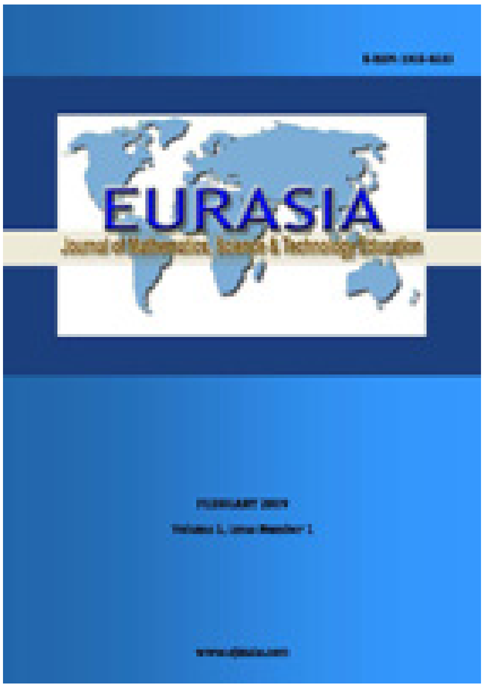
Eurasia Journal of Mathematics, Science & Technology Education
www.ejmste.com



Using Mathematics in Teaching Science Self-efficacy Scale – UMSSS: A Validity and Reliability Study

Bilge Taşkın Can
Pamukkale Üniversitesi, Denizli, TURKEY

Berna Cantürk Günhan
Dokuz Eylül Üniversitesi, İzmir, TURKEY

Sevinç Öngel Erdal
Ohio State University, Columbus, USA

Received 18 May 2011; accepted 19 May 2012
Published on 28 October 2012

APA style referencing for this article: Can, B.T., Gunhan, B. C. & Erdal, S. O. (2012) Using Mathematics in Teaching Science Self-efficacy Scale – UMSSS: A Validity and Reliability Study. *Eurasia Journal of Mathematics, Science & Technology Education*, *8*(4), 269-281.

Linking to this article: DOI: 10.12973/eurasia.2012.845a

URL: http://dx.doi.org/10.12973/eurasia.2012.845a

ISSN: 1305-8223 (electronic) 1305-8215 (paper)

The article starts with the next page.

Eurasia Journal of Mathematics, Science & Technology Education, 2012, **8**(4), 269-281

Using Mathematics in Teaching Science Self-efficacy Scale – UMSSS: A Validity and Reliability Study

Bilge Taşkın Can
Pamukkale Üniversitesi, Denizli, TURKEY

Berna Cantürk Günhan
Dokuz Eylül Üniversitesi, İzmir, TURKEY

Sevinç Öngel Erdal
Ohio State University, Columbus, USA

Received 18 May 2011; accepted 19 May 2012

In this study, an instrument, Using Mathematics in Science Self-efficacy Scale (UMSSS), was developed in order to determine preservice science teachers' self-efficacy toward the use of mathematics in their lessons. Data gathered from 250 preservice science teachers were used for Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The factor analysis revealed 3 factors: Self Perception of Mathematics (SPM), Utilization of Mathematics (UM), and Mathematical Skills (MS). The cronbach alpha coefficient for the overall instrument was computed 0.88. The analyses resulted in the development of a three-factor scale of 18 items that was shown to be valid and reliable. At the same time, this instrument is also the first original instrument developed for determining the preservice science teachers' self-efficacies toward the use of mathematics in their lessons.

Keywords: self-efficacy beliefs, science, teacher education, mathematics

INTRODUCTION

Teachers' beliefs, attitudes and behavior are important for understanding and improving educational process. Studies indicate a strong relationship among teachers' attitudes, beliefs and behavior (Koballa and Crawley, 1985; Pajares, 2002). Koballa and Crawley (1985) use the following example to describe this relationship; "elementary school teachers judged their ability to teach science to be low (belief), resulting in a dislike for science teaching (attitude) that ultimately translated into teachers who avoided teaching science (behaviour)" (cited in Tosun, 2000).Considering the relationship described above, peoples' self-beliefs in most cases are the foundations of their positive attitudes which give rise to positive behavior (Schunk & Zimmerman, 2008). Most of the studies that aim to determine self-efficacy beliefs are based on Banduras' definition of self-efficacy in the late 70's (Bursal & Paznokas, 2006; Enochs & Riggs, 1990; Guskey & Passaro, 1994, Hill, Rowan, Ball, 2005; Swars, Hart, Smith, Smith, & Tolar, 2007; Tschannen-Moran & Woolfolk-Hoy, 2007; Yilmaz-Tuzun & Topcu, 2008). Bandura (1997) defined self-efficacy belief as the "judgments of how well one can execute courses of action required to deal with prospective situations" (p. 122). Self-efficacy has a central role in learning that it contributes to one's motivation to learn (Bandura, 1997; Dornyei, 2009; Huang& Chang, 1998).

Correspondence to: Bilge Can, Assistant Professor of Science Education, Pamukkale Üniversitesi, Eğitim Fakültesi, Denizli, TURKEY
E-mail: *bilgecan@pau.edu.tr*

ISSN: 1305-8223

State of the literature

- There are limited researches on pre-service teachers' self-efficacy beliefs about using mathematics in teaching science.
- The current literature suggests that the level of the ability of using mathemathics enhances learning science.
- Researchers may have become interested in how teacher self-efficacy beliefsaffect the use of mathematics in teaching science. This scale will use some research that focuses on self-efficacy beliefs on using mathematics in science teaching.
- Teacher educators can improve their perspectives on self-efficacy beliefs on using mathematics in teaching science through this study.

Contribution of this paper to the literature

- Through this study, the science teachers can become more aware of their ability and their self-efficacy beliefs on using mathematics.
- Teachers and pre-service teachers can connect two disciplines in their teaching such as using mathematics in teaching science. In this way, they can transfer what they have learned to other disciplines.
- Through this scale, it is possible to analyze self-efficacy beliefs under three subscales: a) Self-perception of mathematics, b) utilization of mathematics, and c) mathematical skills.

Teacher Self-efficacy and Integration

Brody and Davidson (1998) suggested teachers' beliefs may have the greatest impact on teachers' attitudes and behavior in the classroom, such as what they do in the classroom and the ways they conceptualize the instructional process. Similarly, Tschannen-Moran and Woolfolk Hoy (2001) proposed that teachers' self-efficacy beliefs also influence their students' motivation, their achievement drive and their self-efficacy beliefs. When individuals perceive high self-efficacy, they tend to try more time and effort to accomplish the task (Pajares, 2003).

In the last decade, there has been an increasing emphasis on interdisciplinary relationships and approaching problems from multidimensional perspectives for meaningful teaching and learning. Science, mathematics and technology are considered the three disciplines that are most likely to be integrated due to the similarities in their practice areas and their approaches in problem solving process (National Research Council [NRC], 1996). Despite the fact that science (Britner, 2008; Bryan, Glynn and Kittleson, 2010; Karaaslan and Sungur, 2011; Riggs and Enochs, 1990) and mathematics teachers' beliefs (Heneman, Kimball, Milanowski, 2007; Hoffman, 2010; Kahle, 2008; Klassen, Bong, Usher, Chong, Huan, Wong and Georgiou, 2009; Kranzler and Pajares, 1997; Swackhamer, 2010) have long been investigated in educational settings and few studies investigated the integration between them (Huntley 1998; Roebuck and Warden, 1998; Basista and Mathews, 2002; Berlin and White 2010; Kıray, 2010). In their continuum models, Huntley (1998), and Roebuck and Warden (1998) define a mid-point where mathematics and science are truly integrated. The models represent teaching and learning mathematics and science on both ends of the continuum, and increased infusion of each discipline towards the mid-point. (Increased infusion points describe teaching mathematics with science and teaching science with mathematics). Besides, these studies report that the mid-point of the continuum (mathematics and science integration) is hard to achieve, and is not a common teaching and learning practice (Ward, 2009). Basista ve Mathews (2002), stated that teachers need to understand the content of science and mathematics in depth and lack of knowledge in their content knowledge cause their self-efficacy to be low. Similarly, Newton et. al. (2012) also indicated that a positive moderate relationship between content knowledge and personal teaching efficacy was found in their study. Berlin and White (2010), in their study, applied the program of science and mathematics integration to the preservice teachers. When the program was completed, the students found the program quite difficult, and defined the obstacles and difficulties. In spite of this, at the end of the study, it was established that the program prepared for the integration of mathematics, science and technology positively changed the students' attitude and perceptions. Similarly, Kıray (2010), in his/her research, found that the group, to which the program created grounding on science and mathematics integration in elementary 8th grade Science and Technology and mathematics subjects was applied, was more successful than the one to which the present program of the Ministry of Education was applied. As aresult, it was mentioned in various studies that the integration of the fields of science and mathematics produced positive results and may increase the success (Basson, 2002; Furner & Kumar, 2007). In this case, in order for the integration of science and mathematics to be practiced, defining the competences on this subject is of great importance while teacher candidates are being trained.

Measuring Teachers' Mathematics and Science Efficacy

The concept of teacher efficacy has been measured in numerous ways in earlier literature (See Table 1 for a listing of instruments). Although the history of the measurement of self-efficacy spans the last 30 years, presently the most widely-accepted measure of the concept is the Teacher's Sense of Efficacy Scale, or TSES (Tschannen Moran & Woolfolk Hoy, 2001). The TSES measures three constructs: efficacy for instructional strategies, efficacy for student engagement, and efficacy for classroom management.

Gibson and Dembo (1984) developed the Teacher Efficacy Scale (TES), which centered around two factors. These factors consist of the belief in ones' ability to teach effectively, which is the personal teaching efficacy; and the belief that effective teaching will have a positive effect on student learning, which is the teaching outcome expectancy. Guskey and Passaro (1994) on the other hand, reconstructed the scale developed by Gibson and Dembo and named the factors as the internal and external factors. Internal factors are defined as the efficacy beliefs about the influence of teachers on student learning, whereas external factors are defined as the outside factors that cannot be controlled by the teacher and are located outside of the classroom environment.

Based on Fuller's (1969) concern theory, Hall, Wallace and Dosset (1973) developed an evidence-based conceptual framework, called the Concern Based Adoption Model (CBAM). The CBAM provides a construct that helps measure, describe and explain the change process of teachers who are adopting reformed curriculum materials or new instructional practices into their teaching (Anderson, 1997). In this model, the teachers can have concerns in different stages in the process of change, therefore based on these different concerns they need differentiated support, and guidance (Hord et al., 1987).

The CBAM is composed of three dimensions: (a) Stages of Concerns dimension shows teachers' perceptions and feelings about educational innovations, (b) Levels of Use dimension indicates how teachers implement innovations and (c) Innovation Configurations dimension shows the different ways an innovation is implemented. As the focus of this study is on teachers' concerns about reformed curriculum, the Stages of Concern dimension of the CBAM that includes affective aspect of change will be used in this study.

The most popular and widely used scales in science and mathematics are the Science Teaching Efficacy Beliefs Instrument-STEBI (Enochs & Riggs, 1990) and Mathematics Teaching Efficacy Beliefs Instrument-MTEBI (Enochs, Smith, & Huinker, 2000). Both of these instruments explored self-efficacy in two dimensions (self-efficacy beliefs and outcome expectancy beliefs) as described in Banduras' social learning theory.

Science and mathematics are not bodies of knowledge meant to be indoctrinated into students. By encouraging constructivist philosophies of learning, pre-service teachers may begin to alter their conceptions of

Table 1. Existing Self-efficacy instruments

Author	Title	Theoretical Basis
Guskey (1981)	Responsibility for Student Achievement questionnaire (RSA)	Rotter's Social Learning Theory
Ashton et al. (1982)	Ashton Efficacy Vignettes	Bandura's theory of self-efficacy from Social Cognitive Theory
Betz & Hackett (1983)	Mathematics Self-Efficacy Scale (MSES)	Bandura's theory of self-efficacy from Social Cognitive Theory
Gibson & Dembo (1984)	Teacher Efficacy Scale (TES)	Bandura's theory of self-efficacy from Social Cognitive Theory
Riggs & Enochs (1990)	Science Teaching Efficacy Belief Instrument (STEBI)	Bandura's theory of self-efficacy from Social Cognitive Theory with items taken from the TES
Bandura (1997)	Teacher Self-efficacy Scale (TSS)	Bandura's theory of self-efficacy from Social Cognitive Theory
Enochs et al. (2000)	Mathematics Teaching Efficacy Belief Instrument (MTEBI)	The STEBI modified to be math-specific. Bandura's theory of self-efficacy from Social Cognitive Theory with items taken from the TES
Tschannen-Moran & Woolfolk Hoy (2001)	Teacher's Sense of Efficacy Scale (TSES) formerly the Ohio State Teacher Efficacy Scale	Bandura's theory of self-efficacy from Social Cognitive Theory with Likert-scale from the TSS
Dellinger et al. (2008)	TEBS-Self	Bandura's theory of self-efficacy from Social Cognitive Theory

science and mathematics, and realize the importance of explanations and communication in scientific and mathematical thinking. Moreover, through questioning their own perceptions of mathematics and science, preservice elementary teachers may become more adept at noting the similarities and differences in teaching science and mathematics (Yilmaz-Tuzun & Topcu, 2008). Yet, some researchers (i.e. Basista and Mathews, 2002; Frykholm and Glasson, 2005; Gürdal, 1997; Meisel, 2005) assert that preservice teachers cannot even partially connect two disciplines in their teaching such as using mathematics in teaching a science lesson. That is, the teachers cannot transfer what they have learned to other disciplines. Besides, in some researches, a negative correlation between preservice teachers' mathematics anxiety and their mathematics teaching efficacy was found (Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006).

