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Confirmatory Factor Analysis of a School Self-Concept Inventory

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Abstract

One of the valued objectives of education is the enhancement of a positive self-concept, which itself is a mediating variable of other desired outcomes. To facilitate the assessment of this goal, reliable and valid scores on self-concept scales are required for the proper interpretation of related substantive issues. The main purpose of this study is to examine the construct validity of scores on a self-concept scale used with Taiwanese elementary students.

Participants consisted of 1612 students from grades 3 to 6 in Taiwanese elementary schools. The School Self-Concept Measure used in this study was a paper-and-pencil self-reported questionnaire. This measure contained 15 items and used a 4-point Likert-scale format where high scores indicated positive self-concept of students. Confirmatory factor analysis (CFA) with maximum likelihood (ML) estimating method was conducted to analyze the school self-concept scale. Three-factor oblique model was a hypothesized factor model. There were three objectives: 1) Does the correlated three-factor structure of self-concept scale fit the data collected in this study? 2) Is correlated three-factor structure of self-concept scale better than alternative factor models? 3) Is correlated three-factor structure of self-concept scale invariant across gender groups and grade groups?

Results showed that he three-factor oblique model fit the data sampled in this study. So the hypothesis of multidimensionality of self-concept was verified. The results of this investigation also strongly confirmed the invariance of factor loadings, factor variances/covariances, and error variances across gender and grade groups. Some suggestions were made in this study.

Confirmatory Factor Analysis of a School Self-Concept Inventory

One of the valued objectives of education is the enhancement of a positive self-concept, which itself is a mediating variable of other desired outcomes (Shavelson & Bollus, 1982). To facilitate the assessment of this goal, reliable and valid test scores on self-concept scales are required for the proper interpretation of related substantive issues. Byrne (1996) recommended that confirmatory factor analysis (CFA) instead of exploratory factor analysis (EFA) be conducted to ascertain the validity of these scores.

According to Shavelson, Hubner, and Stanton (1976), self-concept of students includes the higher order factors. That is, self-concept is hierarchical. Their self-concept model is a three-order factor structure. The diagram of three-order factor model is shown in Figure 1. As can be seen in Figure 1, the factor of the highest level, denoted the third-order factor, is general self-concept factor. The factor includes three second-order and major factors: academic, social, and physical factors. Each factor has its own first-order factors. Academic factor includes verbal ability, social science ability, science ability, and math ability factors. Social factor includes friendship and appointment factors. And physical factor includes sports and physical appearance factors. Each first-order factor is measured by several observed items. Song and Hattie (1984) also have the same hierarchical view for student self-concept.

The present study focuses on the self-concept of students influenced in the elementary schools, so the school self-concept scale of this study includes three major factors: general, academic and non-academic factors. These factors are hypothesized to be a first-order correlated factors model. The model diagram is shown in Figure 2. Confirmatory factor analysis is used to analyze the validity of self-concept scale.

Consequently, the main purpose of this study is to examine the construct validity of the

scores on self-concept scale for elementary students. There are three objectives: 1) Does the correlated three-factor structure of self-concept scale fit the data collected in this study? 2) Is correlated three-factor structure of self-concept scale better than alternative factor models? 3) Is correlated three-factor structure of self-concept scale invariant across gender groups and grade groups?

Methods

Participants

Participants consist of 1612 students from grade 3 to grade 6 in the elementary school. Because the present study needed participants from grade 3 to grade 6, researchers used the stratified sampling method to sample intact classrooms. The students were sampled from Taipei, Taichung, Tainan, and Hwalan, located in the north, middle, south and east of Taiwan. The proportion of each location, in turn, was 25.5%, 26.6%, 18.3, and 29.6%. The grade composition for each of these four groups from third to sixth grade was approximately 20.3%, 25.6%, 27.4%, and 26.8%. Of the total sample, male comprised 51.7% and females comprised 48.3% of the subjects.

School Self-Concept Inventory

The Self-Concept Measure of this study is a paper-and-pencil self-reported questionnaire designed to assess self-concept of students in the elementary and middle school. The school self-concept measure of students in this study mainly assessed the three domains, including general, academic, and non-academic self-concept. The whole scale was presented in Table 1.

The School Self-Concept Inventory contains 15 items. And this measure is a 4-point Likert-scale format. Participants' responses to the items on the self-concept measure range from 1 (strongly disagree) to 4 (strongly agree). All items were worded in the positive direction. A

total score is computed by adding the numerical values assigned to each marked choice. The possible score range for the self-concept measure is from 15 to 60. High scores indicated that self-concept of students was in the positive direction.

