韓國數學敎育學會誌 시리즈 A <數學敎育>
2013. 08. 제 52권, 제 3호, 363-377.

J. Korean Soc. Math. Ed. Ser. A: The Mathematical Education
August. 2013, Vol. 52, No. 3, 363-377.

Development of the Mathematics Teaching Efficacy Beliefs Instrument Korean Version for Elementary Preservice Teachers

Dohyoung Ryang(Univsersity of North Carolina at Greensboro)

Ⅰ. Introduction

Teacher efficacy is an important construct to explaining teachers' efficaciousness in their classrooms. Teacher efficacy is defined as a teacher's belief system which is a "judgment of his or her capabilities to bring desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated" (Tschannen-Moran & Hoy, 2001, p.783). Teacher efficacy influences students' motivation and achievement (Barr, 2005; Herman, 2000; Mojavezi & Tamiz, 2012; Nelson, 2007).

A teacher's sense of self-efficacy depends on the situation or the context that a teacher faces (Bandura, 1997; Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). Thus, appropriate methods of measuring a construct within teacher efficacy have grown as one of major issues (Tschannen-Morann et al., 1998). Researchers have been claimed that self-efficacy is most suitably measured within the context of specific behaviors (Henson, Kogan, & Vacha-Haase, 2001; Pajares, 1996). But, there is a warning that the development of measures not be so specific that they lose their predictive power and only address very particular skills or context (Tschannen-Moran et al., 1998). With this understanding about the specification of teacher efficacy, there is research need of developing an instrument to measure teaching efficacy in a subject matter.

The Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) is one of most impact instruments of measuring mathematics teaching efficacy. The MTEBI has been a tool to reveal new information on mathematics teaching efficacy. For example, teacher efficacy is a significant predictor of mathematics instructional strategies, and highly efficacious teachers are more effective than teachers with a lower sense of efficacy (Swars, 2005); teachers with a high self-efficacy are more willing to be creative and to use inquiry-based methods of teaching mathematical concepts (Wilkins, 2008). In addition, mathematics teaching efficacy is related to methods courses and field experiences (Evans, 2011; Swars, Smith, Smith, & Hart, 2009; Utley, Bryant, & Moseley, 2005); is negatively correlated to mathematics anxiety (Gresham, 2008; Swars, Daane, & Giesen, 2006); is related to preservice teachers′ ages, lower mathematics history, and methods course performance (Brown, 2012).

The MTEBI is no question to contribute to understanding teachers' efficacy beliefs in teaching mathematics Western cultures. However, we do little know yet about mathematics teaching efficacy in non-Western cultures. It is a big benefit to the global world of mathematics education if we get new knowledge on mathematics teaching efficacy in a

* Received June 02, 2013; revised July 17; accepted August 16, 2013
* ZDM Classification : B59
* 2000 Mathematics Subject Classification : 97C70
* Key words : Culture, mathematics teaching efficacy, reliability, validity

non-Western culture. However, as Lin, Gorrell, and Taylor (2002) pointed out, preservice teachers in different cultures (cf. Taiwan and the United States) have conceptually different expectation of teaching. Thus, the MTEBI also should be revisited when it is used in a different culture from the United States where the MTEBI was developed.

The MTEBI would be translated from the source language (English) to a target language. But, word-to-word translation may not work for equating the instruments in two languages since linguistic usage and cultural understanding are different between the cultures. A rigorous process of translation should take place. And then, empirical verification should follow in order to obtain validity of a scale in a culturally different population (Alkhateeb, 2004). This study is an empirical verification of the MTEBI in Korean elementary preservice teachers. A similar study was done for secondary preservice teachers (Ryang, 2013). Literature review of the current study would be in common with that previous study. This study, instead, review more detail on the history of the MTEBI in the United States and other cultures.

Ⅱ. Related Literature

There have been several models for understanding self-efficacy construct. However, Bandura's (1997) theory of social cognitive learning has been most often employed as a theory framing efficacy beliefs. In his theory, a person's efficacy is defined as a perception regarding an individual's beliefs in one's capabilities to produce designated levels of performance that exercise influence over events that affect their lives. He then conceptualized a psychological mechanism in which a person is motivated to perform an action as result of situational-interaction between personal cognitive interpretations and environmental influences that intertwine interactively. Bandura (1997) proposed that efficacy beliefs were powerful predictors of behavior because they were ultimately self-referent in nature and directed toward specific tasks. And, the predictive power of efficacy belief has well borne out when it is measured concerning specific task (Henson et al., 2001; Pajares, 1996).

Bandura's efficacy mechanism works in two dimensions of self-efficacy and outcome expectancy. Self-efficacy (or personal efficacy) is a person's confidence that he or she can perform the action successfully, and outcome expectancy is the person's beliefs that the action will have a desirable result. These two dimensions were proposed to be used in developing a teacher efficacy measure. Indeed, Gibson and Dembo (1984) stated that "…teachers who believe student learning can be influenced by effective teaching (outcome expectancy) and who also have confidence in their own teaching abilities (self-efficacy) should persist longer, provide a greater academic focus in the classroom, and exhibit different types of feedback …" (p. 570).