Self-efficacy scales previously described have failed to determine in-service and preservice teachers' self-efficacy beliefs toward the use of one discipline in another (Enochs et. all. 2000; Ertkin and Ader, 2004; Richardson and Ling, 2008). There is a need to develop self-efficacy scales to examine the use of one discipline in another for effective practice. In this study, an instrument, Using Mathematics in Science Self-efficacy Scale (UMSSS), was developed in order to determine preservice science teachers' self-efficacy toward the use of mathematics in their lessons. In addition, it is thought that thanks to this scale, determination of the existence of self-efficacies of the teacher candidates toward the use of mathematics in science lessons and also determining its level will be helpful to the process of the application and improvement of teacher training program. However, there has not been such an instrument developed towards Science teachers' perceptions of Self Efficacy in terms of the use of mathematics in science teaching in our country. The basic movement point of this study is the absence of such an instrument towards Turkish preservice science teachers. Furthermore, the validity and reliability of the instrument were established.

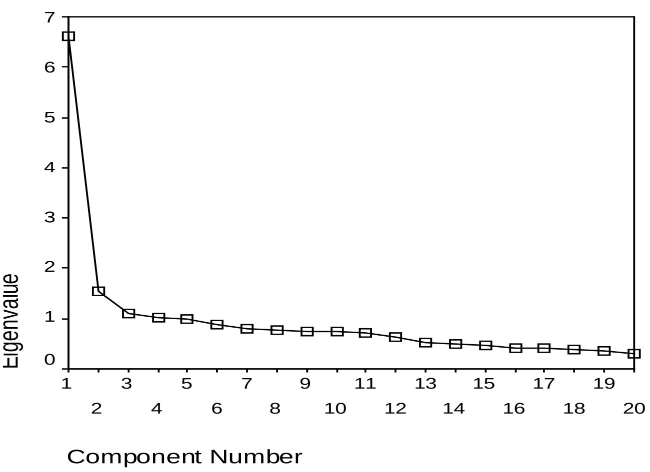


Figure 1. Scree Plot

METHOD

In this study, the validity and reliability of scale was investigated by using internal reliability investigation and factor analysis techniques and survey technique was used as data collection way. .

Participants

The participants of this study were 250 elementary preservice science teachers who were enrolled in a teacher education program in a large state university of Turkey in the spring semester of 2004. The sample consisted of 56.4% males (nm=141) and 43.6% females (nf=109). The age of preservice science teachers varied from 18 and 22. A total of 54 (21.6%) participants from first grade, 67 (26.8%) participants from second grade, 68 (27.2%) participants from third grade, and 61 (24.4%) participants from fourth grade were recruited for the study. Preservice teachers were informed about the main goal of the research, anonymity, and voluntary participation. This scale was administered to these participants by lectures.

The Instrument Development Process

To develop the scale, firstly the literature review was done and scales about self-efficacy were analyzed (see Table 1 for instrument lists). Self-efficacy items were written by investigators for trial and it included 20 items. After, two science and mathematics educators, one science and mathematics teachers' views about items were noted. With respect to their views, the scale was given its final form and the scale included 20 items. The scale has been applied to four preservice science teachers to check readability, understandability and time requirement.The scale was administered by a lecture to these fourth-grade preservice teachers who were randomly selected. They have not reported any sentence about these. Then, the sub-dimensions of the scale were determined according to the factor analysis. During the preparation of the directive, to measure his/her own perception about self-efficacy, the scale was designed in the five-grade Likert format, based on the opinions of an expert in assessment field, to be answered. The items of scale have the following five response categories: Never (1), Seldom (2), Sometimes (3), Frequently (4), Always (5). After the factor analysis, the 5 point Likert scale instrument consisted of 18 items (Appendix 1). Negative items are scored as the opposite form of grading which is above possible scores on the instrument range from 18 to 90. The increase in the scores shows that individual's self-efficacy beliefs of using mathematics in science course is high, the decrease in the scores shows that it is low. Questionnaires took approximately 8-10 minutes to complete.

Analysis

Exploratory factor analysis including principal components analysis was employed to determine the factor structure of scale. After, factors were evaluated using a confirmatory factor analysis. Additionally, item-total correlations were calculated to determine the reliability of the scale, as well as the intercorrelations between the three subscales. Then, the factors were evaluated using a confirmatory factor analysis. Finally, internal reliability values on the factors were also analyzed by using Cronbach alpha reliability. The data were analyzed with the statistical software packages, SPSS 15.00 and Lisrel 8.51.

FINDINGS AND RESULTS

Validity and Reliability of the Instrument

Content Validity

Content validity indicates whether the items constituting the scale are quantitatively and qualitatively adequate for measuring the property intended to be measured (Büyüköztürk, 2006). To provide content validity of the scale, two science and mathematics educators, one science and mathematics teachers' views about items were taken and their coherence about subject was determined. According to their opinions, the scale was given its final form by omitting and revising some items. As a result, the preliminary scale initially included 20 items.

Construct Validity

For science teachers, to determine which sub-structures were formed by self-efficacy beliefs about using mathematics in science education, and to provide construct validity, exploratory factor analysis was used at the beginning. Then, confirmatory factor analysis was conducted to provide "fit index values" for further use of the scale.

Exploratory Factor Analysis

Science teachers' perceptions of Self Efficacy in terms of the use of mathematics in science teaching, which consists of sub-structures to ensure the validity of the exploratory factor analysis was used to determine the structure. Data analyzed by using the statistical package SPSS 10.0. Before conducting the factor analysis, it was first examined whether or no the sample was appropriate for the factor analysis. For this purpose, Kaiser-Meyer-Olkin (KMO) value was determined to be 0.89 which can be placed in the 0.80 - 0.89 range (very good) as defined by Pallant (2001). Furthermore, Bartlett's Spherecity Test was run to check whether the data represent a multivariate normal distribution. The test resulted in Approx. Chi-Square: 1564,09 and $p< .01$, which shows that the results are significant.In this study, the principal component analysis proposes four factors for the exploratory factor analysis to be carried out. However, one important point to be assessed while deciding on factor number is the significance of the contribution each factor made to total variance (Çokluk, Şekercioğlu, and Büyüköztürk, 2010, 230). In this case, it is seen that this contribution from the four components onwards diminishes when the screen plot graphic is taken into account (Figure 1). In such a situation, it can be decided that the number of factors is determined as three. Furthermore, each gap between the two points in the screen plot graphic means one factor (Çokluk, Şekercioğlu, and Büyüköztürk, 2010, 231). On the Screen Plot, graphic produces a sloping plato after the 4th components. In terms of this perspective, the number of factors was decided to be 3.

Later, these factors were analyzed with varimax rotation and it was found that two items did not fall in any of the factors. The scale includes 18 items in its final form. Table 2 presents the distribution of the items by factors, Factor 1 loadings of the items before the rotation factor loadings and factor common variances after varimax rotation given in Table2.

It was found that the three factors explain the 47,111% of the total variance; Self Perception of Mathematics (SPM 15.997%), Utilization of Mathematics (UM 15.943%), and Mathematical Skills (MS 15.171%). The first factor, Self Perception of Mathematics, was composed of the items 5, 6, 7, 9 and 11 and correspond to the awareness of teachers' behaviour concerning mathematics. The second factor, Utilization of Mathematics, was composed of the items 12, 13, 15, 17, 18 and 19 and correspond to the beliefs about the ability to use mathematics in teaching science. Finally, the third factor, Mathematical Skills, was composed of the items 1, 2, 3, 4, 8, 10, and 20 and correspond to the teachers' self-efficacy beliefs about the ability to utilize mathematical skills in science lessons (Table 3).

Table 2. Exploratory Factor Analysis Results

Item No	Before the rotation **Factor 1 Loadings**	Factor Loadings after the Rotation **Factor 1**	**Factor 2**	**Factor 3**	**Factor Common Variances**
5	.476	.567*			.360
6	.560	.692*			.541
7	.581	.745*			.612
9	.687	.608*			.551
11	.520	.434*			.306
12	462		.518*		.374
13	.714		.577		.557
15	.602		.632		.535
17	.605		.663*		.535
18	.555		.621		.452
19	.573		.588*		.430
1	.635			.604	.498
2	.572			.305*	.371
3	.575			.611	.480
4	.426			.780	.630
8	.430			.560	.412
10	.612			.408	.387
20	.609			.533	.446

Total: % 47.111;
Factor -1: % 15.997;
Factor -2: % 15.943;
Factor -3: % 15.171
* The reverse reading of the scale items are scored as negative materials.

Table 3. Factor Name and Items

Factors	Items
Self Perception of Mathematics (SPM)	5. I do not think that I am sufficient enough to teach all kinds of mathematical concepts and rules. 6. I believe that I can solve all the mathematical problems in the science courses if I try hard enough 7. I do not know what to do when I encounter with a mathematical problem in the science courses. 9. I do not possess as much mathematical background as my colleagues in the same department. 11. I do not know how to develop positive attitudes towards mathematics in the science courses
Utilization of Mathematics (UM)	12. I believe that I can not use mathematics in science courses effectively. 13. I can have my students understand the connection between science and mathematics. 15. I can use the mathematical language well in teaching science. 17. I cannot instruct the students on the significance of mathematics in science lessons. 18. I believe that I can help the students to solve their problems related to mathematics. 19. I cannot have logical deductions in science courses by using mathematics.
Mathematical Skills (MS)	1. While teaching science, I feel that I internalize the mathematical concepts better 2. I do not have the necessary mathematical thinking skills to teach the concepts in science. 3. I can increase the success in science by my mathematical skills. 4. I can teach one of the aims of science course, critical thinking, through mathematics. 8. I may have a solution for all kinds of daily life problems in science courses through a mathematical approach. 10. I believe that I can improve the students' problem solving skills through mathematics. 20. I can improve the students' problem solving skills in science courses through a variety of mathematical games.