Procedure

A standard procedure was followed in all schools for administration of the measure. All administrations were held by the memberships of the research group. Informed consent was obtained from the principals of the schools and the teachers in charge of the classes, and participants were assured anonymity.

When the actual testing began, all participants were given a test protocol and asked to report their personal basic information regarding grade in school and gender. The instructions printed at the top of each questionnaire were read aloud by the examiner. Questions about the test were permitted, but we were answered only in a general way in an effort not to influence responses. The participants were instructed to mark the sentence that best describes the way they have been feeling and thinking. There was no time limit on the self-concept measure.

Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) is a theory-testing model as opposed to a theory-generating method like exploratory factor analysis. In CFA, the researchers begin with a hypothesis prior to the analysis. This model, or hypothesis, specifies which variables will be correlated with which factors and which factors are correlated. The hypothesis is based on a strong theoretical and/or empirical foundation (Stevens, 1996). In current study, CFA was conducted to analyze the school self-concept scale using the estimation procedure of maximum likelihood (ML). However, maximum likelihood method assumes multivariate normality when statistical tests are performed.

Models

A CFA analysis of the 15-item self-concept scale was carried out for three alternative factor models. The three models were unidimensional, three-factor orthogonal, and three-factor oblique. The unidimensional model hypothesized that there was only one general factor underlying the 15 indicators. Errors in 15 items were not allowed to be correlated. In the three-factor orthogonal model, the intercorrelations among factors and the intercorrelation among errors in the items were constrained to zero. In the three-factor oblique model, the only difference from the three-factor orthogonal model was that no interrelations among factors were relaxed.

Goodness-of-Fit Indicators.

The fit statistics test how well the hypothesized models fit the data. Mulaik (1987) noted, "a goodness-of-fit test evaluates the model in terms of the fixed parameters used to specify the model, and acceptance or rejection of the model in terms of the overidentifying conditions in the model" (p. 275). In the present study, these statistics include the chi square (χ^2), comparative fit index (CFI), goodness of fit index (GFI), root mean-square error of approximation (RESEA).

Results

Descriptive Statistics

Table 2 shows the means, standard deviations, skewness, and kurtosis of the 15 school SC items. According to the values of skewness and kurtosis, almost all of these ordinal items are approximately normally distributed. Therefore, maximum likelihood estimation used in confirmatory factor analysis would be appropriate. Covariance matrix among these 15 items is shown in Table 3.

Correlation coefficients among three factors of self-concept scale are shown in Table 4. These coefficients are .75, .82, and .82, respectively, and are statistically significant ($p<.05$).

Using EQS software, the estimates of the parameters of the hypothesized model were got. The model diagram and the values of the estimated parameters with standardized solution are showed in Figure 3.

Evaluation of Fit of the Hypothesized Models

Based on the indicators of goodness-of-fit in Table 5, the three-factor oblique model, the hypothesized model of this study, was considered to fit the data most satisfactorily. Although the χ^2 value of 515.68 with degrees of freedom of 87 was statistically significant, it was well-known that χ^2 statistic was sensitive to the sample size. Hence, another indices should be taken into consideration. The values of CFI and GFI were .92 and .96, respectively. These values indicated that the three-factor oblique model fit the data well. The value of RMSEA was .056. This value also indicated that the fit of the hypothesized model was good.

Although the three-factor oblique model fit the data well, it did not mean that this hypothesized model was the only well fitting model. Thus, the hypothesized model had to be compared with other models. In the present study, comparisons of one-factor model and three-factor orthogonal model were made.

Comparisons of the Different Factor Models

Table 5 shows the indices of fit for three-factor oblique model and competing alternative models. As evidenced by the largest χ^2 value and RMSEA value and the lowest magnitudes for the CFI and GFI indicators, the fit of the three-factor orthogonal model was judged to be the least satisfactory among the three models. Although the χ^2 value was statistically significant in the unidimensional factor model and correlated three-factor model, the fit of these two models was considered satisfactory. The magnitudes of CFI and GFI for the unidimesional model were .87 and .93 and for three-factor oblique model were .92 and .96. The RMSEA values for these two

models were .068 and .056, respectively.