In consequence, Gibson and Dembo (1984) developed the Teacher Efficacy Scale (TES), in the frame of Banudra's theory, which taps into self-efficacy as a strong variable to a teacher's behavior in the classroom. The TES consists of 30 items within the two variables of Personal Teaching Efficacy (PTE) and the General Teaching Efficacy (GTE), but a short version TES yielded acceptable reliability in PTE (9 items) and the GTE (7 items). The PTE, corresponding to self-efficacy (or personal efficacy) in Bandura's theory, refers to a teacher's confidence in his/her ability to teach effectively and to effect positive change in student achievement. The GTE, corresponding to outcome expectancy in Bandura's theory, refers to a teacher's belief that a positive impact on student achievement is due primarily to his/her own actions as a teacher rather than by external factors such as a student's socio-economic background.

Because teacher efficacy can be most appropriately measured in specific context, a teaching efficacyscale has been developed in specific subject matters. The TES has provided guide in the development of such measures. For example, Riggs and Enochs (1990) adapted Gibson and Dembo's idea to develop the Science Teaching Efficacy Beliefs Instrument for measuring elementary teachers' science teaching efficacy (STEBI-A). This instrument has 25 items with 5-point rating scale in the two subscales of personal science teaching efficacy and science teaching outcome expectancy. These scale names showed that the instrument is closely related to the Bandura's efficacy dimensions. The STEBI-B (Enochs & Riggs, 1990) is a modification of STEBI-A for elementary preservice teachers. STEBI-B includes 23 items and uses the future tense of the verb in personal efficacy items to reflect the future orientation to teaching of elementary preservice teachers. Fourteen years after original development of the instrument, Bleicher (2004) successfully reexamined the reliability and internal validity of the STEBI-B.

The STEBI-B was modified for mathematics so the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) was developed. Enochs, Smith, and Huinker (2000) confirmed the two factor structure of the MTEBI on a sample of 324 elementary preservice teachers in the United States, in which the two items were deleted from the STEBI-B so the MTEBI would have 21 items in the two subscales: 13 items in the Personal Mathematics Teaching Efficacy (PMTE) and eight items in the Mathematics Teaching Outcome Expectancy (MTOE). In their study, the MTEBI had the comparative fit index (CFI) .919; Cronbach alpha .88 for the PMTE scale and .77 for the MTOE scale.

There have been a little research studies to require validating the MTEBI in other cultures. Chang (2003) pilot tested a Chinese version MTEBI on the sample of 30 Taiwanese senior students. The Chinese version had the coefficient alpha .87 for the PMTE and .67 for the MTOE. Alkhateeb (2004) tested an Arabic version MTEBI on 144 Jordan undergraduate education majors. The coefficient alpha was .84 for the PMTE and .75 for the MTOE; the factorial validity was explored by a principal component analysis with varimax rotation. Cakiroglu (2008) pilot tested a Turkish translation MTEBI; reported alpha coefficient .77 for the PMTE and .65 for the MTOE; the factorial structure was verified as the same as the original MTEBI. The alpha coefficients less than .7 for the MTOE in Turkish and Chinese versions would be minimally acceptable; usually not suggested for using in a research study (Abell, Springer, & Kamata, 2009).

There has been a series of studies to get better Korean version instruments underpinned in the MTEBI. The first work (Ryang, 2007) sought a universal scale for both elementary and secondary preservice teachers in a sample of 165 Korean preservice teachers. The results indicated that deleting five items would show acceptable reliabilities in both subscales but still problematic to factorial validity. Thus, the next work was to seek Korean version MTEBI in deferent levels (cf. elementary and secondary) of preservice teachers. Ryang, Thompson, and Shwery (2011) approached qualitatively to develop mathematics teaching efficacy scales for elementary and separately for secondary preservice teachers in Korea. The suggested measures were believed as reliable and valid for a research study but did not empirically tested.

Consequently, Ryang (2012) explored the year (spent in the program) effect to mathematics teaching efficacy on a sample of 106 students enrolled in an elementary teacher education program in Korea. The instrument used in the study was word-in-word translated; two items were deleted in analysis. The reliability alphas were .86 for the PMTE and .66 for the MTOE. Most recently, Ryang (2013) validated a Korean modification MTEBI for secondary mathematics preservice teachers. The current study is, in fact, a parallel study to this study for elementary preservice teachers.

Ⅲ. Methods

1. Settings and Data Collection

The elementary teacher education program in South Korea is a 4-year program which is exclusively run by the national universities of education. Due to the social belief that education are tremendously valuable and a teacher is very respected in Korean society, entering the national universities of education is so competitive and thus the undergraduates majoring in teacher education are highly qualified. They need to earn about 140 credit hours for graduation. The curriculum consists of various courses in liberal arts and sciences, pedagogy, content, methods, electives, and field experience. A Korean elementary preservice teachers specializing in mathematics teaching should take advanced mathematics courses (usually reduced to 2 credit hours) of Calculus, Set theory, Modern Algebra, Analysis, Geometry, Topology, and Statistics. Preservice teachers should take field experience in local schools, whose typical format is a 2-week observation, a 2-week participation, and a 4-week full practice during the program.