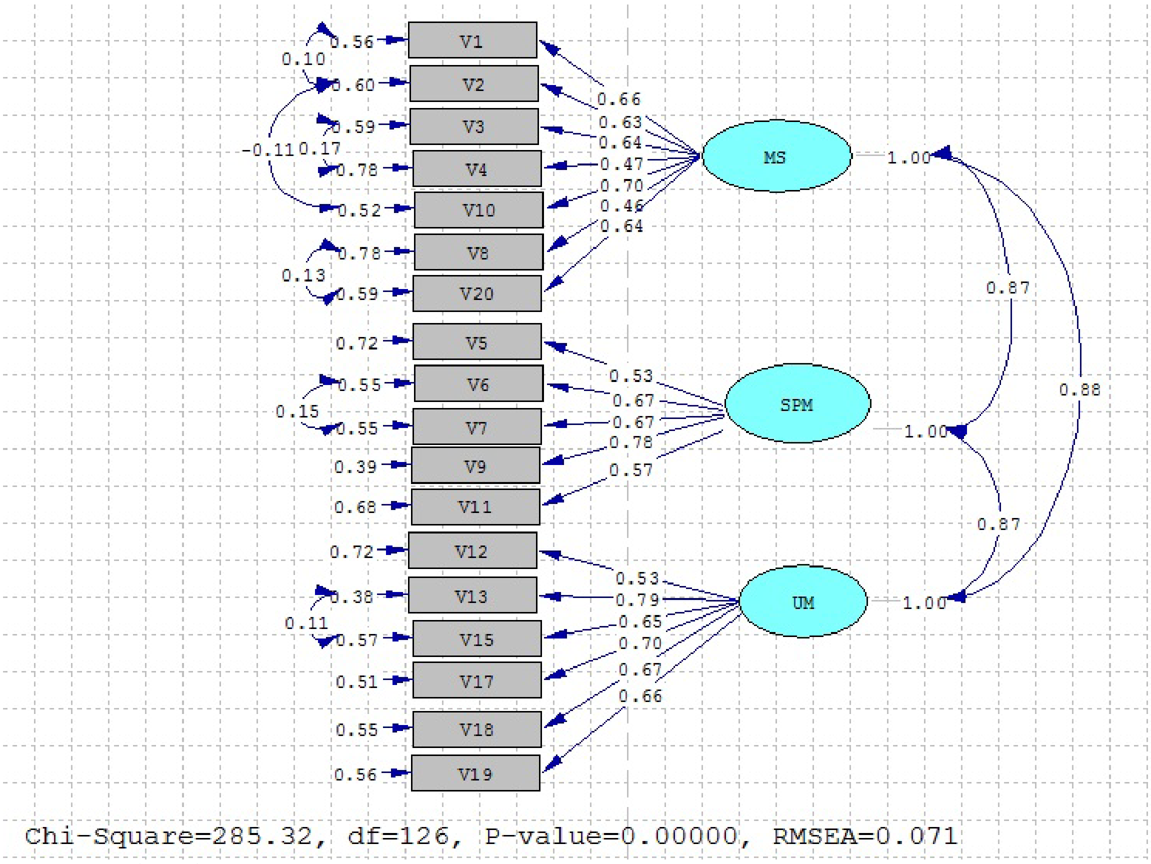


Figure 2. The Three Factor Model-First Order CFA and the Standardized Solutions
MS- Mathematical Skills, SPM-Self Perception of Mathemat ics, UM-Utilization of Mathematics

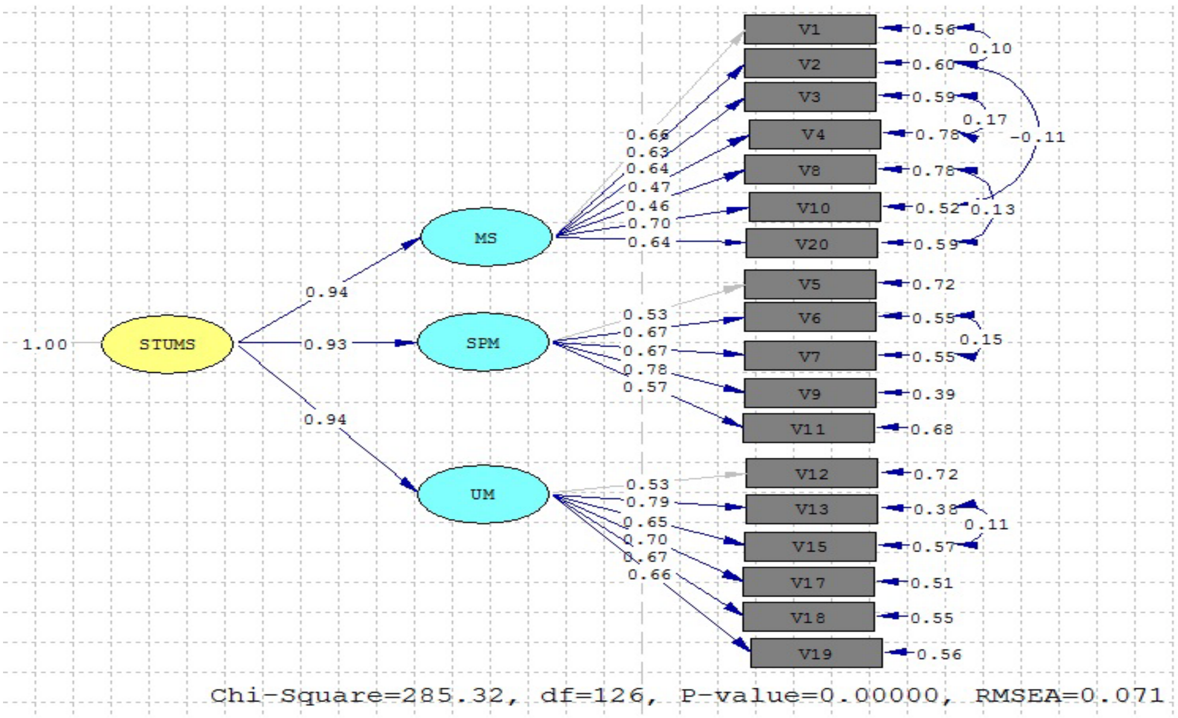


Figure 3. Diagram Generated for Second Order CFA and the Standardized Solutions

Confirmatory Factor Analysis

Confirmatory factor analysis was conducted by using LISREL 8.51 program. There are several criteria which are considered as an indication of good fit of the factorial structure (Hooper, Coughlan, and Mullen 2008; Kelloway 1989; Kline 2005; Sümer 2000 cited in Çokluk, Şekercioğlu, and Büyüköztürk 2010, Şimşek 2007): (1) higher than .90 value for Comparative Fit Index (CFI) and Goodness of Fit Index (GFI), (2) the adjusted goodness-of-fit index (AGFI) such that 0.85 or above indicates an acceptable fit, (3) Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) such that value less than .05 indicates a good fit and values as high as 0.08 are deemed acceptable and (4) 3 or lower value for $\chi 2/df$ ratio indicates a good fit (Byrne, 1998; Hu and Bentler, 1999). Thanks to CFA, both power of representation of the substances were investigated and the relationshipsof the sub-dimensions between one another and the basic dimension were assessed. While the comfirmatory factor analysis results were being interpreted, primarily a three-factor model (the first level CFA) was revised (Figure-2).

When the Figure 2 is examined it is seen that path coefficients (standardized regression coefficients) vary between 0,46 and 0,79. The range of path coefficients for each sub-dimension is as follows: 0,46-0,70 for MS dimension, 0,53-0,78 for SPM dimension, and 0,53-0,79 for UM dimension. The goodness of fit indices of the model was found at an acceptable level (χ^2=285,32 df=126, χ^2/df=2.26, CFI=0.90, GFI=0.89, AGFI=0,85 RMSEA=0.071, and SRMR= 0.053). And correlation between SPM and MS, UM and SPM, MS and UM were respectively 0.87, 0.87, 0.88 suggesting considerable overlap between the factors. In addition to these processes, it was determined that there is more relationship between/among the substances depending on modification indices than the model prediced and error covariance was added between the two variables. It was natural that there is more relationships between these items. Because they are in same factor.

The proposed model was tested with the second level DFA. The last model created in this part reflects a "second level" model in which the predicted three sub-dimensions represented "UMSSS" variable in significant relationships. Thanks to the promotion of this model, it will be indicated that self-efficacy beliefs of the teacher candidates can multi-dimensionally measured and the basic characteristics measured are related to a top-level factor (UMSSS). Analysis results performed from this thought were presented in Figure-3.

As seen in Figure-3, there are 3 pieces of first factors and one piece of second factor in the last model, and coherence coefficients of the model are at acceptable level as those in the first level (χ^2=285,32 df=126, χ^2/df=2.26, CFI=0.90, GFI=0.89, AGFI=0,85 RMSEA=0.071, and SRMR= 0.053). Both of the three factor and the second-order hierarchical models generated kabul edilebilir düzeydedir.

And correlation between SPM and UMSSS, UM and UMSSS, MS and UMSSS were respectively 0,93, 0,94, 0,94 suggesting considerable overlap between the factors. Consequently, the three-factor UMSSS scale, composed of 18 items, is confirmed as a model.

Internal Consistency Reliability

To determine the internal consistency, the corrected item-total correlations were calculated. Besides, the total score was determined according to the scores of the top 27% and bottom 27% of the difference between groups by using t test for significance (Table 4).

Table 4. Corrected Item-Total Correlation and *t* values

Factor	Item Number	Corrected item total correlation	*t*-value
Self Perception of Mathematics	5	.435	-8,48
	6	.495	-10,05
	7	.502	-9,60
	9	.618	-13,54
	11	.447	-8,52
Utilization of Mathematics	12	.396	-7,84
	13	.635	-10,50
	15	.507	-8,89
	17	.541	-9,41
	18	.491	-10,07
	19	.504	-9,31
Mathematical Skills	1	.560	-9,65
	2	.504	-9,65
	3	.520	-9,31
	4	.364	-5,81
	8	.372	-7,14
	10	.540	-9,22
	20	.544	-10,24

* $p<.05$

According to the Table 3, corrected total item correlations of the scale ranged from 0.635 to 0.364. Since obtained item test correlation coefficient is found not to be negative, zero or close to zero (Tavşancıl, 2005), the tool has high internal consistency and construct validity can be said to exist. According to the t test results between the groups 27% of top and 27% of lower, the mean scores of substances, significant differences were found for all substances. These findings indicate that all items were discriminative. In addition, the relationship between the scale factors was checked to determine the correlation between the factors and the obtained results are given Table 5.

As show in Table 5, there is a positively significant relationship between the factor scales and between the factors and total scores. These correlations provide support for the multidimensionality of the scale.

The internal consistency estimates of reliability (Cronbach's alpha coefficient) were computed for the scales representing the three factors (Table 6).

Self-perception of mathematics, utilization of mathematics and mathematical skills all had acceptable alpha levels (0.72, 0.76, 0.76 respectively). The overall reliability was determined to be 0.88.

Descriptive Statistics

In the interpretation of the answers the teacher candidates provided, the difference determined width breadth of score interval within the groups was determined. The value of group interval coefficient was obtained with the division of the "difference between highest value in the series of evaluation results and the lowest value into the number of groups determined (Kan, 2009, s. 407)". In this study, group interval coefficient value was calculated as (5–1)/5=0.80 and the following intervals were predicated on in the evaluation of the answers obtained with the application of the scale: 4.21–5.00 "always", 3.41–4.20 "frequently", 2.61–3.40 "sometimes", 1.81–2.60 "seldom", 1.00–1.80 "never". Also, the highest score to be taken from this scale is 90, and lowest score 18.

When the Table 7 is examined, it is seen that the teachers' views regarding the three sub-dimensions of UMSSS scale (SPM, UM, MS) and concerning the whole scale correspond to the interval of "frequently". Based on this discovery, it is understood that the standpoints of teacher candidates to UMSSS information are positive and the candidates' perceptions that they can perform the denoted skills are high.

CONCLUSIONS AND RECOMMENDATIONS

The present study was aimed to develop the UMSSS in order to determine preservice teachers' beliefs of their self-efficacy toward the use of mathematics in science. Researchers have not yet examined the efficacy beliefs of teachers in an integrated teaching practice

Table 5.Correlations between the Factors of the Scale

Scale	Number of items	Mean	Standard deviation	Correlation Factor1	Factor 2	Factor 3	Total
SPM	5	19,38	3,84	-			
UM	6	23,50	4,40	.598**	-		
MS	7	26,22	4,55	.582**	.607**	-	
Total	18	69,12	10,95	.834**	.864**	.865**	-

** p<0.01

Table 6.The Scale Factors of the Cronbach Alpha Coefficients

	n	Self Perception of Mathematics	Utilization of Mathematics	Mathematical Skills	Total
Cronbach Alpha reliability coefficient	250	0.72	0.76	0.76	0.88

Table 7. Descriptive statistics belonging to the sub-dimensions of UMSSS and to the whole scale

Subscale and Scale	n	$\bar{X}$	sd
SPM	250	3,98	0,94
UM	250	4,08	0,91
MS	250	3,88	0,84
UMSSS	250	4,02	0,78

which many researchers suggest to have a positive effect on student achievement (e.g. Koballa & Bethel, 1984; Friend, 1985). UMSSS is a distinct instrument dealing with beliefs regarding the use of one discipline in another. In this study, validity evidence on content and construct validities have shown consistency between the purpose and the items of the instrument. Following the statistical analyses, a three-factor scale composed of eighteen items was developed. The factors of the scale are entitled as follows: a) Self-perception of mathematics, and, b) utilization of mathematics, c) mathematical skills. In addition, internal consistency of the scores has also provided another set of evidence to use the instrument. In sum, the findings of the study showed that the generated scale is a valid and reliable instrument.

This instrument allows for a richer and more detailed analysis of how preservice teacher efficacy changes over time. The information provided by these analyses can enable teacher educators to adapt their instruction to meet the needs of pre-service teachers and purposely facilitate the development of teacher self-efficacy beliefs regarding the use of mathematics while teaching science during the teacher preparation process (Berlin and White, 2010).

