Construct validity of attitude toward STEM self-inventory

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Abstract. Attitude toward STEM influences on learning outcomes. The research purpose was to validate of attitude toward towards STEM. Sample are 393 students (Grade 7-Grade 12) for validating the Attitude toward STEM Self-Inventory (ASTEM). Totally 21 ASTEM items consist of 6 items of Mathematics Attitude, 6 items of Sciences Attitude, 6 items of Engineer/Technology Attitude, and 6 items of 21st Century Skill Attitude. Second-order confirmatory factor analysis was used to confirm the construct validity. The results confirmed that the construct validity of these test an excellent fit. The results show that: the fitness index of validating the ASTEM were as follow: $x^2$ statistic is 254.650 (degrees of freedom = 220, p= 0.054), and the $x^2$/df ratio having a value of 1.158 indicates a good fit. The comparative fit index (CFI) is 0.988, and Tucker-Lewis coefficient (TLI) is 0.984, Root mean square error approximation (RMSEA) is 0.020, Standardized Root Mean Residual (SRMR) is 0.045.

1. Introduction

Sciences, Technology, Engineer, and Mathematics were combinded for modern science and is called STEM Education. STEM Education is universal approach for competitive 21st student’s learning skills [6]. More specifically, Attitude toward STEM disciplines is the important factor that is the most well-known for enhancing student learning outcomes [5]. There were absolutely data of the attitude toward STEM that can support STEM classroom management. Indeed, the attitude toward STEM should be measured by valid tools.

2. Significant of the Study

STEM education is promoted to prepare their citizen and to have nultidimentional capacities to use in modern life [4]. Researchers reveal that attitude toward STEM disciplines is closely degree to develop the student learning outcomes [5]. There were, however, the specially factor that is lack tool for measuring the attitude toward STEM. Therefore we should have to develop the valid tool for measure there.

3. Conceptual Framework

Underlying the attitudes toward STEM discipline of Unfried, Faber, Stanhope, and Wiebe are student’s attitude toward academic subjects that consists of Mathematics Attitude (MA), Sciences Attitude (SA), Engineer/Technology Attitude (ET). Moreover the attitudes toward STEM are studying more closely the 21st Century Skills Attitudes (SK), too [5].
4. Aim of the Study
ASTEM is the attitudes toward STEM self-inventory and is accepted by three experts for content validity. According to the validity principles, ASTEM should have validated for examining the construct validity. Therefore, current research aimed to investigate the construct validity of ASTEM.

5. Research Methodology
5.1. Sample of this Study
A total of 1,705 (N) population for this survey research were sampling for research. A total of 393 samples consists of students in Grade 7 (n=64), Grade 8 (n=62), Grade 9 (n=68), Grade 10 (n=71), Grade 11 (n=59), and Grade 12 (n=69).

5.2. Research Tool
ASTEM is the self-inventory for measuring the attitudes toward STEM. Totally 24 items of ASTEM consists of 6 items of Mathematics Attitude (MA), 6 items of Sciences Attitude (SA), 6 items of Engineer/Technology Attitude (ET), and 6 items of 21st Century Skill Attitude (SK). Each statement of ASTEM uses a 5-point Likert scale namely 1 represents ‘Does not agree’, 2 represents ‘Does not really agree’, 3 represents ‘Neutral, not sure’, 4 represents ‘Agree somewhat’, and 5 represents ‘Absolutely agree’. For example, some items show in Table 1.

| Table 1. Example items in ASTEM |
|---------------------------------|
| **Mathematics Attitude**       |
| I can understand the most mathematics easily. |
| In the future, I will be mathematicians. |
| **Sciences Attitude**          |
| I can do scientific homeworks. |
| In the future, I will be scientist. |
| **Engineer/Technology Attitude** |
| I need to create the invention. |
| I believe that I can be engineer. |
| **21st Century Skill Attitude** |
| I can be the leader. |
| I can work well with all students. |
5.3 Data Analysis
Descriptive statistics and correlation among the composite scores were computed with SPSS statistical program. Then, a Confirmatory factor analysis (CFA) was used to test the goodness of fit test of the ASTEM. The indices were considered to assess the model fit of CFA: (1) probability value (p-value) >0.05, (2) value of ratio between chi-square statistic and degree of freedom (χ²/df) in 2:1, (3) the Comparative Fit Index (CFI) ≥ 0.90 and good when ≥0.95, (4) Tucker-Lewis coefficient (TLI) ≥ 0.95 is good fit, (5) Standardized Root Means Square Residual (SRMR) should not exceed 0.08 for a good fit, (5) Root Means Square Error of Approximation (RMSEA) value ≤ 0.06 are considered indicative of a good fit, ≤ 0.08 of fair fit, between 0.08 and 0.01 of mediocre fit and > 0.01 of poor fit [2].

6. Research Finding
6.1 Descriptive Statistics
Mean, Standard deviations, and bivariate correlation among the variables are presented in Table 2. As indicated, the ASTEM had significant positive correlation for all, had large positive correlation with the SA4 and the SA1 (r = 0.726 **), and had least positive correlation with the SA2 and the ET2 (r = 0.025 *).