The data was collected from seven different universities out of 12 national universities of education in South Korea. Five hundred and six preservice teachers were participated in the survey. The sample sizes from the sites were pretty much even except one site where only 26 subjects were collected. The participants' ages ranged from 18 to 37 and the average was 21.9 (SD = 3.11) years old. The majority (81.9%) of them was young adults less than 25 years old. Thirteen participants did not report their ages. Among them, there were 159 (31.5%) male, and 346 (68.5%) female students; one did not report the gender. By the year in the program (or class level), there were 69 (13.7%) freshmen, 204 (40.4%) sophomores, 151 (29.8%) juniors, and 81 (16.0%) seniors; one did not report the class level.

2. Instrumentation

The MTEBI is the scale used in this study. The MTEBI consists of the PMTE (13 items) and the MTOE (8 items) as subscales. The PMTE scale measures a preservice teacher's personal beliefs about the person's ability of mathematics teaching efficaciousness; the MTOE scale measures expectancy that effective teaching will increase students' mathematical outcome. A PMTE item is stated in the first person and written in the future tense since preservice teachers are not yet professional teachers while an MTOE item is stated in the third person and written in the present tense. See the following two items as examples:

- I will be able to answer students' mathematics questions.
- The teacher is generally responsible for the achievement of students in mathematics.

About half of the PMTE items are negatively worded while the MTOE items are not negatively worded at all. An item has five options: Strongly Disagree, Disagree, Uncertain, Agree, and Strongly Agree.

The original MTEBI was translated into the language of the participants. Two Korean-English bilingual doctoral students were invited to translate the MTEBI. The first student translated the MTEBI from English to Korean (forward translation), and then the second student, blinded to the forward translation, translated the Korean translation back to English (backward translation). Thus, the original MTEBI and the back-translated version were compared to make adjustment to help get better Korean version. After that, four Korean mathematics teacher education professors, who are fluent in English, thoroughly reviewed on content and semantic equivalencies between the original MTEBI and the Korean version. The full description of equating the two versions was found in Ryang, Thompson, and Shwery's (2011) article. A pilot test to the Korean version suggested revising Items 5 and 7. The initial instrument in this study includes the 21 items from the MTEBI and the two alternatives for Item 5 and Item 7.

3. Procedures

The survey package consisted of three parts. Part I was the introduction including directions, purpose of study, the researcher's contact information, and consent statements. The participants, after reading Part I, would voluntarily give agreement to complete the survey. Part II was the demographic questionnaire asking to provide a participant's personal information such as age, gender, and the year in the program. Part III was the modified MTEBI Korean version. The participants would choose one of five options from Strongly Disagree to Strongly Agree to rate their feelings in each item. The survey was returned in 20 minutes during a method or content class.

4. Data Analysis

For convenience in the statistical process, PMTE items were numbered with the letter P and the MTOE items with the letter O (e.g., P2, O9). The two alternative items numbered with A next to the item number(P5A, O7A). Thus, there are 14 P-items and nine O-items. The participants' responses were coded by the 5-point rating scale from 1= Strongly Disagree through 5 = Strongly Agree. The negatively items were reversely coded (1 = 5, 2 = 4, 4 = 2, 5 = 1) so the PMTE score ranges from 14 to 70 and the MTOE score ranges from 9 to 45. Among 506 (participants) × 23 (items) = 11638 responses in total, only 26 were not responded so the missing rate was only 0.2%. Case-wisely, 15 out of 506 subjects did not answer to an item; the case-wise missing rate was 2.96%, below the suggested guideline 5% (Nosal & Nosal, 2003).

The missed values were pairwise deleted in analyzing the data. The IBM SPSS 21 program was used to analyze normality in theoretical and practical views. Next, the scales' reliability was examined by item-total correlation (Pearson r) and internal consistency coefficient (Cronbach α). Then, the factorial validity of the instrument was explored by component principal analysis.

Ⅳ. Results and Discussion

1. Normality

Descriptive statistics shown in Table 1 indicates that all items are negatively skewed except Item O7. Also, in the last two columns in Table 1, the two normality test indicated that all variables were significant and thus violated the normality assumption. However, the numerical tests of normality are very sensitive to the sample size so social/behavioral science scholars are suggested using a criterion developed from Monte Carlo simulation: Normality is suspected when |skewness| > 3.0 and |kurtosis| > 8.0 (Bae, 2006; Curran, West, & Finch, 1996). All items and scales did not violate the normality by this alternative criterion. However, P5 had relatively larger skewness and kurtosis than others; O7 was positively skewed while the others negatively skewed. Thus, these two items were flagged for further investigation.