Because the unidimensional was nested with the three-factor oblique model, the χ^2 difference test could be used to compare the models. The value of the χ^2 difference was 245.5 with $df = 3$ ($p < .001$). The statistically significant χ^2 difference value suggested that there was a significant improvement in fit when the three factors were correlated rather than one factor. In this present study, the three-factor oblique model could be considered to be reasonably satisfactory.

Factorial Invariance

Because the three-factor oblique model appeared to indicate the most satisfactory representation of the data, two sets of multigroup analyses to examine the invariance of the three-factor oblique model were carried out across gender and grade. The following sequential models were tested using EQS software (Bentler, 1995).

Model 1 is a baseline model to test fit of factor models with comparable configurations across gender and age. If fit of Model 1 was not satisfactory, no further multiple group tests were conducted. In Model 2, factor loadings were held invariant across gender and grade. If fit of Model 2 was not satisfactory, no further multiple group tests were conducted. In Model 3, the factor loadings and factor variance/covariance were held invariant across gender and age. If fit of Model 3 was not satisfactory, no further multiple group tests were conducted. In Model 4, the factor loadings, factor variances/covariances, and error variances were held invariant across gender and grade.

The results for the invariance analyses of the three-factor oblique model across gender and grade groups are presented in Table 6. For the gender groups tests, the χ^2 values from Model 1 to 4 were statistically significant because of large sample size in this study. The values of CFI

were greater than .90 and the GFI estimates were close to .95 in these four models across two gender groups. The values of RMSEA from Model 1 to Model 4 were less than .50. These results indicated that the hypothesis of invariance of factor loadings, factor variances/covariances, and error variances across two gender groups was supported satisfactorily. The χ^2 difference values between Model 2 and Model 1 as well as between Model 3 and Model 2 across gender groups were statistically non-significant, $\Delta \chi^2 = 18.66$, df=15, $p > .05$ and $\Delta \chi^2 = 7.43$, df=3, $p > .05$. These outcomes suggested that the two hypotheses of equal factor loadings and of equal factor variances/covariances across two gender groups would be tenable. In Model 4, although the χ^2 difference values between Model 4 and Model 3 across gender groups was statistically significant, $\Delta \chi^2 = 64.64$, df=15, $p < .001$, meaning that the hypothesis of invariance of error variances would be untenable, the magnitudes of CFI and GFI were .91 and .94 and the values of RMSEA was .039. These indices strongly supported the hypothesis of invariance of error variance across two gender groups.

As for the invariance tests across the grade groups, the χ^2 values from Model 1 to 4 were still statistically significant across grade groups due to the same reason as the gender groups. However, from Model 1 to 4, all the magnitudes of CFI and GFI were greater than .90 and the values of RMSEA were close to .30. The set of results showed that the hypothesis of invariance of factor loadings, factor variances/covariances, and error variances across four grade groups was supported satisfactorily. Furthermore, the χ^2 difference values between Model 2 and Model 1, between Model 3 and Model 2, as well as between Model 4 and Model 3 across grade groups were statistically non-significant, $\Delta \chi^2 = 13.94$, $df = 15$, $p > .05$, $\Delta \chi^2 = 0.66$, $df = 3$, $p > .05$, and $\Delta \chi^2 = 15.69$, $df = 15$, $p > .05$, respectively. These outcomes suggested that the three

hypotheses of equal factor loadings, of equal factor variances/covariances, and of equal error variances across four grade groups would be tenable.

In summary, although the χ^2 value was statistically significant for each model for both gender groups and grade groups, the magnitudes for CFI and GFI varied from .90 to .95 and the magnitudes for RMSEA varied from .031 to .40. The data supported the invariance of factor loadings, factor variance/covariance, and error variance across gender and grade groups.

Conclusions and Suggestions

The primary purpose of this study was to examine the construct validity of the scores on a self-concept. Results from CFA provided rather strong evidence to support the hypothesis of correlated three factors of self-concept. The three-factor oblique model fit the data sampled in this study. So the hypothesis of multidimensionality of self-concept was verified. The results of this investigation also strongly confirmed the invariance of factor loadings, factor variances/covariances, and error variances across gender and grade groups.

Self-concept was also considered to have a hierarchical order. The higher order model of self-concept can be compared in future studies. Moreover, convergent and discriminant validity are useful to examine the construct validity of self-concept. And the multitrait-multimethod (MTMM) matrix is an approach to investigate the convergent and discriminant validity. A CFA approach to the analysis of data in a MTMM matrix should be worthy to be explored. Besides, replication of this investigation with other samples could strengthen conclusion regarding the construct validity of self-concept.

