Examining the Factor Structure and Measurement Invariance of Science Attitude Items across Genders

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OVERVIEW

- Introduction & Research Questions
- Data Source
- Modeling Methods
  - Exploratory structural equation modeling (ESEM)
  - Independent-clusters model of confirmatory factor analysis (ICM-CFA)
- Results
- Discussion & Limitations
- References
The power of favorable attitudes toward science (science attitudes) is that they reinforce higher performance.

There continue to be gender disparity in science attitudes across many countries (Provasnik et al, 2012).

Most research related to science attitudes have been based on the TIMSS Student Questionnaire.

However, there remain two open questions about TIMSS science attitudes items: (1) the latent factor structure, and (2) the existence of measurement invariance across genders.
What is TIMSS?
- The Trends in International Mathematics and Science Study
- Conducted by the International Association for the Evaluation of Educational Achievement (IEA)
- Measuring students’ mathematics and science achievement
- **TIMSS Student Questionnaire**: student attitudes, home background, and school experiences

- TIMSS 2015 Student Questionnaire
- USA sample - 10,221 students (50.1% girls, 49.9% boys)
- Eighth grade students
STEP 1: Identifying the Best Fitting Model

- Bifactor structure
  - A general factor and three secondary factors (Foy, 2017)
    - Students Enjoy Learning Science (SES)
    - Students’ Confidence in Science (SCS)
    - Students’ Perceived Value of Learning Science (SVS)
- Independent-clusters model of confirmatory factor analysis (ICM-CFA)
- Exploratory structural equation modeling (ESEM)
- Model comparison: approximate fit indices, general and local fits, and interpretability of each model
MODELING METHODS

STEP 1: Identifying the Best Fitting Model

- Bifactor ICM-CFA Model

Figure 1. Path Diagram for Bifactor ICM-CFA Model
STEP 1: Identifying the Best Fitting Model

- Bifactor ESEM Model

Figure 2. Path Diagram for Bifactor ESEM Model
STEP 2: Examining Measurement Invariance

- Nested models were tested progressively (Meredith, 1993)
- **Configural** invariance model
  - Same factor structure, and similar pattern of factor loadings
- **Metric** invariance model
  - Same factor structure, and equal factor loadings
- **Strict** invariance model
  - Same factor structure, equal factor loadings, and equal intercept values

MODELING METHODS
STEP 2: Examining Measurement Invariance

- **Changes in goodness-of-fit indices** were examined to make comparison between nested models.

- A diminution of .010 and .015 for CFI and RMSEA are respectively indicative of a preferred model (Chen, 2007).

- Models with lower Bayesian information criterion (BIC) values are considered superior in terms of fit and parsimony.
RESULTS

STEP 1: Identifying the Best Fitting Model

- Model fit comparison

<table>
<thead>
<tr>
<th></th>
<th>(\chi^2)</th>
<th>(df)</th>
<th>SCF</th>
<th>RMSEA</th>
<th>RMSEA 90% CI</th>
<th>CFI</th>
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<tbody>
<tr>
<td>ICM-CFA Bifactor</td>
<td>11880</td>
<td>273</td>
<td>1.331</td>
<td>.065</td>
<td>.064 to .066</td>
<td>.910</td>
<td>.893</td>
<td>.067</td>
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<td>1.343</td>
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Note. \(\chi^2\) = adjusted chi-square fit statistic with robust standard errors; \(df\) = degrees of freedom; SCF = Scale correction factor; RMSEA = root mean square error of approximation; CI = confidence interval; CFI = comparative fit index; TLI = Tucker-Lewis index; SRMR = standardized root mean residual; BIC = Bayesian information correction.

Table 1. Goodness-of-fit Indices for ICM-CFA and ESEM Models
**RESULTS**

**STEP 1: Identifying the Best Fitting Model**

- Model fit comparison

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Table 1. Goodness-of-fit Indices for ICM-CFA and ESEM Models
RESULTS

STEP 1: Identifying the Best Fitting Model

- Factor loadings for bifactor ICM-CFA

Figure 3. Standardized Bifactor ICM-CFA Factor Loadings
STEP 1: Identifying the Best Fitting Model

- Factor loadings for bifactor ESEM

Figure 4. Standardized Bifactor ESEM Factor Loadings
RESULTS

STEP 1: Identifying the Best Fitting Model

- All items in the bifactor ESEM had substantial loadings on the general factor ($\lambda = .42$ to $.85$; $M = .59$) as well as most questions had specific factor loadings that exceeded $.30$.
- The **bifactor ESEM** yielded an improved level of fit in comparison to the corresponding ICM-CFA model.
- Interpretability of the model – **science attitudes** are general and enduring feelings about science, and predisposition to learn science (Lovelace & Brickman, 2013).
STEP 2: Examining Measurement Invariance

- The model fit for each gender group

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Table 2. Goodness-of-fit Indices for the Baseline Model across Genders
### RESULTS

#### STEP 2: Examining Measurement Invariance

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<th>BIC</th>
<th>$p$</th>
<th>$\Delta$CFI</th>
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<tr>
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<td>.941</td>
<td>.915</td>
<td>.025</td>
<td>534258</td>
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<td>.001</td>
<td>−.001</td>
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<tr>
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<td>.056 to .058</td>
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<td>0</td>
<td>.001</td>
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<td>.052 to .054</td>
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<td>−.003</td>
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Table 3. Goodness-of-fit Indices for Measurement Invariance across Genders
STEP 2: Examining Measurement Invariance

- All the configural, metric, and scalar invariance models were tenable.
  - All the changes between nested models in CFIs and RMSEAs were less than .010 and .015 respectively.
- The results support the constraints of equal factor structure, factor loadings, and intercepts for the TIMSS science attitude items across genders.
**DISCUSSION**

- The **bifactor ESEM** should be the model of choice.
  - An excellent level of good-of-fit indices
  - Considerable general factor loadings and reasonable local fits
  - Information about both a composite score and residualized subscores
  - The substantive interpretability of the model
- The model allows more in-depth analyses of the relationship between student attitudes and other external variables.
- The TIMSS science attitudes items can be safely used when inspecting the effect of genders on science attitudes-related issues.
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- An excellent level of good-of-fit indices
- Considerable general factor loadings and reasonable local fits
- Information about both a composite score and residualized subscores
- The substantive interpretability of the model

The model allows more in-depth analyses of the relationship between student attitudes and other external variables.

The TIMSS science attitudes items can be safely used when inspecting the effect of genders on science attitudes-related issues.
LIMITATIONS

- This study is focused only on science attitudes in USA eighth grade students.
- The direction of future research can be applied to other content areas such as mathematics, and to samples derived from other countries.
- More in-depth qualitative analyses of each construct – general factor, SES, SCS, and SVS – should be performed in future studies.
REFERENCES


THANK YOU

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