[Table 1] Descriptive Statistics and Normality Tests

Item	Mean	S.D.	Skewness	Kurtosis	Kolmogorov-Smirnov[a]	Shapiro-Wilk[a]
O1	3.49	.79	-.59	.42	.290	.839
P2	4.14	.65	-.50	.93	.306	.782
P3	3.84	.93	-.87	.80	.290	.844
O4	4.05	.64	-.63	1.73	.332	.762
P5	4.15	.78	-1.13	2.30	.292	.779
P5R	3.65	.71	-.40	.63	.305	.821
P6	3.64	.83	-.42	0.16	.272	.865
O7	2.91	.88	.07	-.44	.207	.887
O7R	3.95	.61	-.73	2.37	.373	.729
P8	3.86	.76	-.55	.54	.306	.833
O9	3.90	.69	-.87	2.05	.356	.772
O10	4.07	.68	-.73	1.49	.319	.777
P11	3.36	.82	-.13	-.03	.240	.873
O12	3.74	.70	-.51	.76	.329	.810
O13	3.51	.73	-.45	.09	.301	.825
O14	3.94	.79	-.91	1.27	.335	.797
P15	3.56	.85	-.55	.19	.289	.858
P16	3.54	.80	-.25	-.07	.259	.864
P17	3.72	.88	-.62	.23	.293	.857
P18	3.30	.94	-.22	-.14	.206	.896
P19	3.81	.76	-1.04	1.74	.367	.773
P20	3.61	.85	-.45	.31	.261	.868
P21	3.48	.84	-.32	-.21	.262	.869
PMTE	51.69	.28	-.285	.85	.074	.987
MTOE	33.63	.16	-.155	1.03	.075	.981

Note. Skewness statistic has standard error .11 in all item and scale variables; kurtosis statistics have standard error .22 in all item and scale variables. [a]Kolmogorov-Smirnov and Shapiro-Wilk's normality statistics are all significant (p = .000) for all item and scale variables.

2. Reliability Analysis

An item with a low correlation (Pearson $r < .3$) to the scale may weaken the scale's reliability. Deleting such an item will increase the scale's reliability. In this study for the 23 item instrument, the internal consistency coefficients were α = .820 for the PMTE, α = .690 for the MTOE, and .823 for the whole scale. For each item, the item-total correlation (ITC) and alpha coefficient after deleting the item (AID) was calculated (see Table 2). The result indicated that P5 had very low ITC both to the PMTE (r = .025) and to the whole scale (r = .098). Also, Deleting P5 increased alpha from .830 to .836 for the PMTE and from .823 to .828 for the whole scale.

[Table 2] Reliability Analysis

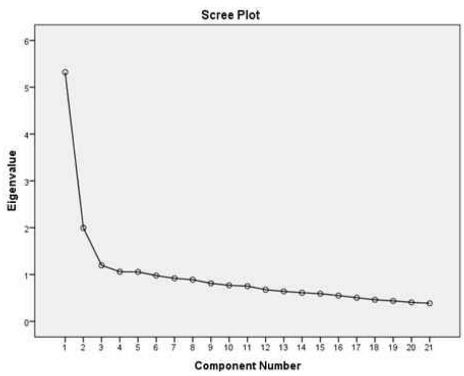
	Subscale		Full Scale	
Item	ITC	AID	ITC	AID
MTEBI				.823
PMTE		.820		
P2	.408	.811	.396	.816
P3	.460	.807	.391	.816
P5	.025	.836	.098	.828
P5A	.554	.802	.543	.810
P6	.466	.807	.391	.816
P8	.620	.796	.555	.808
P11	.461	.807	.418	.814
P15	.429	.810	.377	.816
P16	.532	.802	.488	.811
P17	.644	.793	.564	.807
P18	.405	.812	.377	.817
P19	.455	.808	.399	.815
P20	.361	.815	.364	.817
P22	.476	.806	.470	.812
MTOE		.690		
O1	.289	.681	.234	.823
O4	.386	.661	.385	.816
O7	.204	.704	.026	.833
O7A	.441	.653	.470	.814
O9	.406	.657	.362	.817
O10	.379	.662	.360	.817
O12	.448	.648	.360	.817
O13	.473	.642	.302	.820
O14	.338	.671	.339	.818

Note. P5 and O7 showed low ITCs less than .3 and higher AID than the scale alpha.

Item O7 had also low ITC both to the MTOE (r = .204) and to the whole scale (r = .026). Deleting item O7 increased alpha from .690 to .704 for the MTOE; increased from .823 to .833 for the whole scale. These results strongly suggest removing these items P5 and O7 from the instrument. The item O1 also has low ITCs less than .3 for the subscale and for the whole scale, but deleting O1 did not increase the alpha for the scales.

3. Factorial Validity

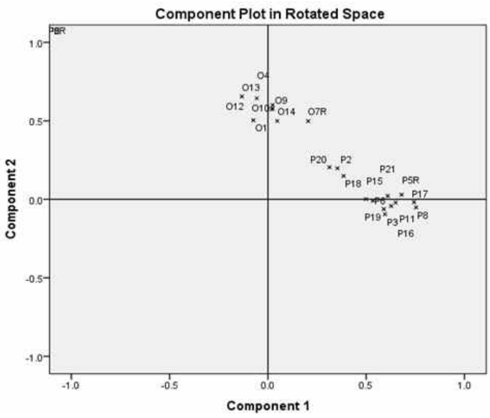
There are several ways to explore the factor structure on a scale. Maximum Likelihood (ML) method was suggested to use for normally distributed data; an oblique rotation method for non-orthogonally proposed factors (Costello & Osborne, 2005). The PMTE and the MTOE are intertwined of each other within Bandura's theory. This study used principal component analysis, which uses maximum likelihood method, with promax (a type of oblique rotation) to extract factor solutions to the 21 items after deleting the two items of P5 and O7. KMO measure of sampling adequacy index was .869, and Bartlett's sphericity test was significant (χ^2 = 2414.677, DF = 210, p = 0.000).