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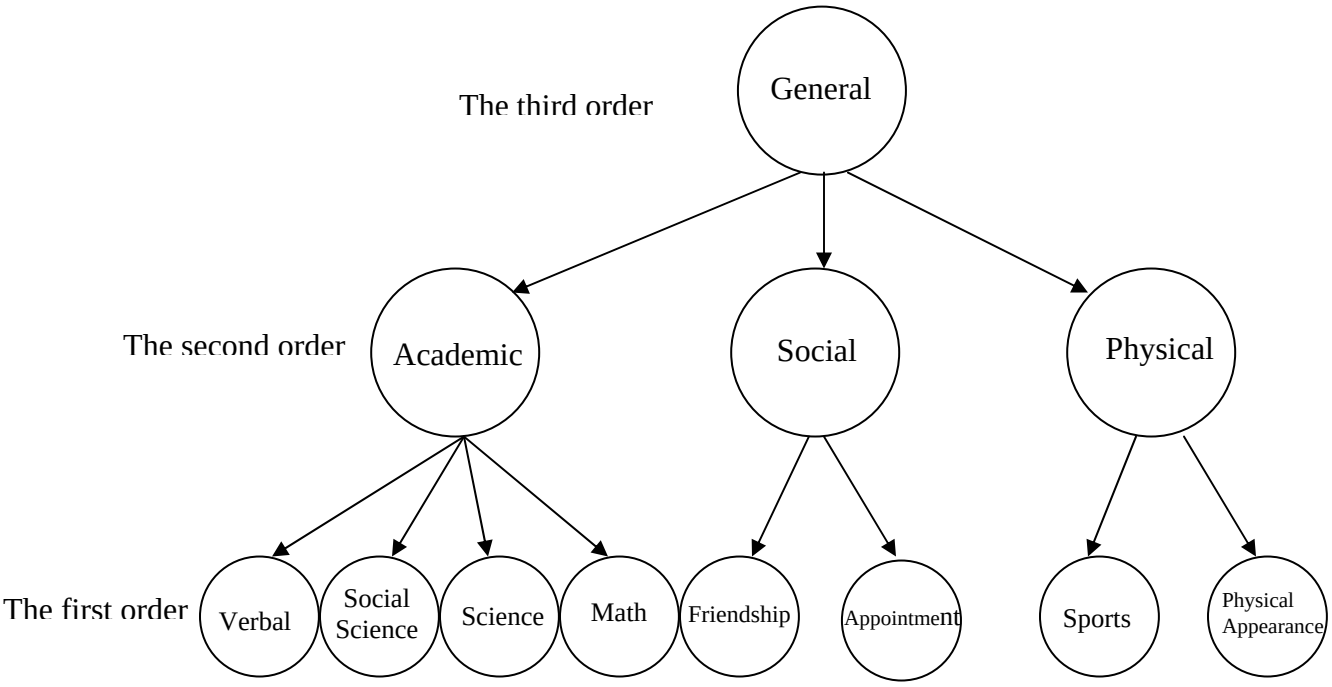

Figure 1. Three hierarchical orders of self-concept of students created by shavelson, Hubner, and Stanton (1976)

