Science teaching	6					0.590		0.613
		7					0.515		0.601
		8					0.780		0.729
		9					0.776		0.609
		10					0.745		0.605
State anxiety	SA3. Instruction	11	0.575						0.380
		12	0.787						0.756
		13	0.790						0.719
		14	0.808						0.712
		15	0.732						0.596
		16	0.620						0.569
	SA4. Science activities	17				0.804			0.716
		18				0.682			0.592
		19				0.816			0.713
		20				0.747			0.635
		21				0.682			0.541
		22				0.521			0.475
	SA5. Student assessment	23		0.788					0.702
		24		0.750					0.759
		25		0.719					0.666
		26		0.796					0.688
		27		0.708					0.582
		28		0.631					0.487
	SA6. Professional responsibilities	29						0.724	0.581
		30						0.594	0.490
		31						0.562	0.456
		32						0.670	0.571
		33			0.670			0.449	0.723
Eigenvalue			7.591	3.791	3.571	2.026	1.890	1.367	
% of Variance			23.002	11.489	10.820	6.138	5.728	4.142	

Table 3

Relationships between STAQ and STAI (N=104)

		Anxiety factors of STAI		
		Trait anxiety	State anxiety	Total
Anxiety factors of STAQ	Trait anxiety	**.562***	.491*	.586*
	State anxiety	.431*	**.621***	.603*
	Total	.494*	.636*	**.633***

* $p < 0.01$ level

3) Science Teaching Efficacy Belief Instrument (STEBI-B)

In examining the domain specific area of science from self-efficacy framework, Enochs and Riggs (1990) developed and validate the Science Teaching Efficacy Belief Instrument (STEBI-B), containing twenty three items in a five-point Likert-scale for preservice elementary teachers in the United States.

STEBI-B consists of two scales: Personal Science Teaching Efficacy (PSTE, 13 items) and Science Teaching Outcome Expectancy (STOE, 10 items). PSTE is a teachers' belief in his or her own skills and abilities to positively impact on student achievements and indicates a strong personal belief in his or her own efficacy as a science teacher, while STOE is a teacher's belief that the educational system may work for all students, regardless of outside influences such as socio-economic status and parental involvement in education.

The STEBI-B has been used in numerous studies and the data has consistently been found to be reliable and valid (Bleicher, 2004). The STEBI-B was translated into Korean and used for measuring Korean preservice elementary teachers' science teaching-efficacy. In this study, the STEBI-B has a Cronbach's alpha coefficient of 0.800.

Ⅲ. Results and Discussion

Descriptive statistics were generated for the Likert-type items. Table 4 presents the results of descriptive statistics and correlations between science teaching-anxiety and teaching-efficacy. The mean value of science teaching-anxiety was 2.60 (SD=.48). In detail, they felt more anxious about professional responsibilities (SA6: M=2.90, SD=.67), science teaching (SA2: M=2.71, SD=.84), nature of science (SA1: M=2.60, SD=.48), instruction (SA3: M=2.58, SD=.78), science activities (SA4: M=2.44, SD=.76), and student assessment (SA5: M=2.40, SD=.74), in this order. Teachers' professional responsibilities are reflected on teaching, communication with students' parents, and professional community. In particular, while their teaching practices are evaluated by expert group (M=3.56, SD=.99), they worried about what they might experience, even they had confidence in their abilities to teach science effectively. It seems that it comes from unexpected teaching conditions, such as students' behaviors and achievement with laboratory works. And mean of science teaching-efficacy was 3.41 (SD=.36). STOE (M=3.44, SD=.43) was higher than PSTE (M=3.39, SD=.51). As results, subjects have somewhat low teaching-anxiety and high teaching-efficacy. In other words, they not only felt confident in their teaching abilities but also believed their abilities in teaching behaviors will cause desire outcome in students' achievements. It means, in general, that they have expectations that their science teaching would influence students' science learning. However, there are interesting observations that the majority of preservice teachers are afraid of their professional responsibilities. Anxiety about professional

Table 4

Means, SD, and correlations for science teaching-anxiety and teaching-efficacy (N=128)