In the last decades, both preservice and in-service teachers' beliefs become the center of attention for teacher education research. Researchers have become interested in how teacher self-efficacy beliefs regarding the use of mathematics while teaching science. The instrument appears to be a valid and reliable assessment of the use of mathematics in science lessons based on the population used in this study. It is thought that the fact that the results are shared by applying the studies related to the scale to different sample groups will contribute to the employability of the scale. The validation of the instruments is an ongoing process; therefore, researchers should take this into consideration when utilizing the instrument. We suggest further studies are needed to enhance the reliability and support the validity of the instrument. At the same time, it is thought that this scale will help those who are working on this field to carry out a number of studies as to preservice science teachers' self-efficacy beliefs toward use of mathematics and to the variables depending on this. Moreover, future research needs to consider the efficacy beliefs of teachers in integrating other disciplines such as science and technology.

***Authors' note**

A preliminary version of this paper was presented at the Mid-Western Educational Research Association Conference, 11–14th October 2006, Columbus, USA.

REFERENCES

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and Company.

Basista, B., & Mathews, S. (2002). Integrated science and mathematics Professional development programs. *School Science And Mathematics*, *102*(7), 359–370.

Basson, I. (2002). Physics and mathematics as interrelated fields of thought development using acceleration as an example, *International Journal of Mathematical Education in Science and Technology, 33*(5), 679 – 690.

Bates, A. B., Latham, N., & Kim, J. (2011). Linking preservice teachers' mathematics self-efficacy and mathematics teaching efficacy to their mathematical performance. *School Science and Mathematics, 111(*7), 325-333.

Berlin, D.F., & White, A.L. (2010). Preservıce mathematics and science teachers in an integrated teacher preparation program for grades 7–12: a 3-year study of attitudes and perceptions related to integration. *International Journal of Science and Mathematics Education, 8*, 97-115.

Betz, N. E. & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329-345.

Britner, S.L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical and earth science classes. *Journal of Research in Science Teaching, 45*, 955-970.

Brody, C. M. & Davidson, N. (1998). Professional development for cooperative learning: Issues and approaches. New York: NY: State University of New York Press.

Bryan, R. R., Glynn, S. M., & Kittleson, J. M. (2011). Motivation, achievement, and advanced placement intent of high school students learning science. *Science Education, 14*, 1047-1065.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*, 173–180.

Büyüköztürk, Ş. (2006). *Sosyal bilimler için veri analizi el kitabı.* PegemA Yayınları, Ankara.

Byrne, B.M. (1998). *Structural equation modeling with LISREL, PRELIS and SIMPLIS: Basic concepts, applications and programming.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

Çokluk, Ö., Şekercioğlu, G., & Büyüköztürk, Ş. (2010). *Sosyal Bilimler için çok değişkenli İstatistik SPSS ve Lisrel uygulamaları.* Ankara: Pegem Yayıncılık.

Dornyei, Z. (2009). Motivation and motivating in the foreign language classroom. *The Modern Language Journal, 78,* 273-284.

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,* 695-706.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100,* 194-202.

Erktin, E., & Ader, E. (2004). Sınavda öğrencilerin başarısını neler etkiliyor? (What effects student achievement in examinations?) *Cumhuriyet Gazetesi, 894*, 21.

Friend, H. (1985). The effect of science and mathematics integration on selected seventh grade students' attitudes toward and achievement in science. *School Science and Mathematics, 85*, 453-461.

Frykholm, J., & Glasson, G. (2005). Connecting science and mathematics instruction: pedegogical context knowlege for teachers. *School Science and Mathematics, 105*(3), 127–141.

Furner, J. M., & Kumar, D. D. (2007). The mathematics and science integration argument: a stand for teacher education. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(3), 185-189.

Gürdal, A. (1997). Sınıf öğretmenliği öğrencilerinin fene karşı tutumları ve fen öğretiminde entegrasyonun önemi. *Marmara Universitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi, 9*, 237-253.

Guskey, T. (1981). Measurement of responsibility teachers assume for academic successes and failures in the classroom. *Journal of Teacher Education, 32,* 44-51.

Guskey, T. R., & Passaro, P. D. (1994). Teacher efficacy: a study of construct dimensions. *American Educational Research Journal, 31*, 627-643.

Heneman, H. G., Kimball, S., & Milanowski, A. (2007). The teacher sense of efficacy scale: validation evidence and behavioral prediction. WCER Working Paper No. 2006-7.

Hill, H., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371 – 406.

Hoffman, B. (2010). "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem solving efficiency. *Learning and Individual Differences, 20*, 276-283.

Hu, L.T., & Bentler, P.M. (1999). Cut off criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling, 6(*1), 1-55.

Huang, S. C., & Chang, S. F. (1998). Self-efficacy in learners of English as a second language: Four examples. *Journal of Intensive English Studies, 12*, 23-40.

Huntley, M. A. (1998). Design and implementation of a framework for defining integrated mathematics and science education. *School Science and Mathematics, 98,* 320-327.

Kahle, D. K. B. (2008). How elementary school teachers' mathematical self-efficacy and mathematics teaching self-efficacy relate to conceptually and procedurally oriented teaching practices. (Doctoral dissertation). Retrieved from Proquest. (1555882761).

Kan, A. (2009). Ölçme sonuçları üzerinde istatistiksel işlemler (Statistical processes on the results of measurement). H. Atılgan (Ed.), *Eğitimde Ölçme ve Değerlendirme* (pp. 397-456). Ankara: Anı Publications.

Karaarslan, G. & Sungur, S. (2011). Elementary students‟ self-efficacy beliefs in science: Role of grade level, gender, and socio-economic status. *Science Education International, 22,* 1, 72-79.

Kıray, S. A. (2010). İlköğretim ikinci kademede uygulanan fen ve matematik entegrasyonunun etkililiği.Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü İlköğretim Anabilimdalı. Ankara

Klassen, R. M., Bong, M., Usher, E. L., Chong, W. H., Huan, V. S., Wong, I. Y. R., & Georgiou, T. (2009). Exploring the validity of a teachers' self-efficacy scale in five countries. *Contemporary Educational Psychology, 34*, 67-76, doi: 10.1016/j.cedpsych.2008.08.001.

Koballa, T. R. Jr., & Bethel, L. J. (1984). Integration of science and other school subjects. In D. Holdzkom & P. B. Lutz (Eds.) Research Within Reach: Science Education (pp 79-107). Washington DC: National Science Teacher Association.

Koballa, T. R., & Crawley, F. E. (1985). The influence of attitude on science teaching and learning. *School Science and Mathematics, 85*, 222-232.

Kranzler, J. H., & Pajares, F. (1997). An exploratory factor analysis of the mathematics self-efficacy scale revised. *Measurement and Evaluation in Counseling and Development, 29,* 215-228.

Meisel, E. M. (2005). A study of the continuum of integration of mathematics content with science concepts at the middle school level in the west virginia. Department of Educational Theory and Practice, Morgantown West Virginia.

Newton, K., J., Leonard, J., Evans, B., R., & Eastburn, J., A. (2012). Preservice elementary teachers' mathematics content knowledge and teacher efficacy. *School Science and Mathematics, 112*(5), 289-299.

National Research Council [NRC]. (1996). National science education standards. Washington, DC: National Academy Press.

Pajares, F. (2002). Overview of social cognitive theory and of self-efficacy. Retrieved April 15, 2004 from http://www.emory.edu/EDUCATION/mfp/eff.htm

Pajares, F. (2003). Self-efficacy beliefs, motivation, and achievement in writing: A review of the literature. *Reading and Writing Quarterly, 19*, 139–158

Pallant, J. (2001). *Spss survival manual. a step-by-step guide to data analysis using spss for windows*. Philadelphia, PA: Open University Press.

Richardson, G.M., Ling, L.L. (2008). The use of inquiry in the development of reservice teacher efficacy in mathematics and science. *Journal of Elementary Science Education, 20,* 1-15.

Riggs, I. M. & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74(*6), 625 – 637. doi: 10.1002/sce.3730740605

Roebuck, K., & Warden, M. A. (1998). Searching for the center on the mathematics-science continuum. *School Science and Mathematics, 98*, 328-333.

Schunk, D. H. & Zimmerman, B.J. (2008). *Motivation and self-regulated learning: theory, research, and applications* (1st ed.) Lawrence Erlbaum Associates, New York.

Şimşek, Ö. F. (2007). *Yapısal eşitlik modellemesine giriş temel ilkeler ve lisrel uygulamaları.* Ankara: Ekinoks.

Swackhamer, L. E. (2010). Measuring mathematics specific teacher efficacy: Can a global instrument produce valid results? *Paper presented at the 2010 American Educational Research Association Annual Meeting*, Denver, CO.

Swars, S. L, Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106,* 306–315.

Swars, S., Hart, L., Smith, S., Smith, M. & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' mathematics beliefs and content knowledge. *School Science and Mathematics, 107*(8), 325 – 335.

Tavşancıl, E. (2005). *Tutumların ölçülmesi ve SPSS ile veri analizi.* Ankara: Nobel Yayıncılık.

Tosun, T. (2000). The beliefs of preservice elemantary teachers toward science and science education. *School Science and Mathematics, 100*, 374-379.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing elusive construct. *Teaching and Teacher Education, 17*, 783-805.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2007). The differential antecedents of selfefficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23,* 944- 956.

Ward, E. K. (2009). Latent Transition Analysis of Preservice Teachers' Efficacy in Mathematics and Science. University of North Texas.

Yilmaz-Tuzun, O. & Topcu, M. S. (2008). Relationships among preservice science teachers' epistemological beliefs, epistemological world views, and self-efficacy beliefs. *International Journal of Science Education, 30*(1), 65 – 85.

Zengin, U. (2003). *İlköğretim Öğretmenlerinin Özyeterlik Algıları ve Sınıf İçi İletişim Örüntüleri*. D.E.Ü. Eğitim Bilimleri Enstitüsü Yayımlanmamış Yüksek Lisans Tezi, İzmir.

◈◇◈

Appendix 1. The five point Likert type "Using Mathematics in Science Self-efficacy Scale" (UMSSS)* **(Fen Bilgisi Öğretmen Adaylarının Matematiğe Yönelik Özyeterlik Algısı Ölçeği)**

1 Never, 2 Seldom, 3 Sometimes, 4 Frequently, 5 Always

(1 .Hiçbir Zaman, 2 Ender olarak, 3 Bazen, 4 Çoğu zaman, 5 Her zaman)

The original form of UMSSS in Turkish	The translated form of UMSSS in English
1. Fen dersini öğretmede kendimde matematiksel kavramların iyi oluştuğunu düşünüyorum.	While teaching science, I feel that I internalize the mathematical concepts better.
2. Fen dersindeki kavramları etkili bir şekilde öğretebilmek için gerekli matematiksel düşünme becerilerine sahip değilim.	I do not have the necessary mathematical thinking skills to teach the concepts in science.
3. Fen dersindeki başarıyı matematiksel becerilerimle arttırabilirim.	I can increase the success in science by my mathematical skills.
4. Fen dersinin amaçlarından biri olan eleştirel düşünme becerisini kazandırmayı matematik ile yapabilirim.	I can teach one of the aims of science course, critical thinking, through mathematics.
5. Fen derslerinde her türlü matematiksel kavram ve kuralları öğretme konusunda kendimi yeterli görmüyorum.	I do not think that I am sufficient enough to teach all kinds of mathematical concepts and rules.
6. Yeterince çalışırsam fen derslerindeki matematiksel problemleri kolayca çözebileceğime inanıyorum.	I believe that I can solve all the mathematical problems in the science courses if I try hard enough.)
7. Fen dersinde matematiksel bir problem ile karşılaşınca ne yapılacağımı bilemem.	I do not know what to do when I encounter with a mathematical problem in the science courses.
8. Fen dersinde her türlü günlük yaşam problemine matematiksel yaklaşımla bir çözüm önerisi getirebilirim.	I may have a solution for all kinds of daily life problems in science courses through a mathematical approach.
9. Fen öğretiminde yararlandığım matematiğe, aynı branştaki diğer arkadaşlarım kadar hâkim değilim.	I do not possess as much mathematical background as my colleagues in the same department.
10. Matematik ile öğrencilerin fen derslerindeki problem çözme becerilerini arttırabileceğime inanıyorum.	I believe that I can improve the students' problem solving skills through mathematics
11. Fen derslerinde matematiğe yönelik olumlu tutumun nasıl geliştirileceğini bilmiyorum.	I do not know how to develop positive attitudes towards mathematics in the science courses.
12. Fen dersinde matematiği etkili olarak kullanamadığımı düşünüyorum.	I believe that I cannot use mathematics in science courses effectively.
13. Öğrencilere fen ve matematik dersleri arasındaki ilişkileri kavratabilirim.	I can have my students understand the connection between science and mathematics.
14. Fen derslerini öğretirken matematiksel dili iyi bir şekilde kullanabilirim.	I can use the mathematical language well in teaching science. (15th item)
15. Fen derslerinde matematiğin önemi üzerinde öğrencileri bilgilendiremem.	I cannot instruct the students on the significance of mathematics in science lessons. (17th item)
16. Öğrencilerin matematikle ilgili sorunlarını çözebilmelerinde yardımcı olabileceğime inanıyorum.	I believe that I can help the students to solve their problems related to mathematics. (18th item)
17. Matematiği kullanarak fen derslerinde mantıksal çıkarımlar yapamam.	I cannot have logical deductions in science courses by using mathematics. (19th item)
18. Fen dersinde çeşitli matematiksel oyunlarla öğrencilerin problem çözme becerilerini geliştirebilirim.	I can improve the students' problem solving skills in science courses through a variety of mathematical games. (20th item)

* For the English version of the items given in parenthesis above we used three experts to do the translations into Engilish, and two experts to do the back translations into Turkish. Content validity was not performed.