[Fig. 1] Scree Plot of the 21 Item scale

To investigate the latent variables explaining mathematics teaching efficacy, the number of factors was not constrained at the first place. In Figure 1, the first two eigenvalues are dominantly high while the others are gradually decreasing below eigenvalue 1 and lay off to the right. The result indicated a two-factor solution is the best fit on the 21 items.

We now determine whether or not the two factors suggested in the scree plot are the PMTE and the MTOE. Figure 2 is the component plot depicting where the items are clustered. All P-items are clustered around the center at the intersection of the Component 2 line of 0 and the Component 1 line of .5; All O-items are clustered around the center at the intersection of the Component 2 line of .5 and the Component 1 line of 0. That is, the Component 1 consists of all P-items and the Component 2 of all O-items. Therefore, the Component 1 is the PMTE and the Component 2 the MTOE.



[Fig. 2] Component Plot in Rotated Space

More detail, Table 3 is the pattern matrix where all 13 P-items loaded to Component 1 and all eight O-items loaded to Component 2. The factor loading range of the P-items was from .753 down to .313, and that of the O-items was from .655 down to .498. Further, nine out of 13 P-items and six out of eight O-items had factor loadings greater than .5, so these two factors are strong (Costello & Osborne, 2005). Also, Component 1 accounted for 24.79% with eigenvalue 5.20 of the total variance, and Component 2 explained 9.58% with eigenvalue 2.01 of the total variance; the two factors together explained 34.38% of the total variance. Therefore, Component 1 must be the PMTE and Component 2 must be the MTOE. The PMTE had reliability α = .836; the MTOE reliability α = .705.

[Table 3] Pattern Matrix: Promax PCA

Item	Component 1	Component 2
P8	.753	
P17	.743	
P5A	.680	
P16	.650	
P11	.626	
P21	.610	
P3	.596	
P19	.590	
P6	.534	
P15	.498	
P18	.385	
P2	.354	
P20	.313	
O13		.655
O12		.644
O4		.600
O10		.579
O9		.573
O1		.504
O14		.499
O7A		.498
Eigenvalue	5.21	2.01
Variance, %	24.79	9.58

4. Discussion

In a cross-cultural study, translation process is of utmost importance. Despite sincere forward-backward translations, the Korean version MTEBI would not be perfect because of linguistic and cultural discrepancies. The reviewers detected potential weaknesses in the translation of Items 5 and 7; the pilot test also showed that those two were problematic. In this study, Items P5 and O7 were removed from the scale but the alternatives P5A and O7A well behaved in the scale.

The original Item 5 (I know how to teach mathematics concepts effectively) seems to violate the tense agreement in the Korean version. To fix this problem, a reviewer suggested using the future tense in the main clause and the present tense in the subordinate clause. However, a suggested modification P5 (Since I already *know* how to teach mathematics concepts effectively, I *will* not need to learn more about it in the future) was lengthy and complicated. Also, it is still questionable whether or not using two tenses in the item can fix the tense disagreement.

The alternative P5A (I will teach mathematics in such a way that the students easily understand the concepts) was well behaved in the scale. However, the original Item 5 looks nice and simple. Despite the tense violation, the item might be properly responded among the preservice teachers. The use of original Item 5, or a little modification (e. g., I will be able to know how to teach mathematics concepts effectively) ought to be tested in a future study. In addition, there is no reason not to use the original Item 5 for inservice teachers.

The original Item 7 (If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching) have double negations. Since all participants of this study were preservice teachers and they want to become effective teachers, they would respond to each item with positive sense. Thus, all item variables would naturally be slightly skewed negatively (i.e., the mean is greater than the median). However, Item 7 was of positive skewness. The double negation possibly made confusion in the participants' thinking when they responded to this item. The contrapositive, logically equivalent to the original statement, can fix the problem without changing the meaning. Thus, the contrapositive O7A (If a teacher effectively teaches mathematics, students improve in an assessment) was tested and resulted as making the instrument stronger while O7 made the instrument weaker.

This study is parallel to Ryang's (2013) study on developing the Korean version MTEBI for secondary preservice teachers. The result of deleting the two items P5 and O7 was the same in the two studies. Also, the two versions look identical except one item P3 (Even if I try very hard, I will not teach mathematics as well as I will most subjects). This item was appropriately modified for secondary teachers who are one-subject (mathematics) specialists in the secondary version.

Despite the similarity, we here see differences by comparing the samples and the data analysis of the two studies (see Table 4). Sample sizes in both studies were greater than 500, which are big enough to use the ML method in factor analysis. Data missing rate was very small in both samples and thus additional treatment was not necessary; the missing cases were simply pairwise deleted. Participants' age was quite same in average; the major population was young adult less than 25 years old in both studies. But, the gender ratios were different. The majority was female in the elementary sample but male in the secondary sample.