				Correlations			
		M	*SD*	Science teaching-efficacy	Science teaching-anxiety		
					State anxiety	Trait anxiety	Total
Science teaching-anxiety		**2.60**	**.48**				1
Trait anxiety	SA1. Nature of science	2.60	.48			0.856*	0.714*
	SA2. Science teaching	2.71	.84			0.819*	0.609*
	Total	**2.66**	**.67**			1	**0.792***
State anxiety	SA3. Instruction	2.58	.78		0.634*	0.337*	0.605*
	SA4. Science activities	2.44	.76		0.698*	0.223*	0.606*
	SA5. Student assessment	2.40	.74		0.675*	0.243*	0.588*
	SA6. Professional responsibilities	2.90	.67		0.557*	0.567*	0.606*
	Total	**2.59**	**.48**		1	**0.531***	**0.937***
Science teaching-efficacy		**3.41**	**.36**	1	**-0.702***	**-0.676***	**-0.743***
Personal science teaching efficacy		3.39	.51	0.849*	-0.799*	-0.733*	-0.829*
Science teaching outcome expectancy		3.44	.43	0.593*	-0.106	-0.159	-0.137

* $p < 0.01$ level

responsibilities, as a factor of transitory anxious state, is an emotion that arises when someone experiences reflecting on teaching and developing professionalism. The state anxiety about specific situation can be influenced by training (Spielberger, 1991). In addition, professional development is an important factor to teaching effectiveness. Darling-Hammond, and McLaughlin (1995) argued professional development experiences provide teachers with rich content and opportunities to practice what they are learning. It is recognized that the level of professional responsibilities as a state anxiety can be altered through experience or training such as supplementary practical classes or in-school internship. Moreover, trait anxiety which is permanent personality characteristic is based on science content and pedagogical knowledge. According to Westerback (1982), preservice elementary teachers are anxious about teaching science and this anxiety can be reduced during a sequence of science content courses. In addition, the lack of knowledge of science contents has been suggested as one of the main reasons for avoidance of science teaching (Dobley & Schafer, 1984; Victor, 1961). These findings support the notion that knowledge about both science content and teaching instruction should be emphasized in course for elementary preservice teachers, which may provide preservice teachers with positive experiences, help to improve their anxiety about science and science teaching, and enhance their beliefs that they may become effective science teachers.

An independent samples t-test and *ANOVA* were conducted to examine whether any interaction existed between genders, and the level of willingness and confidence. There were no significant differences between genders in both science teaching-anxiety (t =-.263, M_f[1]=2.52, M_m[2]=2.55) and teaching-efficacy (t=1.442, M_f=3.45, M_m=3.35); it is consistent with previous studies of science self-efficacy (Britner & Pajares, 2001; Pajares et al., 1999) and science teaching-anxiety (Westerback, & Gonzalez, 1985). And results revealed that preservice teachers with higher levels of willingness and confidence have lower teaching-anxiety (F_w[3]=13.811, F_c[4]=8.532, p <.001) and higher teaching-efficacy (F_w=11.213, F_c =7.620, p<.001).

To examine the relationships between science teaching-anxiety and teaching-efficacy, pearson correlation coefficients and linear regression were run on the data. A statistically significant, and negative relationship was founded between teaching-anxiety and teaching-efficacy (r=-.743, p<.01, N=128). This results support Czerniak (1989), Czerniak and Schriver (1994) and Riggs (1995)'s hypothesized source of relationship between teaching-anxiety and teaching-efficacy. Negative relationship between teaching-anxiety and teaching-efficacy was observed, which means that as science teaching-anxiety decreases, the preservice elementary teachers' level of teaching-efficacy increase. More detailed investigation showed that this relationship was primarily due to a strong relationship at PSTE (r=-.829, p<.01); however, the relationship did not hold at STOE. Thus, it could be argued that, for preservice elementary teachers, favorable changes in science teaching-anxiety may have the educational effect on students' achievement and teachers' own efficacy. And there is a weak relationship between science teaching-anxiety and STOE. Further studies might be required to search other factors which have relations with STOE.