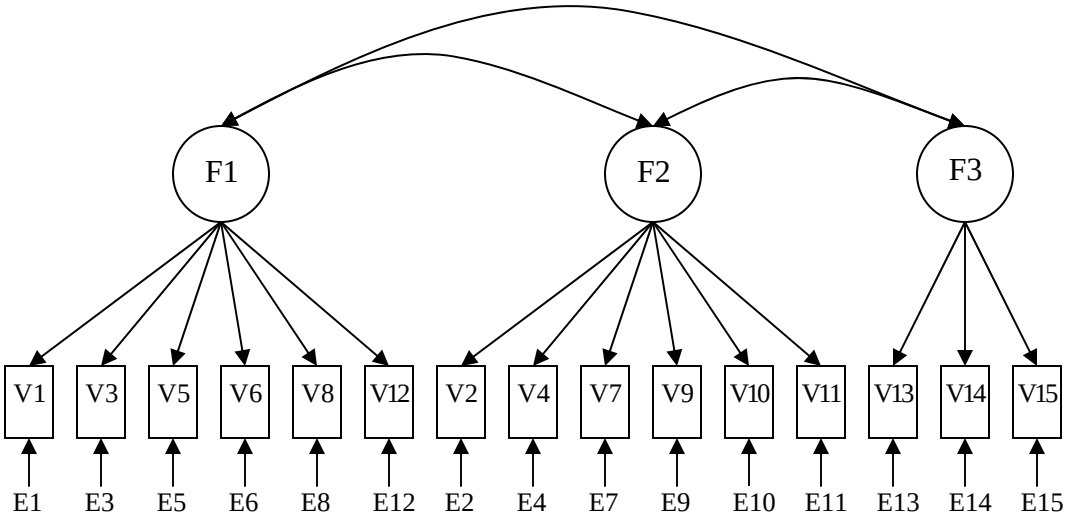

Figure 2. Three-Factor Oblique Model of School Self-Concept Scale

Note. F1 represents general factor; F2 represents academic factor; F3 represents non-academic factor.

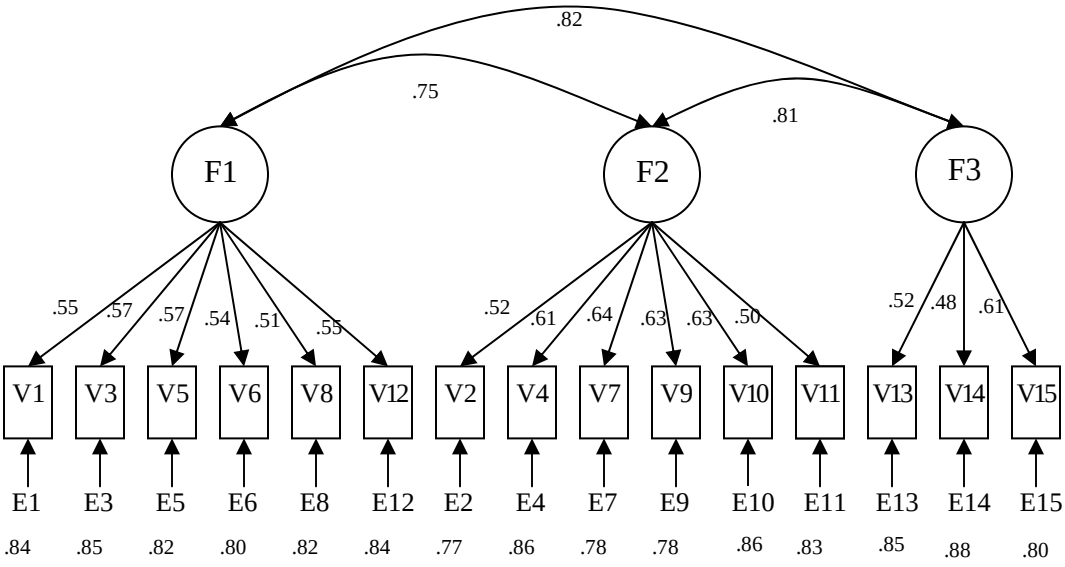

Figure 3. Three-Factor Oblique Model of the School Self-Concept Scale with the Standardized Solution

Table 1

15 Items in the School Self-concept Scale

		Strongly Agree	Agree	Disagree	Strongly Disagree
1. Generally speaking, I like myself.	……	☐	☐	☐	☐
2. I like to answer questions in classes.	……	☐	☐	☐	☐
3. I feel I am a happy person.	……	☐	☐	☐	☐
4. I often get prizes at school.	……	☐	☐	☐	☐
5. I believe I will be very successful.	……	☐	☐	☐	☐
6. I feel people expect high of me at school.	……	☐	☐	☐	☐
7. Everyone often praise me for my grades.	……	☐	☐	☐	☐
8. I feel that going to school is interesting.	……	☐	☐	☐	☐
9. I am capable of being a leaning helper.	……	☐	☐	☐	☐
10. The teacher always praises me for my homework	……	☐	☐	☐	☐
11. I feel the courses at school are easy.	……	☐	☐	☐	☐
12. I am satisfied with myself.	……	☐	☐	☐	☐
13. When I help the teacher do something, I can do it well.	……	☐	☐	☐	☐
14. My classmates like to play with me.	……	☐	☐	☐	☐
15.When my classmates have some questions, they like me to help them.	……	☐	☐	☐	☐

Table 2

Means, Standard Deviations, Skewness, and Kurtosis of 15 Items in the School Self-Concept Scale