Class distributions were also look different; sophomores were excessively collected than others in the elementary sample while all classes were collected more evenly in the secondary sample. However, the lowest percent point 13.7 for 506 elementary preservice teachers is about 70 subjects, which are considered as large as representing characteristics of a

[Table 4] Comparing the Instruments for Elementary and Secondary Preservice Teachers

	Elementary	Secondary
Sample		
Size	506	658
Age average(S.D.)	21.9(S.D.=3.11)	21.7(S.D.=2.72)
Gender ratio[a](%)	31.5 : 68.5	58.9 : 41.1
Class ratio[b](%)	31.5 : 40.4 : 29.8 : 16.0	23 : 21 : 27.1 : 28.9
Data missing rate(%)	.2	.2
Reliability		
PMTE alpha	.836	.839
MTOE alpha	.705	.742
Factor stucture		
P-item factor loadings	.313 - .753	.436 - .779
O-item factor loadings	.498 - .655	.421 - .716
No. of P-items > .5 FL[c]	9	10
No. of O-items > .5 FL[c]	6	6
Top three P-items	P8, P17, P5A	P17, P8, P21
Bottom three P-items	P20, P2, P18	P18, P2, P6
Top two O-items	O13, O12	O13, O12
Bottom two O-items	O7A, O14	O14, O4

Note. [a]Males: Females, [b]Freshmen : Sophomores : Juniors : Seniors, [c]FL=Factor Loading

group in a parametric statistical analysis. Above all, the same treatment in the sampling process would produce more reliable results in the studies.

To discuss how strong the two-factor structure, look at factor loadingrange and the number of items whose loading is greater than .5. The P-items' factor loadings to the PMTE ranged from .313 to .753 in the elementary version while from .436 to .779 in the secondary version. Nine P-items were greater than .5 of factor loadings in the elementary version while 10 P-items in the secondary version.

The O-items factor loadings to the MTOE ranged from .498 to .655 in the elementary version while from .421 to .716 in the secondary version. Six O-items were greater than .5 of factor loadings in both versions. The strongest and weakest items between both versions were not exactly same, but some items were common in both versions. Items P8, P17, O12, O13 were strong items in both version and Items P2, P18, O14 were weak in both versions.

Factor analysis is a way of examining construct validity. The final version instrument has the two-factor structure as theoretically assumed and as established in the Enochs et al.'s MTEBI. Further, alpha coefficients at least .7 in the PMTE and the MTOE are a way of establishing validity in the instrument. In this study, after deleting the Items P5 and O7, the alpha coefficients were .836 for the PMTE (13 items), and .705 for the MTOE (8 items). According to Abell et al. (2009), the PMTE can be used for deciding an individual person's and also a group's efficacy trait; the MTOE can be used for deciding a group efficacy trait.

For researchers, the validation of an instrument is an ongoing and never ending process requiring close scrutiny and persistent cross-checking (Bleicher, 2004). Since the reliability and factorial validity is dependent of the scores of the scale, if the sample is changed, the reliability and factorial validity are changed too. Thus, an instrument should maintain reasonable level of reliability and validity across samples. The two studies resulted that the PMTE reliabilities were very similar while the MTOE reliabilities looked different between elementary and secondary samples (see Table 4). This finding implies that self-efficacy in mathematics teaching is consistent between both elementary and secondary preservice teachers at the same level. However, how and why outcome expectancy looks different between the two groups remains as a future study.

Even though this study well set the reliability and factorial validity, it is necessary to re-establish the factor structure using a theoretical model than a set of measured data. Enochs et al. (2000) reported a model fit index, CFI = .919. A future study is to confirm that the Korean version has the factor structure as theoretically assumed using the structural equation modeling which will produce various model fit indices.

Ⅴ. Conclusion and Implications

This study developed a Korean modification MTEBI. See the Appendix for the full items in Korean as well as in English. The results indicated that the Korean version is reliable and valid enough to measure mathematics teaching efficacy of Korean elementary preservice teachers as the original MTEBI does for the U.S. elementary preservice teachers. A most useful implication of this study is that the instrument would contribute to produce plenty of knew knowledge on Korean elementary preservice teachers' self-efficacy and outcome expectancy in mathematics teaching.

According to Bandura, it is no doubt that mathematics teaching efficacy is a strong predictor to teachers' effectiveness of mathematics teaching in the classroom than any other psychological constructs. In this sense, mathematics teacher educators must consider efficacy beliefs as well as mathematical knowledge in their teacher education programs. Therefore, there is a research need to determine how mathematics teaching efficacy influences various venues in teacher education program. Further, there are a lot of research topics for future study. Examples follow:

- Relation of teacher knowledge and efficacy in mathematics teaching
- Relations to mathematics anxiety and mathematics attitudes
- Impact of mathematics teaching efficacy on the quality of the field experience
- Impact of mathematics teaching efficacy on student achievement
- Changing mathematics teaching efficacy beliefs from prospective teachers to novice and then to expert teachers
- Methods of increasing mathematics teaching efficacy in teacher education program

The Korean version developed in this study are not totally revised but slightly modified from the original MTEBI. It can give a benefit that an international study using the original and Korean version MTEBI can be item-wise compared with better synchronization. Thus, the result will have higher trustworthiness than any other studies using differently conceptualized instruments. Therefore, globalizing the knowledge on mathematics teaching efficacy including similarities and differences amongst cultures is very valuable to the world of mathematics education.