Eurasia Journal of Mathematics, Science & Technology Education, 2012, **8**(4), 269-281

Using Mathematics in Teaching Science Self-efficacy Scale – UMSSS: A Validity and Reliability Study

Bilge Taşkın Can
Pamukkale Üniversitesi, Denizli, TURKEY

Berna Cantürk Günhan
Dokuz Eylül Üniversitesi, İzmir, TURKEY

Sevinç Öngel Erdal
Ohio State University, Columbus, USA

Received 18 May 2011; accepted 19 May 2012

In this study, an instrument, Using Mathematics in Science Self-efficacy Scale (UMSSS), was developed in order to determine preservice science teachers' self-efficacy toward the use of mathematics in their lessons. Data gathered from 250 preservice science teachers were used for Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). The factor analysis revealed 3 factors: Self Perception of Mathematics (SPM), Utilization of Mathematics (UM), and Mathematical Skills (MS). The cronbach alpha coefficient for the overall instrument was computed 0.88. The analyses resulted in the development of a three-factor scale of 18 items that was shown to be valid and reliable. At the same time, this instrument is also the first original instrument developed for determining the preservice science teachers' self-efficacies toward the use of mathematics in their lessons.

Keywords: self-efficacy beliefs, science, teacher education, mathematics

INTRODUCTION

Teachers' beliefs, attitudes and behavior are important for understanding and improving educational process. Studies indicate a strong relationship among teachers' attitudes, beliefs and behavior (Koballa and Crawley, 1985; Pajares, 2002). Koballa and Crawley (1985) use the following example to describe this relationship; "elementary school teachers judged their ability to teach science to be low (belief), resulting in a dislike for science teaching (attitude) that ultimately translated into teachers who avoided teaching science (behaviour)" (cited in Tosun, 2000).Considering the relationship described above, peoples' self-beliefs in most cases are the foundations of their positive attitudes which give rise to positive behavior (Schunk & Zimmerman, 2008). Most of the studies that aim to determine self-efficacy beliefs are based on Banduras' definition of self-efficacy in the late 70's (Bursal & Paznokas, 2006; Enochs & Riggs, 1990; Guskey & Passaro, 1994, Hill, Rowan, Ball, 2005; Swars, Hart, Smith, Smith, & Tolar, 2007; Tschannen-Moran & Woolfolk-Hoy, 2007; Yilmaz-Tuzun & Topcu, 2008). Bandura (1997) defined self-efficacy belief as the "judgments of how well one can execute courses of action required to deal with prospective situations" (p. 122). Self-efficacy has a central role in learning that it contributes to one's motivation to learn (Bandura, 1997; Dornyei, 2009; Huang& Chang, 1998).

Correspondence to: Bilge Can, Assistant Professor of Science Education, Pamukkale Üniversitesi, Eğitim Fakültesi, Denizli, TURKEY
E-mail: *bilgecan@pau.edu.tr*

ISSN: 1305-8223

State of the literature

- There are limited researches on pre-service teachers' self-efficacy beliefs about using mathematics in teaching science.
- The current literature suggests that the level of the ability of using mathemathics enhances learning science.
- Researchers may have become interested in how teacher self-efficacy beliefsaffect the use of mathematics in teaching science. This scale will use some research that focuses on self-efficacy beliefs on using mathematics in science teaching.
- Teacher educators can improve their perspectives on self-efficacy beliefs on using mathematics in teaching science through this study.

Contribution of this paper to the literature

- Through this study, the science teachers can become more aware of their ability and their self-efficacy beliefs on using mathematics.
- Teachers and pre-service teachers can connect two disciplines in their teaching such as using mathematics in teaching science. In this way, they can transfer what they have learned to other disciplines.
- Through this scale, it is possible to analyze self-efficacy beliefs under three subscales: a) Self-perception of mathematics, b) utilization of mathematics, and c) mathematical skills.

Teacher Self-efficacy and Integration

Brody and Davidson (1998) suggested teachers' beliefs may have the greatest impact on teachers' attitudes and behavior in the classroom, such as what they do in the classroom and the ways they conceptualize the instructional process. Similarly, Tschannen-Moran and Woolfolk Hoy (2001) proposed that teachers' self-efficacy beliefs also influence their students' motivation, their achievement drive and their self-efficacy beliefs. When individuals perceive high self-efficacy, they tend to try more time and effort to accomplish the task (Pajares, 2003).

In the last decade, there has been an increasing emphasis on interdisciplinary relationships and approaching problems from multidimensional perspectives for meaningful teaching and learning. Science, mathematics and technology are considered the three disciplines that are most likely to be integrated due to the similarities in their practice areas and their approaches in problem solving process (National Research Council [NRC], 1996). Despite the fact that science (Britner, 2008; Bryan, Glynn and Kittleson, 2010; Karaaslan and Sungur, 2011; Riggs and Enochs, 1990) and mathematics teachers' beliefs (Heneman, Kimball, Milanowski, 2007; Hoffman, 2010; Kahle, 2008; Klassen, Bong, Usher, Chong, Huan, Wong and Georgiou, 2009; Kranzler and Pajares, 1997; Swackhamer, 2010) have long been investigated in educational settings and few studies investigated the integration between them (Huntley 1998; Roebuck and Warden, 1998; Basista and Mathews, 2002; Berlin and White 2010; Kıray, 2010). In their continuum models, Huntley (1998), and Roebuck and Warden (1998) define a mid-point where mathematics and science are truly integrated. The models represent teaching and learning mathematics and science on both ends of the continuum, and increased infusion of each discipline towards the mid-point. (Increased infusion points describe teaching mathematics with science and teaching science with mathematics). Besides, these studies report that the mid-point of the continuum (mathematics and science integration) is hard to achieve, and is not a common teaching and learning practice (Ward, 2009). Basista ve Mathews (2002), stated that teachers need to understand the content of science and mathematics in depth and lack of knowledge in their content knowledge cause their self-efficacy to be low. Similarly, Newton et. al. (2012) also indicated that a positive moderate relationship between content knowledge and personal teaching efficacy was found in their study. Berlin and White (2010), in their study, applied the program of science and mathematics integration to the preservice teachers. When the program was completed, the students found the program quite difficult, and defined the obstacles and difficulties. In spite of this, at the end of the study, it was established that the program prepared for the integration of mathematics, science and technology positively changed the students' attitude and perceptions. Similarly, Kıray (2010), in his/her research, found that the group, to which the program created grounding on science and mathematics integration in elementary 8th grade Science and Technology and mathematics subjects was applied, was more successful than the one to which the present program of the Ministry of Education was applied. As aresult, it was mentioned in various studies that the integration of the fields of science and mathematics produced positive results and may increase the success (Basson, 2002; Furner & Kumar, 2007). In this case, in order for the integration of science and mathematics to be practiced, defining the competences on this subject is of great importance while teacher candidates are being trained.

Measuring Teachers' Mathematics and Science Efficacy

The concept of teacher efficacy has been measured in numerous ways in earlier literature (See Table 1 for a listing of instruments). Although the history of the measurement of self-efficacy spans the last 30 years, presently the most widely-accepted measure of the concept is the Teacher's Sense of Efficacy Scale, or TSES (Tschannen Moran & Woolfolk Hoy, 2001). The TSES measures three constructs: efficacy for instructional strategies, efficacy for student engagement, and efficacy for classroom management.

Gibson and Dembo (1984) developed the Teacher Efficacy Scale (TES), which centered around two factors. These factors consist of the belief in ones' ability to teach effectively, which is the personal teaching efficacy; and the belief that effective teaching will have a positive effect on student learning, which is the teaching outcome expectancy. Guskey and Passaro (1994) on the other hand, reconstructed the scale developed by Gibson and Dembo and named the factors as the internal and external factors. Internal factors are defined as the efficacy beliefs about the influence of teachers on student learning, whereas external factors are defined as the outside factors that cannot be controlled by the teacher and are located outside of the classroom environment.

Based on Fuller's (1969) concern theory, Hall, Wallace and Dosset (1973) developed an evidence-based conceptual framework, called the Concern Based Adoption Model (CBAM). The CBAM provides a construct that helps measure, describe and explain the change process of teachers who are adopting reformed curriculum materials or new instructional practices into their teaching (Anderson, 1997). In this model, the teachers can have concerns in different stages in the process of change, therefore based on these different concerns they need differentiated support, and guidance (Hord et al., 1987).

The CBAM is composed of three dimensions: (a) Stages of Concerns dimension shows teachers' perceptions and feelings about educational innovations, (b) Levels of Use dimension indicates how teachers implement innovations and (c) Innovation Configurations dimension shows the different ways an innovation is implemented. As the focus of this study is on teachers' concerns about reformed curriculum, the Stages of Concern dimension of the CBAM that includes affective aspect of change will be used in this study.

The most popular and widely used scales in science and mathematics are the Science Teaching Efficacy Beliefs Instrument-STEBI (Enochs & Riggs, 1990) and Mathematics Teaching Efficacy Beliefs Instrument-MTEBI (Enochs, Smith, & Huinker, 2000). Both of these instruments explored self-efficacy in two dimensions (self-efficacy beliefs and outcome expectancy beliefs) as described in Banduras' social learning theory.

Science and mathematics are not bodies of knowledge meant to be indoctrinated into students. By encouraging constructivist philosophies of learning, pre-service teachers may begin to alter their conceptions of

Table 1. Existing Self-efficacy instruments

Author	Title	Theoretical Basis
Guskey (1981)	Responsibility for Student Achievement questionnaire (RSA)	Rotter's Social Learning Theory
Ashton et al. (1982)	Ashton Efficacy Vignettes	Bandura's theory of self-efficacy from Social Cognitive Theory
Betz & Hackett (1983)	Mathematics Self-Efficacy Scale (MSES)	Bandura's theory of self-efficacy from Social Cognitive Theory
Gibson & Dembo (1984)	Teacher Efficacy Scale (TES)	Bandura's theory of self-efficacy from Social Cognitive Theory
Riggs & Enochs (1990)	Science Teaching Efficacy Belief Instrument (STEBI)	Bandura's theory of self-efficacy from Social Cognitive Theory with items taken from the TES
Bandura (1997)	Teacher Self-efficacy Scale (TSS)	Bandura's theory of self-efficacy from Social Cognitive Theory
Enochs et al. (2000)	Mathematics Teaching Efficacy Belief Instrument (MTEBI)	The STEBI modified to be math-specific. Bandura's theory of self-efficacy from Social Cognitive Theory with items taken from the TES
Tschannen-Moran & Woolfolk Hoy (2001)	Teacher's Sense of Efficacy Scale (TSES) formerly the Ohio State Teacher Efficacy Scale	Bandura's theory of self-efficacy from Social Cognitive Theory with Likert-scale from the TSS
Dellinger et al. (2008)	TEBS-Self	Bandura's theory of self-efficacy from Social Cognitive Theory

science and mathematics, and realize the importance of explanations and communication in scientific and mathematical thinking. Moreover, through questioning their own perceptions of mathematics and science, pre-service elementary teachers may become more adept at noting the similarities and differences in teaching science and mathematics (Yilmaz-Tuzun & Topcu, 2008). Yet, some researchers (i.e. Basista and Mathews, 2002; Frykholm and Glasson, 2005; Gürdal, 1997; Meisel, 2005) assert that preservice teachers cannot even partially connect two disciplines in their teaching such as using mathematics in teaching a science lesson. That is, the teachers cannot transfer what they have learned to other disciplines. Besides, in some researches, a negative correlation between preservice teachers' mathematics anxiety and their mathematics teaching efficacy was found (Bursal & Paznokas, 2006; Swars, Daane, & Giesen, 2006).