Variable	Mean	Std	Skew	Kurtosis
V1	1.74	0.74	0.73	0.08
V2	2.55	0.90	-0.20	0.73
V3	1.78	0.82	0.80	-0.08
V4	2.92	0.92	-0.57	-0.48
V5	2.04	0.86	0.41	-0.60
V6	2.68	0.85	-0.24	-0.54
V7	2.74	0.89	-0.30	-0.64
V8	1.93	0.96	0.70	-0.60
V9	2.82	0.95	-0.38	-0.79
V10	2.70	0.87	-0.30	-0.58
V11	2.37	0.94	0.035	-0.93
V12	2.05	0.92	0.46	-0.72
V13	2.10	0.87	0.36	-0.63
V14	2.01	0.87	0.55	-0.42
V15	2.37	0.93	0.09	-0.86

Table3

Covariance Matrix of School Self-Concept Scale

	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15
V 1	0.549														
V 2	0.156	0.803													
V 3	0.200	0.167	0.678												
V 4	0.105	0.267	0.148	0.852											
V 5	0.199	0.185	0.235	0.159	0.739										
V 6	0.156	0.171	0.194	0.260	0.215	0.730									
V 7	0.146	0.243	0.176	0.391	0.194	0.242	0.798								
V 8	0.200	0.266	0.253	0.164	0.242	0.191	0.167	0.930							
V 9	0.168	0.300	0.166	0.345	0.224	0.283	0.336	0.270	0.907						
V10	0.161	0.219	0.200	0.344	0.175	0.269	0.324	0.232	0.294	0.763					
V11	0.164	0.248	0.219	0.198	0.224	0.195	0.243	0.302	0.290	0.253	0.883				
V12	0.283	0.170	0.273	0.126	0.275	0.197	0.195	0.205	0.201	0.180	0.240	0.853			
V13	0.159	0.207	0.167	0.131	0.199	0.200	0.180	0.233	0.260	0.233	0.202	0.183	0.754		
V14	0.131	0.152	0.185	0.139	0.188	0.193	0.156	0.179	0.174	0.168	0.136	0.174	0.190	0.764	
V15	0.153	0.215	0.193	0.283	0.214	0.266	0.270	0.206	0.308	0.286	0.206	0.175	0.231	0.263	0.861

Table 4

Correlation Coefficients among Factors of School Self-Concept Scale

Factor	General	Academic	Non-Academic
General	-	-	-
Academic	0.75*	-	-
Non-Academic	0.82*	0.82*	-

Table 5

Goodness-of-Fit Indexes for Three Different Factor Models

Factor Model	*df*	χ^2	CFI	GFI	RMSEA
Unidimensional	90	761.18*	.87	.93	.068
Orthogonal	90	1772.64*	.68	.87	.108
Oblique	87	515.68*	.92	.96	.056
χ^2 difference	3	245.5	$p < .001$	Between Unidimensional and Oblique models	

Note. *df* = degree of freedom; CFI = comparable fit index; GFI = goodness fit index; RMSEA = root mean-square error of approximation.

Table 6

Invariance Analyses of Self-Concept Scale Across Gender groups and Grade Groups

Model	*df*	χ^2	CFI	GFI	RMSEA	χ^2 difference
Across gender group						
Model 1	174	615.59*	.92	.95	.040	
Model 2	189	634.25*	.92	.95	.038	M2-M1 $\triangle \chi^2$=18.66, *df* =15(p>.05)
Model 3	192	641.68*	.92	.95	.038	M3-M2 $\triangle \chi^2$=7.43, *df* =3(p>.05)
Model 4	207	706.32*	.91	.94	.039	M4-M3 $\triangle \chi^2$=64.64, *df* =15(p<.001)
Across grade group						
Model 1	348	868.90*	.90	.95	.031	
Model 2	263	882.84*	.90	.93	.030	M2-M1 $\triangle \chi^2$=13.94, *df* =15(p>.05)
Model 3	366	883.50*	.90	.93	.030	M3-M2 $\triangle \chi^2$= 0.66, *df* =3(p>.05)
Model 4	381	899.19*	.90	.93	.029	M4-M3 $\triangle \chi^2$=15.69, *df* =15(p>.05)

Note 1. *df* = degree of freedom; CFI = comparable fit index; GFI = goodness fit index; RMSEA = root mean-square error of approximation.

Note 2. Constraints in each model. Model 1: No constraints; Model 2: factor loadings; Model 3: factor loadings and factor variances/covariances; Model 4: factor loadings, factor variances/covariances, and error variances.