Theoretically, physical and affective states would account for some of the science teaching-efficacy (Bandura, 1997). Therefore, we concerned that science teaching-anxiety may represent the affective state about science teaching. The multiple regression was used to determine the degree to which each science teaching-anxiety factor in this study contributed to level of science teaching-efficacy. As the results of the simple linear regression analysis, teaching-anxiety explained teaching-efficacy by 55.2% (β=-.571, p <.001) variance of self-efficacy. Additionally, stepwise procedures were conducted both to determine influential factors of teaching-anxiety which explains teaching-efficacy and to assess the extent to which a

1) mean of female
2) mean of male
3) F ratio of willingness
4) F ratio of confidence

Table 5
Summary of regression analysis

Dependent variable: science teaching-efficacy	β	R^2
Independent variables:		
SA2. Trait anxiety about science teaching	-.259	46.3%
SA3. State anxiety about instruction	-.144	7.6%
SA6. State anxiety about professional responsibilities	-.129	3.1%
		57.0%

※ Correlation is significant at the 0.001 level

reciprocal relationship may exist between teaching-anxiety and teaching-efficacy. As shown in Table 5, trait anxiety about science teaching (SA2) was the most influential factor that explained 46.3% (β =-.259, p<.001) variance of self-efficacy, followed by instruction (SA3: R^2=7.6%, β=-.144, p<.001) and professional responsibilities (SA6: R^2=3.1%, β=-.129, p<.001). Both SA2 and SA3 which explain teaching-efficacy by 53.9% are related with teaching and learning strategies; SA2, as a stable proneness, is based on teaching attitude and knowledge about content and pedagogy, while SA3 is an anxious feeling when someone experiences teaching class under various conditions. As a regression result, anxiety factors about content knowledge, science activities, and student assessment had no significant power in predicting teaching-efficacy, however, it dose not mean that these factors have no relevance or weight to teaching-efficacy. In ongoing research, we investigate levels of science teaching-anxiety and efficacy by group which is different from experiences of content course or field training.

IV. Conclusion and Implications

The primary aim of this study was to understand Korean preservice elementary teachers' anxiety and efficacy about teaching science. For this purpose, the STAQ, which was developed from a theoretical framework, was developed to measure science teaching-anxiety. The STAQ is composed of thirty three Likert-type items and consisted of two scales with six factors: trait anxiety about nature of science and science teaching, and state anxiety about instruction, science activities, student assessment, and professional responsibilities. It could be utilized to measure preservice elementary teachers' science teaching-anxiety and lead to further understanding of their behaviors. The framework of science teaching-anxiety and STAQ may prove to be useful to measure level of science teaching-anxiety. Because the anxiety, one of the significant personal characteristics, is complex in nature, further research is needed to examine the quality of STAQ more thoroughly by qualitative research methods. In addition, the further research will be meaningful if it introduces a different sample of preservice or inservice teachers.

In Korea, elementary science teachers have been allowed to receive degrees and teach with few required science courses completed. Therefore, there is emphasis on science teaching course in college. Understanding preservice elementary teachers' preparation for teaching science is the first step to enhance their science teaching. Several outcomes offer potential for improvement in elementary science teacher training. In general, this study supports the importance of both science background and pedagogical training. Successful teaching experience for individuals is needed to help preservice teachers to overcome their anxiety about teaching science. Bandura (1997) believed that performance accomplishments are the strongest sources of efficacy expectations which might be encouraged by one's own teaching experiences or others' instruction attending class visiting. Also, teacher professional development programs, for both preservice and inservice, can be used to improve teaching-efficacy. Professional development efforts should focus on teaching instructions as well as science contents knowledge for reducing anxiety and increasing efficacy in teaching science. Verbal activities such as discussions and writing essays about their instructional experiences could enhance teaching-efficacy and teacher's professional responsibility. Furthermore, interacting with colleagues, discussing about their follow-up experiences might be helpful.

Acknowledgement

An earlier version of this paper was presented at the annual meeting of the National Association of

Research in Science Teaching, March 30 - April 2, 2008, Baltimore, MD.

References

Bandura, A. (1997). Self-efficacy: The exercise of control. New York: Freeman.

Bleicher, R. E. (2004). Revisiting the STEBI-B: Measuring self-efficacy in preservice elementary teachers. School Science and Mathematics, 104(8), 383-391.

Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race, and gender in middle school science. Journal of Women and Minorities in Science and Engineering, 7, 269-283.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. Journal of Research in Science Teaching, 43(5), 485-499.

Brouwers, A., & Tomic, W. (2000). A longitudinal study of teacher burnout and perceived self-efficacy in classroom management. Teaching and Teacher Education, 16(2), 239-253.

Cattell, R. B., & Scheier, I. H. (1961). The meaning and measurement of neuroticism and anxiety. New York: Ronald.

Chiappetta, E. L., & Koballa, T. R. (2005). Science instruction in the middle and secondary schools (6th ed.). Prentice Hall.

Coladarci, T. (1992). Teachers' sense of efficacy and commitment to teaching. Journal of Experimental Education, 60(4), 323-337.

Czerniak, C. M. (1989). An investigation of the relationships among science teaching anxiety, self-efficacy, teacher education variables, and instructional strategies. Unpublished doctoral dissertation, The Ohio State University, Columbus.

Czerniak, C. M., & Schriver, M. (1994). An examination of preservice science teachers' beliefs and behaviors as related to self-efficacy. Journal of Science Teacher Education, 5(3), 77-86.

Danielson, C. (2007). Enhancing professional practice: A framework for teaching (2nd ed.). Alexandria, Va: Association for Supervision and Curriculum Development.

Darling-Hammond, L. (2000). Teacher quality and student achievement: A review of state policy evidence. Education Policy Analysis Archives, 8(1), 1-48.

Darling-Hammond, L., & McLaughlin, M. W. (1995). Policies that support professional development in an era of reform. Phi Delta Kappan, 76(8), 597-604.

Dobley, D. C., & Schafer, L. E. (1984). The effects of knowledge on elementary science inquiry teaching. Science Education, 68(1), 39-51.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. School Science and Mathematics, 90(8), 694-706.

Enochs, L. G., Scharmann, L. C., & Riggs, I. M. (1995). The relationship of pupil control to preservice elementary science teacher self-efficacy and outcome expectancy. Science Education, 79(1), 63-75.

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. Journal of Educational Psychology, 76(4), 569-582.

Glickman, C. D., & Tamashiro, R. T. (1982). A comparison of first-year, fifth-year, and former teachers on efficacy, ego development, and problem solving. Psychology in the Schools, 19(4), 558-562.

Goldhaber, D. (2002). The mystery of good teaching: Surveying the evidence on student achievement and teacher's characteristics. Education Next, 2(1), 50-55.

Goodlad, J. I. (1984). A place called school: Prospects for the future. New York: McGraw-Hill.

Henson, R. K. (2001, January). Teacher self-efficacy: Substantive implications and measurement dilemmas. Paper presented at the annual meeting of the Educational Research Exchange, Texas. (ERIC Document Reproduction Service No. ED 452208).

Hunt, J. B., Jr. (2003). Unrecognized progress. Education Next, 3(2), 24-27.

Keegan, L. G. (2003). Help wanted. Education Next, 3(2), 28-31.

Mallow, J. V. (1981). Science anxiety: Fear of science and how to overcome it. New York: Thomond Press.

National Research Council (U.S.). (1996). National science education standards: Observe, interact, change, learn. Washington, DC: National Academy Press.

Pajares, F., Miller, M. D., & Johnson, M. J. (1999). Gender differences in writing self-beliefs of elementary school students. Journal of Educational Psychology, 91(1), 51-61.

Ramey-Gassert, L., Shroyer, M. G., & Staver, J. R. (1996). A qualitative study of factors influencing science teaching self-efficacy of elementary level

teachers. Science Education, 80(3), 283-315.

Riggs, I. M. (1995, March). The characteristics of high and low efficacy elementary teachers. Paper presented at the annual meeting of the National Association of Research in Science Teaching, San Francisco, CA.

Spielberger, C. D. (1966). Theory and research on anxiety. In C. D. Spielberger (Eds.), Anxiety and behavior, (pp. 3-20). New York: Academic Press.

Spielberger, C. D. (1991). Manual for the state-trait anxiety inventory STAI. Palo Alto, CA: Consulting Psychologists Press.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. Review of Educational Research, 68(2), 202-248.