Self-efficacy scales previously described have failed to determine in-service and preservice teachers' self-efficacy beliefs toward the use of one discipline in another (Enochs et. all. 2000; Ertkin and Ader, 2004; Richardson and Ling, 2008). There is a need to develop self-efficacy scales to examine the use of one discipline in another for effective practice. In this study, an instrument, Using Mathematics in Science Self-efficacy Scale (UMSSS), was developed in order to determine preservice science teachers' self-efficacy toward the use of mathematics in their lessons. In addition, it is thought that thanks to this scale, determination of the existence of self-efficacies of the teacher candidates toward the use of mathematics in science lessons and also determining its level will be helpful to the process of the application and improvement of teacher training program. However, there has not been such an instrument developed towards Science teachers' perceptions of Self Efficacy in terms of the use of mathematics in science teaching in our country. The basic movement point of this study is the absence of

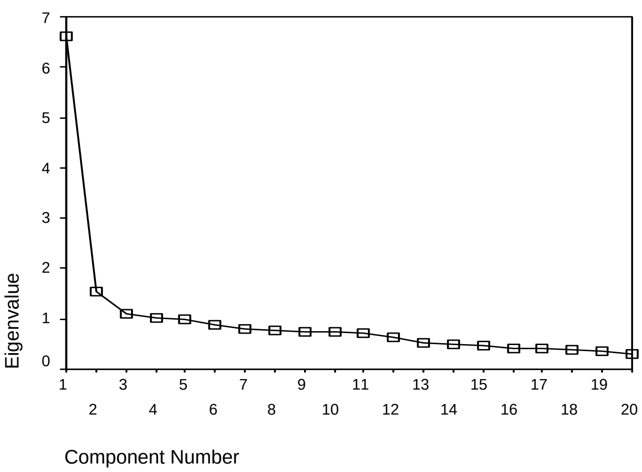


Figure 1. Scree Plot

such an instrument towards Turkish preservice science teachers. Furthermore, the validity and reliability of the instrument were established.

METHOD

In this study, the validity and reliability of scale was investigated by using internal reliability investigation and factor analysis techniques and survey technique was used as data collection way. .

Participants

The participants of this study were 250 elementary preservice science teachers who were enrolled in a teacher education program in a large state university of Turkey in the spring semester of 2004. The sample consisted of 56.4% males (nm=141) and 43.6% females (nf=109). The age of preservice science teachers varied from 18 and 22. A total of 54 (21.6%) participants from first grade, 67 (26.8%) participants from second grade, 68 (27.2%) participants from third grade, and 61 (24.4%) participants from fourth grade were recruited for the study. Preservice teachers were informed about the main goal of the research, anonymity, and voluntary participation. This scale was administered to these participants by lectures.

The Instrument Development Process

To develop the scale, firstly the literature review was done and scales about self-efficacy were analyzed (see Table 1 for instrument lists). Self-efficacy items were written by investigators for trial and it included 20 items. After, two science and mathematics educators, one science and mathematics teachers' views about items were noted. With respect to their views, the scale was given its final form and the scale included 20 items. The scale has been applied to four preservice science teachers to check readability, understandability and time requirement.The scale was administered by a lecture to these fourth-grade preservice teachers who were randomly selected. They have not reported any sentence about these. Then, the sub-dimensions of the scale were determined according to the factor analysis. During the preparation of the directive, to measure his/her own perception about self-efficacy, the scale was designed in the five-grade Likert format, based on the opinions of an expert in assessment field, to be answered. The items of scale have the following five response categories: Never (1), Seldom (2), Sometimes (3), Frequently (4), Always (5). After the factor analysis, the 5 point Likert scale instrument consisted of 18 items (Appendix 1). Negative items are scored as the opposite form of grading which is above possible scores on the instrument range from 18 to 90. The increase in the scores shows that individual's self-efficacy beliefs of using mathematics in science course is high, the decrease in the scores shows that it is low. Questionnaires took approximately 8-10 minutes to complete.

Analysis

Exploratory factor analysis including principal components analysis was employed to determine the factor structure of scale. After, factors were evaluated using a confirmatory factor analysis. Additionally, item-total correlations were calculated to determine the reliability of the scale, as well as the intercorrelations between the three subscales. Then, the factors were evaluated using a confirmatory factor analysis. Finally, internal reliability values on the factors were also analyzed by using Cronbach alpha reliability. The data were analyzed with the statistical software packages, SPSS 15.00 and Lisrel 8.51.

FINDINGS AND RESULTS

Validity and Reliability of the Instrument

Content Validity

Content validity indicates whether the items constituting the scale are quantitatively and qualitatively adequate for measuring the property intended to be measured (Büyüköztürk, 2006). To provide content validity of the scale, two science and mathematics educators, one science and mathematics teachers' views about items were taken and their coherence about subject was determined. According to their opinions, the scale was given its final form by omitting and revising some items. As a result, the preliminary scale initially included 20 items.

Construct Validity

For science teachers, to determine which sub-structures were formed by self-efficacy beliefs about using mathematics in science education, and to provide construct validity, exploratory factor analysis was used at the beginning. Then, confirmatory factor analysis was conducted to provide "fit index values" for further use of the scale.

Exploratory Factor Analysis

Science teachers' perceptions of Self Efficacy in terms of the use of mathematics in science teaching, which consists of sub-structures to ensure the validity of the exploratory factor analysis was used to determine the structure. Data analyzed by using the statistical package SPSS 10.0. Before conducting the factor analysis, it was first examined whether or no the sample was appropriate for the factor analysis. For this purpose, Kaiser-Meyer-Olkin (KMO) value was determined to be 0.89 which can be placed in the 0.80 - 0.89 range (very good) as defined by Pallant (2001). Furthermore, Bartlett's Spherecity Test was run to check whether the data represent a multivariate normal distribution. The test resulted in Approx. Chi-Square: 1564,09 and $p < .01$, which shows that the results are significant.In this study, the principal component analysis proposes four factors for the exploratory factor analysis to be carried out. However, one important point to be assessed while deciding on factor number is the significance of the contribution each factor made to total variance (Çokluk, Şekercioğlu, and Büyüköztürk, 2010, 230). In this case, it is seen that this contribution from the four components onwards diminishes when the screen plot graphic is taken into account (Figure 1). In such a situation, it can be decided that the number of factors is determined as three. Furthermore, each gap between the two points in the screen plot graphic means one factor (Çokluk, Şekercioğlu, and Büyüköztürk, 2010, 231). On the Screen Plot, graphic produces a sloping plato after the 4th components. In terms of this perspective, the number of factors was decided to be 3.

Later, these factors were analyzed with varimax rotation and it was found that two items did not fall in any of the factors. The scale includes 18 items in its final form. Table 2 presents the distribution of the items by factors, Factor 1 loadings of the items before the rotation factor loadings and factor common variances after varimax rotation given in Table2.

It was found that the three factors explain the 47,111% of the total variance; Self Perception of Mathematics (SPM 15.997%), Utilization of Mathematics (UM 15.943%), and Mathematical Skills (MS 15.171%). The first factor, Self Perception of Mathematics, was composed of the items 5, 6, 7, 9 and 11 and correspond to the awareness of teachers' behaviour concerning mathematics. The second factor, Utilization of Mathematics, was composed of the items 12, 13, 15, 17, 18 and 19 and correspond to the beliefs about the ability to use mathematics in teaching science. Finally, the third factor, Mathematical Skills, was composed of the items 1, 2, 3, 4, 8, 10, and 20 and correspond to the teachers' self-efficacy beliefs about the ability to utilize mathematical skills in science lessons (Table 3).

Table 2. Exploratory Factor Analysis Results

Item No	Before the rotation **Factor 1 Loadings**	Factor Loadings after the Rotation			
		Factor 1	**Factor 2**	**Factor 3**	**Factor Common Variances**
5	.476	.567*			.360
6	.560	.692*			.541
7	.581	.745*			.612
9	.687	.608*			.551
11	.520	.434*			.306
12	462		.518*		.374
13	.714		.577		.557
15	.602		.632		.535
17	.605		.663*		.535
18	.555		.621		.452
19	.573		.588*		.430
1	.635			.604	.498
2	.572			.305*	.371
3	.575			.611	.480
4	.426			.780	.630
8	.430			.560	.412
10	.612			.408	.387
20	.609			.533	.446

Total: % 47.111;
Factor -1: % 15.997;
Factor -2: % 15.943;
Factor -3: % 15.171
* The reverse reading of the scale items are scored as negative materials.

Table 3. Factor Name and Items

Factors	Items
Self Perception of Mathematics (SPM)	5. I do not think that I am sufficient enough to teach all kinds of mathematical concepts and rules. 6. I believe that I can solve all the mathematical problems in the science courses if I try hard enough 7. I do not know what to do when I encounter with a mathematical problem in the science courses. 9. I do not possess as much mathematical background as my colleagues in the same department. 11. I do not know how to develop positive attitudes towards mathematics in the science courses
Utilization of Mathematics (UM)	12. I believe that I can not use mathematics in science courses effectively. 13. I can have my students understand the connection between science and mathematics. 15. I can use the mathematical language well in teaching science. 17. I cannot instruct the students on the significance of mathematics in science lessons. 18. I believe that I can help the students to solve their problems related to mathematics. 19. I cannot have logical deductions in science courses by using mathematics.
Mathematical Skills (MS)	1. While teaching science, I feel that I internalize the mathematical concepts better 2. I do not have the necessary mathematical thinking skills to teach the concepts in science. 3. I can increase the success in science by my mathematical skills. 4. I can teach one of the aims of science course, critical thinking, through mathematics. 8. I may have a solution for all kinds of daily life problems in science courses through a mathematical approach. 10. I believe that I can improve the students' problem solving skills through mathematics. 20. I can improve the students' problem solving skills in science courses through a variety of mathematical games.

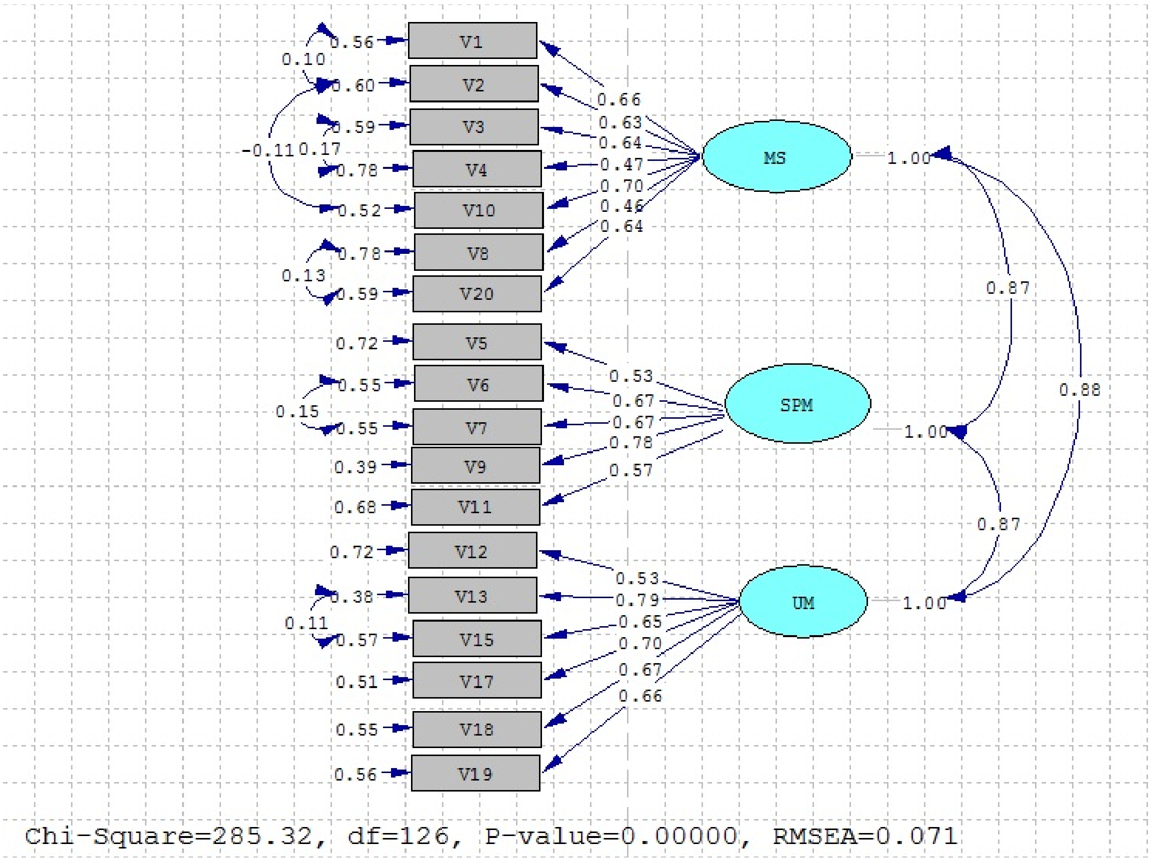


Figure 2. The Three Factor Model-First Order CFA and the Standardized Solutions

MS- Mathematical Skills, SPM-Self Perception of Mathemat ics, UM-Utilization of Mathematics