This study and the previous study (Ryang, 2013) provide the two versions of Korean MTEBI, one for elementary and the other for secondary preservice teachers. Using these instruments, research on mathematics teaching efficacy for elementary and for secondary preservice teachers can be now performed with one unique perspective. There will be a lot of interesting research topics involving both levels of teacher education programs. For example, we may naturally assume that secondary preservice teachers would have higher level of personal efficacy but lower outcome expectancy in mathematics teaching, based on the programs' conceptual differences and social expectations in Korea. A future research can test this hypothesis.

References

Abell, N., Springer, D. W., & Kamata, A. (2009). *Developing and validating rapid assessment instruments.* Oxford University Press.

Alkhateeb, H. M. (2004). Internal consistency reliability and validity of the Arabic translation of the mathematics teaching efficacy beliefs instrument. *Psychological Reports, 94*, 833-838.

Bae, B. (2006). LISREL structural equation model: Understanding, practice, and programming. Seoul: Chongram. (In Korean).

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

Barr, L. C. (2005). *The effects of parent and teacher self-efficacy on the academic achievement motivation of preschool children.* Unpublished master's thesis, Wake Forest University.

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

Brown, A. B. (2012). Non-Traditional Preservice Teachers and Their Mathematics Efficacy Beliefs, *School Science and Mathematics, 112*(3), 191-198.

Cakiroglu, E. (2008). The teaching efficacy beliefs ofpre-service teachers in the USA and Turkey, *Journal of Education for Teaching, 34*(1), 33-44.

Chang, Y. L. (2003). *An examination of knowledge assessment and self-efficacy ratings in teacher preparation programs in Taiwan and the United States.* Unpublished Doctoral Dissertation, University of Idaho.

Costello, A. B., & Osborne, A. B. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment Research & Evaluation, 10*(7), 1-9.

Curran, P. J., West, S. G., & Finch, J. F. (1996). The robustness of test statistics to nonnormality and specification error in confirmatory factor analysis. *Psychological Methods, 1*(1), 16-29.

Enochs, L., & Riggs, I. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90*(8), 194-202.

Enochs, L., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194-202.

Evans, B. R. (2011). Content knowledge, attitudes, and self-efficacy in the mathematics New York City Teaching Fellows (NYCTF) program. *School Science and Mathematics, 111*(5), 225 - 235.

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

Gresham, G. (2008). Mathematics anxiety and mathematics teacher efficacy in elementary preservice teachers. *Teaching Education, 19*(3), 171-184.

Henson, R. K., Kogan, L. R., & Vacha-Hasse, T. (2001).A Reliability generalization study of the teacher efficacy scale and related instruments. *Educational and Psychological Measurement, 61*(3), 404-420.

Herman, P. (2000). *Teacher experience and teacher* *efficacy: Relations to student motivation and achievement.* Unpublished doctoral dissertation. University of North Carolina at Chapel Hill.

Lin, H., Gorrell, J., & Taylor, J. (2002). Influence of culture and education on U. S. and Taiwan preservice teachers' efficacy beliefs. *Journal of Educational Research, 96*(1), 37-46.

Mojavezi, A., & Tamiz, M. P. (2012). The Impact of Teacher Self-efficacy on the Students' Motivation and Achievement. *Theory and Practice in Language Studies, 2*(3), 483-491.

Nelson, S. L. (2007). *Teacher efficacy and student motivation: A link to achievement in elementary mathematics.* Unpublished doctoral dissertation, University of South Dakota.

Norsal, M., & Norsal, E. (2003, June). *Three-parameter Weibull generator for replacing missing observations.* Papers presented at the meeting of the International Conference on Statistics and Related Fields, Honolulu, HI.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*, 543-578.

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.

Ryang, D. (2007). Reliability and validity of the MTEBI among Korean pre-service mathematics teachers.(In Korean). *KSME Journal Series A: The Mathematical Education, 46*, 263-273.

Ryang, D., Thompson, T., Shwery, C. (2011). Analysis of Korean mathematics teacher educators' response to the Mathematics Teaching Efficacy Beliefs Instrument. *KSME Journal Series D: Reseach in Mathematical Education, 15*(3), 229-250.

Ryang, D. (2012). Exploratory Analysis of Korean elementary preservice teachers' mathematics teaching efficacy beliefs. *International Electronic Journal of Mathematics Education, 7*(2), 45-61.

Ryang, D. (2013). Exploring validation of the MTEBI for secondary mathematics preservice teachers. *KSME Journal Series A: The Mathematical Education, 52*(2), 231-245.

Swars, S. L. (2005). Examining perceptions of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional Psychology, 32*(2), 139-147.

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*(7), 306-315.

Swars, S. L., Smith, S. Z., Smith, M. E., & Hart, L. C. (2009). A longitudinal study of effects of a developmental teacher preparation program on elementary prospective teachers' mathematics beliefs. *Journal of Mathematics Teacher Education, 12*(1), 47-66.

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

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

Utley, J., Bryant, R., & Moseley, C. (2005). Relationship between science and mathematics teaching efficacy of preservice elementary teachers. *School Science and Mathematics, 105*(2), 82-87.

Wilkins, J. L. M. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs and practices. *Journal of Mathematics Teacher Education, 11*, 139-164.