Turner, T., & DiMarco, W. (1998). Learning to teach science in the secondary school: A companion to school experience. London: Routledge.

Victor, E. (1961). Why are elementary school teachers reluctant to teach science? The Science Teacher, 27(7), 17-19.

Weiss, I. R., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). Report of the 2000 national survey of science and mathematics education. Chapel Hill, NC: Horizon Research.

Westerback, M. E. (1982). Studies on attitude toward teaching science and anxiety about teaching science in preservice elementary teachers. Journal of Research in Science Teaching, 19(7), 603-616.

Westerback, M. E. (1984). Studies on anxiety about teaching science in preservice elementary teachers. Journal of Research in Science Teaching, 21(9), 937-950.

Westerback, M. E., & Gonzalez, C. (1985). Comparison of preservice elementary teachers anxiety about teaching students to identify minerals and rocks and students in geology course anxiety about identification of minerals and rocks. Journal of Research in Science Teaching, 22(1), 63-79.

Woolfolk, A. E., & Hoy, W. K. (1990). Prospective teachers' sense of efficacy and beliefs about control. Journal of Educational Psychology, 82(1), 81-91.

Wright, P., Horn, S., & Sanders, W. (1997). Teachers and classroom heterogeneity: Their effects on educational outcomes. Journal of Personnel Evaluation in Education, 11(1), 57-67.

Zuckerman, M., & Lubin, B. (1965). Manual for the multiple affect adjective check list (pp. 23). San Diego, CA: Educational and Industrial Testing Service.

Appendix. Science Teaching-Anxiety Questionnaire (STAQ)

The STAQ, which translated into English, scored on a Likert-scale ranging from 1 (low level of anxiety) to 5 and items 1, 7, 11, 22, 28, and 31 are reverse scored.

Anxiety scales	Factors of science teaching-anxiety	Items (reverse scored item)
Trait anxiety	Trait anxiety about nature of science	1 - 5 (1)
	Trait anxiety about science teaching	6 - 10 (7)
State anxiety	State anxiety about instruction	11 - 16 (11)
	State anxiety about science activities	17 - 22 (22)
	State anxiety about student assessment	23 - 28 (28)
	State anxiety about professional responsibilities	29 - 33 (31)

1. Knowing science concepts, I could understand the world with joy.
2. I am nervous when I have to be with scientists because I have nothing to talk to him/her.
3. I easily get tired when I am doing scientific activities.
4. I am afraid that advances in science and technology may destroy humanity.
5. I am worrying about machines which I use, are out of control.
6. I want to get away from teaching science.
7. I do not worry about teaching science, because I am well educated with science concepts.
8. It is a very difficult for me to understand science curriculum.
9. It is difficult for me to choose adequate strategies to teach science.
10. I have no idea where I can get instructional materials and resources for science classes.
11. It is easy for me to meet various needs of every student.
12. I feel panic during science classes, because I have no idea what I should teach.
13. I have groundless fears about teaching science.
14. I am worrying about students' misunderstanding because of my poor ways of delivering science concepts.
15. I am worrying that students may not concentrate in class.
16. I become easily embarrassed when students ask questions about science.
17. I do not want to have laboratory activities because they seem dangerous.
18. I would follow other teacher's lesson plan since preparing laboratory activities is hard to me.
19. Laboratory activities make me nervous because it is disordered and hard to control.
20. I am not comfortable with operating laboratory equipments because of the lack of skills.
21. We, I and students, can never get accurate results of experience, only scientist can do.
22. I am excited when thinking of managing science festivals.
23. It is not easy to design assignments to meet the strategies of lesson plans.
24. Assessment-related work makes me tired and exhausted.
25. I am worrying about designing criteria and standards.
26. I become nervous and distracted because making assessment is a very stressful work.
27. I want to avoid doing 'performance assessments' because it is difficult to evaluate.
28. I am willing to open my reporting results to others.
29. I would be nervous if education-related experts visit my classes.
30. It is hard to give career advice to students who are interested in taking science-related jobs later on.
31. I am confident to help students to develop scientific literacy.
32. I am too jumpy to put my voice when I participate in a professional community.
33. Because I am not confident with my science teaching, I am depressed when participating in professional development programs for science teachers.