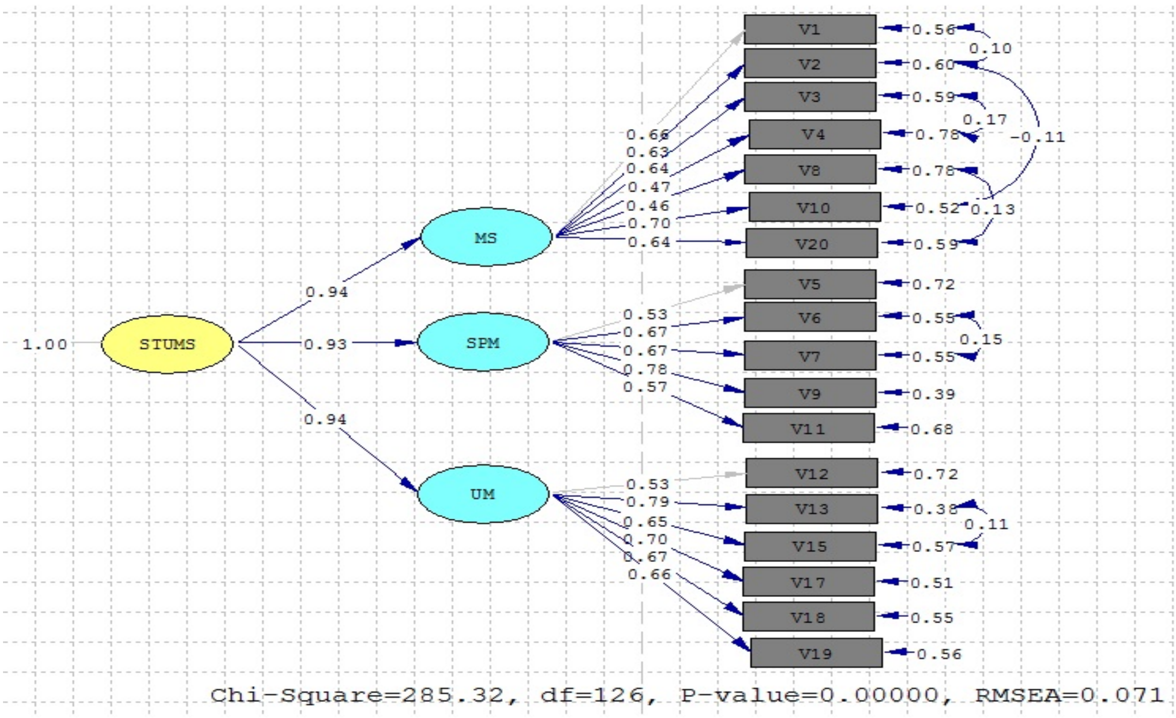


Figure 3. Diagram Generated for Second Order CFA and the Standardized Solutions

Confirmatory Factor Analysis

Confirmatory factor analysis was conducted by using LISREL 8.51 program. There are several criteria which are considered as an indication of good fit of the factorial structure (Hooper, Coughlan, and Mullen 2008; Kelloway 1989; Kline 2005; Sümer 2000 cited in Çokluk, Şekercioğlu, and Büyüköztürk 2010, Şimşek 2007): (1) higher than .90 value for Comparative Fit Index (CFI) and Goodness of Fit Index (GFI), (2) the adjusted goodness-of-fit index (AGFI) such that 0.85 or above indicates an acceptable fit, (3) Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR) such that value less than .05 indicates a good fit and values as high as 0.08 are deemed acceptable and (4) 3 or lower value for $\chi 2$/df ratio indicates a good fit (Byrne, 1998; Hu and Bentler, 1999). Thanks to CFA, both power of representation of the substances were investigated and the relationshipsof the sub-dimensions between one another and the basic dimension were assessed. While the comfirmatory factor analysis results were being interpreted, primarily a three-factor model (the first level CFA) was revised (Figure-2).

When the Figure 2 is examined it is seen that path coefficients (standardized regression coefficients) vary between 0,46 and 0,79. The range of path coefficients for each sub-dimension is as follows: 0,46-0,70 for MS dimension, 0,53-0,78 for SPM dimension, and 0,53-0,79 for UM dimension. The goodness of fit indices of the model was found at an acceptable level (χ^2=285,32 df=126, χ^2/df=2.26, CFI=0.90, GFI=0.89, AGFI=0,85 RMSEA=0.071, and SRMR= 0.053). And correlation between SPM and MS, UM and SPM, MS and UM were respectively 0.87, 0.87, 0.88 suggesting considerable overlap between the factors. In addition to these processes, it was determined that there is more relationship between/among the substances depending on modification indices than the model prediced and error covariance was added between the two variables. It was natural that there is more relationships between these items. Because they are in same factor.

The proposed model was tested with the second level DFA. The last model created in this part reflects a "second level" model in which the predicted three sub-dimensions represented "UMSSS" variable in significant relationships. Thanks to the promotion of this model, it will be indicated that self-efficacy beliefs of the teacher candidates can multi-dimensionally measured and the basic characteristics measured are related to a top-level factor (UMSSS). Analysis results performed from this thought were presented in Figure-3.

As seen in Figure-3, there are 3 pieces of first factors and one piece of second factor in the last model, and coherence coefficients of the model are at acceptable level as those in the first level (χ^2=285,32 df=126, χ^2/df=2.26, CFI=0.90, GFI=0.89, AGFI=0,85 RMSEA=0.071, and SRMR= 0.053). Both of the three factor and the second-order hierarchical models generated kabul edilebilir düzeydedir.

And correlation between SPM and UMSSS, UM and UMSSS, MS and UMSSS were respectively 0,93, 0,94, 0,94 suggesting considerable overlap between the factors. Consequently, the three-factor UMSSS scale, composed of 18 items, is confirmed as a model.

Internal Consistency Reliability

To determine the internal consistency, the corrected item-total correlations were calculated. Besides, the total score was determined according to the scores of the top 27% and bottom 27% of the difference between groups by using t test for significance (Table 4).

Table 4. Corrected Item-Total Correlation and *t* values

Factor	Item Number	Corrected item total correlation	*t*-value
	5	.435	-8,48
Self Perception of Mathematics	6	.495	-10,05
	7	.502	-9,60
	9	.618	-13,54
	11	.447	-8,52
	12	.396	-7,84
	13	.635	-10,50
	15	.507	-8,89
Utilization of Mathematics	17	.541	-9,41
	18	.491	-10,07
	19	.504	-9,31
	1	.560	-9,65
	2	.504	-9,65
	3	.520	-9,31
Mathematical Skills	4	.364	-5,81
	8	.372	-7,14
	10	.540	-9,22
	20	.544	-10,24

* $p<.05$

According to the Table 3, corrected total item correlations of the scale ranged from 0.635 to 0.364. Since obtained item test correlation coefficient is found not to be negative, zero or close to zero (Tavşancıl, 2005), the tool has high internal consistency and construct validity can be said to exist. According to the t test results between the groups 27% of top and 27% of lower, the mean scores of substances, significant differences were found for all substances. These findings indicate that all items were discriminative. In addition, the relationship between the scale factors was checked to determine the correlation between the factors and the obtained results are given Table 5.

As show in Table 5, there is a positively significant relationship between the factor scales and between the factors and total scores. These correlations provide support for the multidimensionality of the scale.

The internal consistency estimates of reliability (Cronbach's alpha coefficient) were computed for the scales representing the three factors (Table 6).

Self-perception of mathematics, utilization of mathematics and mathematical skills all had acceptable alpha levels (0.72, 0.76, 0.76 respectively). The overall reliability was determined to be 0.88.

Descriptive Statistics

In the interpretation of the answers the teacher candidates provided, the difference determined width breadth of score interval within the groups was determined. The value of group interval coefficient was obtained with the division of the "difference between highest value in the series of evaluation results and the lowest value into the number of groups determined (Kan, 2009, s. 407)". In this study, group interval coefficient value was calculated as (5–1)/5=0.80 and the following intervals were predicated on in the evaluation of the answers obtained with the application of the scale: 4.21–5.00 "always", 3.41–4.20 "frequently", 2.61–3.40 "sometimes", 1.81–2.60 "seldom", 1.00–1.80 "never". Also, the highest score to be taken from this scale is 90, and lowest score 18.

When the Table 7 is examined, it is seen that the teachers' views regarding the three sub-dimensions of UMSSS scale (SPM, UM, MS) and concerning the whole scale correspond to the interval of "frequently". Based on this discovery, it is understood that the standpoints of teacher candidates to UMSSS information are positive and the candidates' perceptions that they can perform the denoted skills are high.

CONCLUSIONS AND RECOMMENDATIONS

The present study was aimed to develop the UMSSS in order to determine preservice teachers' beliefs of their self-efficacy toward the use of mathematics in science. Researchers have not yet examined the efficacy beliefs of teachers in an integrated teaching practice

Table 5.Correlations between the Factors of the Scale

Scale	Number of items	Mean	Standard deviation	Correlation			
				Factor1	Factor 2	Factor 3	Total
SPM	5	19,38	3,84	-			
UM	6	23,50	4,40	.598**	-		
MS	7	26,22	4,55	.582**	.607**	-	
Total	18	69,12	10,95	.834**	.864**	.865**	-

** $p<0.01$

Table 6.The Scale Factors of the Cronbach Alpha Coefficients

	n	Self Perception of Mathematics	Utilization of Mathematics	Mathematical Skills	Total
Cronbach Alpha reliability coefficient	250	0.72	0.76	0.76	0.88

Table 7. Descriptive statistics belonging to the sub-dimensions of UMSSS and to the whole scale

Subscale and Scale	n	$\overline{X}$	sd
SPM	250	3,98	0,94
UM	250	4,08	0,91
MS	250	3,88	0,84
UMSSS	250	4,02	0,78

which many researchers suggest to have a positive effect on student achievement (e.g. Koballa & Bethel, 1984; Friend, 1985). UMSSS is a distinct instrument dealing with beliefs regarding the use of one discipline in another. In this study, validity evidence on content and construct validities have shown consistency between the purpose and the items of the instrument. Following the statistical analyses, a three-factor scale composed of eighteen items was developed. The factors of the scale are entitled as follows: a) Self-perception of mathematics, and, b) utilization of mathematics, c) mathematical skills. In addition, internal consistency of the scores has also provided another set of evidence to use the instrument. In sum, the findings of the study showed that the generated scale is a valid and reliable instrument.

This instrument allows for a richer and more detailed analysis of how preservice teacher efficacy changes over time. The information provided by these analyses can enable teacher educators to adapt their instruction to meet the needs of pre-service teachers and purposely facilitate the development of teacher self-efficacy beliefs regarding the use of mathematics while teaching science during the teacher preparation process (Berlin and White, 2010).

In the last decades, both preservice and in-service teachers' beliefs become the center of attention for teacher education research. Researchers have become interested in how teacher self-efficacy beliefs regarding the use of mathematics while teaching science. The instrument appears to be a valid and reliable assessment of the use of mathematics in science lessons based on the population used in this study. It is thought that the fact that the results are shared by applying the studies related to the scale to different sample groups will contribute to the employability of the scale. The validation of the instruments is an ongoing process; therefore, researchers should take this into consideration when utilizing the instrument. We suggest further studies are needed to enhance the reliability and support the validity of the instrument. At the same time, it is thought that this scale will help those who are working on this field to carry out a number of studies as to preservice science teachers' self-efficacy beliefs toward use of mathematics and to the variables depending on this. Moreover, future research needs to consider the efficacy beliefs of teachers in integrating other disciplines such as science and technology.

***Authors' note**

A preliminary version of this paper was presented at the Mid-Western Educational Research Association Conference, 11–14th October 2006, Columbus, USA.

REFERENCES

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W. H. Freeman and Company.

Basista, B., & Mathews, S. (2002). Integrated science and mathematics Professional development programs. *School Science And Mathematics*, *102*(7), 359–370.

Basson, I. (2002). Physics and mathematics as interrelated fields of thought development using acceleration as an example, *International Journal of Mathematical Education in Science and Technology, 33*(5), 679 – 690.