Appendix. MTEBI Korean Version Items

Item	English Korean
P8	I will be unable to teach mathematics effectively. 나는 효율적으로 수학을 가르칠 것 같지 않다.
P17	I wonder if I will have the necessary skills to teach mathematics. 나는 수학교사가 된 뒤에 수학을 가르치는데 필요한 기술을 가지고 있을지 잘 모르겠다.
P5A	I will teach mathematics in such a way that the students easily understand the concepts. 나는 학생들이 쉽게 이해할 수 있게 수학을 가르칠 수 있을 것이다.
P16	I will be able to answer students' mathematics questions. 나는 수학 수업시간에 학생들의 질문에 대답을 잘 할 수 있을 것이다.
P11	Since I understand mathematics concepts well, I will teach mathematics effectively in the future. 나는 수학 개념을 잘 이해하고 있기 때문에, 장래에 수학을 잘 가르칠 수 있을 것이다.
P21	I do not know what to do to turn students on to mathematics. 나는 수학교사가 되었을 때, 학생들이 수학에 관심을 갖게 하기 위해 무엇을 해야 할지 잘 모를 것 같다.
P3	Even if I try very hard, I will not teach mathematics as well as I will most subjects. 내가 아무리 애를 써도 다른 과목만큼 수학을 잘 가르치지는 못할 것이다.
P19	When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better. 학생이 수학 개념을 잘 이해하지 못할 경우, 나는 그 학생에게 도움을 주지 못할 것 같다.
P6	I will not be very effective in monitoring students' mathematics activities in the classroom. 나는 교실에서 학생들의 수학 학습 활동을 관찰할 때 그리 효과적이지 못할 것이다.
P15	I will find it difficult to use manipulatives to explain to students why mathematics works. 나는 교사가 된 뒤에도 교구를 사용하여 수학을 설명하는 것이 어려울 것 같다.
P18	I will agree to open my mathematics class so others evaluate the class. 나는 수학 수업을 다른 사람들이 평가하도록 공개하는 것에 대하여 동의할 것이다.
P2	I will continually find better ways to teach mathematics. 나는 수학을 가르치는 더 좋은 방법을 찾으려고 언제나 노력할 것이다.
P20	When teaching mathematics, I will usually welcome student questions. 나는 수학 수업 시간에 학생들이 질문에 대답하기를 좋아할 것이다.
O13	Students' achievement in mathematics is directly related to their teachers' effectiveness in mathematics teaching. 학생들의 수학성취도는 교사가 얼마나 효과적으로 수학을 가르쳤느냐에 직접적으로 관계가 있다.
O12	The teacher is generally responsible for the achievement of students in mathematics. 교사는 일반적으로 학생의 수학성취도에 책임이 있다.
O4	When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach. 학생들의 수학 성적이 향상되는 것은, 때로는 교사가 더 효과적인 수학 교수 방법을 찾아낸 덕분이다.
O10	When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher. 교사가 수학 성적이 낮은 학생에게 좀 더 관심을 기울이면, 그 학생은 수학 실력이 나아진다.
O9	The inadequacy of a student's mathematics background can be overcome by good teaching. 교사가 수학을 잘 가르치면 학생들의 나쁜 수학 공부 습관을 고칠 수 있다.
O1	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort. 학생이 평소보다 수학을 더 잘 할때, 이는 교사가 추가 노력을 기울인 결과다.
O14	If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher. 교사가 수학을 가르치는 능력이 뛰어나면, 수학에 대한 학생들의 흥미가 높아진다.
O7A	If a teacher effectively teaches mathematics, then students improve in an assessment. 교사가 수학을 효과적으로 가르치면, 학생들은 수학 평가에서 좋은 성적을 거둔다.
Note.	The items are listed in the same order shown in Table 3; P5A and O7A are replacement of P5 and O7.

초등 예비 수학 교사를 대상으로 하는 MTEBI 한글판 개발

량도형
Dept. Math. & Stat., University of North Carolina at Greensboro, U.S.A. 27402
E-mail : d_ryang@uncg.edu

교수효능감은 교사가 교실에서 얼마나 효율적으로 가르칠 것인지를 예측하는 매우 강력한 구인이다. MTEBI는 초등 예비교사를 대상으로 수학 교수 효능감을 재는 유효한 척도이다. 그러나 MTEBI는 미국에서 개발되어 다른 문화에서 바로 사용할 수는 없다. 본 연구는 MTEBI가 한국에서 유효한 지에 대한 실증적 조사이다. 먼저, 영문의 MTEBI를 국문으로 번역하고, 번역한 것을 다수의 수학교사 교육자가 철저하게 검토하였다. 그다음, 506명의 예비 초등교사 표본에서 정규성, 신뢰도, 타당도 등의 통계적 검정을 실시하였다. 그 결과, 한글판 MTEBI의 하위척도인 PMTE와 MTOE의 알파계수가 각각 .836과 .705이었다. 이로써 한글판 MTEBI가 한국에서 효능감 연구에 사용할 수 있을 만큼 믿을 수 있고 문항 구성이 타당함을 입증하였다. 나아가 본 연구에서 제시된 영문판을 바탕으로 한국과 교육에 대한 전통과 문화가 비슷한 이웃 문화에서도 효능감 연구가 일어나기를 기대한다.

* ZDM분류 : B59
* MSC2000분류 : 97C70
* 주제어 : 문화, 수학교수효능감, 신뢰도, 타당도