Bates, A. B., Latham, N., & Kim, J. (2011). Linking preservice teachers' mathematics self-efficacy and mathematics teaching efficacy to their mathematical performance. *School Science and Mathematics, 111*(7), 325-333.

Berlin, D.F., & White, A.L. (2010). Preservıce mathematics and science teachers in an integrated teacher preparation program for grades 7–12: a 3-year study of attitudes and perceptions related to integration. *International Journal of Science and Mathematics Education, 8*, 97-115.

Betz, N. E. & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329-345.

Britner, S.L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical and earth science classes. *Journal of Research in Science Teaching, 45*, 955-970.

Brody, C. M. & Davidson, N. (1998). Professional development for cooperative learning: Issues and approaches. New York: NY: State University of New York Press.

Bryan, R. R., Glynn, S. M., & Kittleson, J. M. (2011). Motivation, achievement, and advanced placement intent of high school students learning science. *Science Education, 14*, 1047-1065.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*, 173–180.

Büyüköztürk, Ş. (2006). *Sosyal bilimler için veri analizi el kitabı.* PegemA Yayınları, Ankara.

Byrne, B.M. (1998). *Structural equation modeling with LISREL, PRELIS and SIMPLIS: Basic concepts, applications and programming.* Mahwah, New Jersey: Lawrence Erlbaum Associates.

Çokluk, Ö., Şekercioğlu, G., & Büyüköztürk, Ş. (2010). *Sosyal Bilimler için çok değişkenli İstatistik SPSS ve Lisrel uygulamaları.* Ankara: Pegem Yayıncılık.

Dornyei, Z. (2009). Motivation and motivating in the foreign language classroom. *The Modern Language Journal, 78,* 273-284.

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,* 695-706.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100,* 194-202.

Erktin, E., & Ader, E. (2004). Sınavda öğrencilerin başarısını neler etkiliyor? (What effects student achievement in examinations?) *Cumhuriyet Gazetesi, 894*, 21.

Friend, H. (1985). The effect of science and mathematics integration on selected seventh grade students' attitudes toward and achievement in science. *School Science and Mathematics, 85*, 453-461.

Frykholm, J., & Glasson, G. (2005). Connecting science and mathematics instruction: pedegogical context knowlege for teachers. *School Science and Mathematics, 105*(3), 127–141.

Furner, J. M., & Kumar, D. D. (2007). The mathematics and science integration argument: a stand for teacher education. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(3), 185-189.

Gürdal, A. (1997). Sınıf öğretmenliği öğrencilerinin fene karşı tutumları ve fen öğretiminde entegrasyonun önemi. *Marmara Universitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi, 9*, 237-253.

Guskey, T. (1981). Measurement of responsibility teachers assume for academic successes and failures in the classroom. *Journal of Teacher Education, 32,* 44-51.

Guskey, T. R., & Passaro, P. D. (1994). Teacher efficacy: a study of construct dimensions. *American Educational Research Journal, 31*, 627-643.

Heneman, H. G., Kimball, S., & Milanowski, A. (2007). The teacher sense of efficacy scale: validation evidence and behavioral prediction. WCER Working Paper No. 2006-7.

Hill, H., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371 – 406.

Hoffman, B. (2010). "I think I can, but I'm afraid to try": The role of self-efficacy beliefs and mathematics anxiety in mathematics problem solving efficiency. *Learning and Individual Differences, 20*, 276-283.

Hu, L.T., & Bentler, P.M. (1999). Cut off criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling, 6(*1), 1-55.

Huang, S. C., & Chang, S. F. (1998). Self-efficacy in learners of English as a second language: Four examples. *Journal of Intensive English Studies, 12*, 23-40.

Huntley, M. A. (1998). Design and implementation of a framework for defining integrated mathematics and science education. *School Science and Mathematics, 98,* 320-327.

Kahle, D. K. B. (2008). How elementary school teachers' mathematical self-efficacy and mathematics teaching self-efficacy relate to conceptually and procedurally oriented teaching practices. (Doctoral dissertation). Retrieved from Proquest. (1555882761).

Kan, A. (2009). Ölçme sonuçları üzerinde istatistiksel işlemler (Statistical processes on the results of measurement). H. Atılgan (Ed.), *Eğitimde Ölçme ve Değerlendirme* (pp. 397-456). Ankara: Anı Publications.

Karaarslan, G. & Sungur, S. (2011). Elementary students‟ self-efficacy beliefs in science: Role of grade level, gender, and socio-economic status. *Science Education International, 22,* 1, 72-79.

Kıray, S. A. (2010). İlköğretim ikinci kademede uygulanan fen ve matematik entegrasyonunun etkililiği.Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü İlköğretim Anabilimdalı. Ankara

Klassen, R. M., Bong, M., Usher, E. L., Chong, W. H., Huan, V. S., Wong, I. Y. R., & Georgiou, T. (2009). Exploring the validity of a teachers' self-efficacy scale in five countries. *Contemporary Educational Psychology, 34*, 67-76, doi: 10.1016/j.cedpsych.2008.08.001.

Koballa, T. R. Jr., & Bethel, L. J. (1984). Integration of science and other school subjects. In D. Holdzkom & P. B. Lutz (Eds.) Research Within Reach: Science Education (pp 79-107). Washington DC: National Science Teacher Association.

Koballa, T. R., & Crawley, F. E. (1985). The influence of attitude on science teaching and learning. *School Science and Mathematics, 85*, 222-232.

Kranzler, J. H., & Pajares, F. (1997). An exploratory factor analysis of the mathematics self-efficacy scale revised. *Measurement and Evaluation in Counseling and Development, 29,* 215-228.

Meisel, E. M. (2005). A study of the continuum of integration of mathematics content with science concepts at the middle school level in the west virginia. Department of Educational Theory and Practice, Morgantown West Virginia.

Newton, K., J., Leonard, J., Evans, B., R., & Eastburn, J., A. (2012). Preservice elementary teachers' mathematics content knowledge and teacher efficacy. *School Science and Mathematics, 112*(5), 289-299.

National Research Council [NRC]. (1996). National science education standards. Washington, DC: National Academy Press.

Pajares, F. (2002). Overview of social cognitive theory and of self-efficacy. Retrieved April 15, 2004 from http://www.emory.edu/EDUCATION/mfp/eff.htm

Pajares, F. (2003). Self-efficacy beliefs, motivation, and achievement in writing: A review of the literature. *Reading and Writing Quarterly, 19*, 139–158

Pallant, J. (2001). *Spss survival manual. a step-by-step guide to data analysis using spss for windows*. Philadelphia, PA: Open University Press.

Richardson, G.M., Ling, L.L. (2008). The use of inquiry in the development of reservice teacher efficacy in mathematics and science. *Journal of Elementary Science Education, 20,* 1-15.

Riggs, I. M. & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74(*6), 625 – 637. doi: 10.1002/sce.3730740605

Roebuck, K., & Warden, M. A. (1998). Searching for the center on the mathematics-science continuum. *School Science and Mathematics, 98*, 328-333.

Schunk, D. H. & Zimmerman, B.J. (2008). *Motivation and self-regulated learning: theory, research, and applications* (1st ed.) Lawrence Erlbaum Associates, New York.

Şimşek, Ö. F. (2007). *Yapısal eşitlik modellemesine giriş temel ilkeler ve lisrel uygulamaları*. Ankara: Ekinoks.

Swackhamer, L. E. (2010). Measuring mathematics specific teacher efficacy: Can a global instrument produce valid results? *Paper presented at the 2010 American Educational Research Association Annual Meeting*, Denver, CO.

Swars, S. L, Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106,* 306–315.

Swars, S., Hart, L., Smith, S., Smith, M. & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' mathematics beliefs and content knowledge. *School Science and Mathematics, 107*(8), 325 – 335.

Tavşancıl, E. (2005). *Tutumların ölçülmesi ve SPSS ile veri analizi.* Ankara: Nobel Yayıncılık.

Tosun, T. (2000). The beliefs of preservice elemantary teachers toward science and science education. *School Science and Mathematics, 100*, 374-379.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing elusive construct. *Teaching and Teacher Education, 17*, 783-805.

Tschannen-Moran, M., & Woolfolk Hoy, A. (2007). The differential antecedents of selfefficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23,* 944- 956.

Ward, E. K. (2009). Latent Transition Analysis of Preservice Teachers' Efficacy in Mathematics and Science. University of North Texas.

Yilmaz-Tuzun, O. & Topcu, M. S. (2008). Relationships among preservice science teachers' epistemological beliefs, epistemological world views, and self-efficacy beliefs. *International Journal of Science Education, 30*(1), 65 – 85.

Zengin, U. (2003). *İlköğretim Öğretmenlerinin Özyeterlik Algıları ve Sınıf İçi İletişim Örüntüleri.* D.E.Ü. Eğitim Bilimleri Enstitüsü Yayımlanmamış Yüksek Lisans Tezi, İzmir.

◈◇◈

**Appendix 1. The five point Likert type "Using Mathematics in Science Self-efficacy Scale" (UMSSS)*
(Fen Bilgisi Öğretmen Adaylarının Matematiğe Yönelik Özyeterlik Algısı Ölçeği)**

1 Never, 2 Seldom, 3 Sometimes, 4 Frequently, 5 Always
(1 .Hiçbir Zaman, 2 Ender olarak, 3 Bazen, 4 Çoğu zaman, 5 Her zaman)

The original form of UMSSS in Turkish	The translated form of UMSSS in English
1. Fen dersini öğretmede kendimde matematiksel kavramların iyi oluştuğunu düşünüyorum.	While teaching science, I feel that I internalize the mathematical concepts better.
2. Fen dersindeki kavramları etkili bir şekilde öğretebilmek için gerekli matematiksel düşünme becerilerine sahip değilim.	I do not have the necessary mathematical thinking skills to teach the concepts in science.
3. Fen dersindeki başarıyı matematiksel becerilerimle arttırabilirim.	I can increase the success in science by my mathematical skills.
4. Fen dersinin amaçlarından biri olan eleştirel düşünme becerisini kazandırmayı matematik ile yapabilirim.	I can teach one of the aims of science course, critical thinking, through mathematics.
5. Fen derslerinde her türlü matematiksel kavram ve kuralları öğretme konusunda kendimi yeterli görmüyorum.	I do not think that I am sufficient enough to teach all kinds of mathematical concepts and rules.
6. Yeterince çalışırsam fen derslerindeki matematiksel problemleri kolayca çözebileceğime inanıyorum.	I believe that I can solve all the mathematical problems in the science courses if I try hard enough.)
7. Fen dersinde matematiksel bir problem ile karşılaşınca ne yapılacağımı bilemem.	I do not know what to do when I encounter with a mathematical problem in the science courses.
8. Fen dersinde her türlü günlük yaşam problemine matematiksel yaklaşımla bir çözüm önerisi getirebilirim.	I may have a solution for all kinds of daily life problems in science courses through a mathematical approach.
9. Fen öğretiminde yararlandığım matematiğe, aynı branştaki diğer arkadaşlarım kadar hâkim değilim.	I do not possess as much mathematical background as my colleagues in the same department.
10. Matematik ile öğrencilerin fen derslerindeki problem çözme becerilerini arttırabileceğime inanıyorum.	I believe that I can improve the students' problem solving skills through mathematics
11. Fen derslerinde matematiğe yönelik olumlu tutumun nasıl geliştirileceğini bilmiyorum.	I do not know how to develop positive attitudes towards mathematics in the science courses.
12. Fen dersinde matematiği etkili olarak kullanamadığımı düşünüyorum.	I believe that I cannot use mathematics in science courses effectively.
13. Öğrencilere fen ve matematik dersleri arasındaki ilişkileri kavratabilirim.	I can have my students understand the connection between science and mathematics.
14. Fen derslerini öğretirken matematiksel dili iyi bir şekilde kullanabilirim.	I can use the mathematical language well in teaching science. (15th item)
15. Fen derslerinde matematiğin önemi üzerinde öğrencileri bilgilendiremem.	I cannot instruct the students on the significance of mathematics in science lessons. (17th item)
16. Öğrencilerin matematikle ilgili sorunlarını çözebilmelerinde yardımcı olabileceğime inanıyorum.	I believe that I can help the students to solve their problems related to mathematics. (18th item)
17. Matematiği kullanarak fen derslerinde mantıksal çıkarımlar yapamam.	I cannot have logical deductions in science courses by using mathematics. (19th item)
18. Fen dersinde çeşitli matematiksel oyunlarla öğrencilerin problem çözme becerilerini geliştirebilirim.	I can improve the students' problem solving skills in science courses through a variety of mathematical games. (20th item)

* For the English version of the items given in parenthesis above we used three experts to do the translations into Engilish, and two experts to do the back translations into Turkish. Content validity was not performed.