6.2 Second-order CFA of ASTEM
As for the factor of the ASTEM, Second-order CFA was used to evaluate the goodness of fit. Second-order CFA were conducted using MPlus program. Model fit was assessed using χ², χ²/df, CFI, TLI, SRMR and RMSEA. Results showed that all indicators indicated that there was a goodness of fit between the empirical data and the hypothetical measurement model for model. In other word, χ² statistic of 254.650 (degrees of freedom = 220), the p-value in CFA models are not significant (0.054), χ²/df values are fall in 2:1 (1.158), the CFI = 0.988 indicate the good fit model (CFI should have more than 0.95). Similarity all the TLI = 0.984 indicate the good fit model (TLI should have more than 0.95). Moreover all the RMSEA = 0.020 is considered indicative of a good fit (RMSEA should have less than 0.06). Finally all the SRMR = 0.045  is accepted for a good fit (SRMR should have less than 0.08). There are showed the detailed in Table 3 and are concluded in Figure 2.
| Var  | MA1  | MA2  | MA3  | MA4  | MA5  | MA6  | SA1  | SA2  | SA3  | SA4  | SA5  | SA6  | ET1  | ET2  | ET3  | ET4  | ET5  | ET6  | SK1  | SK2  | SK3  | SK4  | SK5  | SK6  |
|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|      | .491** | 1   |      | .592** | .414** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|      | .453** | .605** | .649** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
|      | .572** | .427** | .615** | .660** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| MA6  | 1.99** | .307** | .519** | .512** | .612** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SA1  | 1.267 | .173** | .382** | .373** | .423** | .461** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SA2  | .195** | .282** | .225** | .280** | .248** | .246** | .396** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SA3  | .239** | .113** | .319** | .347** | .322** | .409** | .500** | .464** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SA4  | .315** | .199** | .376** | .418** | .408** | .477** | .726** | .490** | .566** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SA5  | .223** | .109** | .274** | .324** | .337** | .390** | .471** | .446** | .669** | .588** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |      |
| SA6  | .243** | .160** | .274** | .426** | .350** | .341** | .593** | .465** | .426** | .640** | .553** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |      |
| ET1  | .248** | .136** | .239** | .272** | .319** | .321** | .295** | .196** | .379** | .300** | .333** | .258** | 1   |      |      |      |      |      |      |      |      |      |      |      |      |
| ET2  | .173** | .116** | .045** | .132** | .137** | .051** | .046** | .025** | .109** | .053** | .078** | .087** | .414** | 1   |      |      |      |      |      |      |      |      |      |      |      |
| ET3  | .238** | .133** | .170** | .227** | .180** | .195** | .250** | .175** | .360** | .260** | .277** | .284** | .520** | .602** | 1   |      |      |      |      |      |      |      |      |      |      |
| ET4  | .190** | .131** | .114** | .161** | .198** | .278** | .264** | .165** | .363** | .256** | .267** | .217** | .533** | .387** | .623** | 1   |      |      |      |      |      |      |      |      |      |      |
| ET5  | .196** | .133** | .204** | .235** | .240** | .271** | .293** | .170** | .371** | .368** | .304** | .279** | .458** | .324** | .588** | .562** | 1   |      |      |      |      |      |      |      |      |      |
| ET6  | .150** | .148** | .151** | .206** | .224** | .146** | .202** | .138** | .172** | .226** | .255** | .257** | .505** | .543** | .451** | .419** | .451** | 1   |      |      |      |      |      |      |      |      |
| SK1  | .125** | .153** | .221** | .250** | .252** | .262** | .362** | .305** | .341** | .400** | .323** | .390** | .269** | .144** | .276** | .257** | .213** | .304** | 1   |      |      |      |      |      |      |
| SK2  | .244** | .167** | .262** | .323** | .351** | .401** | .452** | .274** | .393** | .484** | .386** | .464** | .367** | .113** | .313** | .324** | .311** | .339** | .660** | 1   |      |      |      |      |      |
| SK3  | .178** | .029** | .229** | .208** | .313** | .413** | .289** | .159** | .345** | .346** | .377** | .235** | .351** | .096** | .235** | .306** | .301** | .221** | .429** | .565** | 1   |      |      |      |      |
| SK4  | .198** | .045** | .211** | .226** | .307** | .343** | .298** | .188** | .292** | .394** | .336** | .292** | .291** | .087** | .221** | .292** | .295** | .213** | .444** | .550** | .703** | 1   |      |      |      |
| SK5  | .198** | .109** | .194** | .237** | .299** | .316** | .305** | .143** | .327** | .334** | .296** | .312** | .290** | .088** | .214** | .253** | .202** | .163** | .419** | .530** | .481** | .561** | 1   |      |      |
| SK6  | .219** | .119** | .201** | .266** | .363** | .358** | .325** | .226** | .259** | .370** | .351** | .368** | .335** | .189** | .303** | .292** | .321** | .299** | .446** | .513** | .485** | .575** | .619** | 1   |      |      |

Note: *p<0.05, **p<0.01

Table 2. Mean, Standard deviations (S.D.), and correlation between the variables (N=393)
### Table 3. Second-order CFA statistics results for ASTEM

| Observed Variables | Factor Loading | β     | Factor Score | R²   |
|--------------------|----------------|-------|--------------|------|
|                    | b     | SE   | t     |       |       |
| **First-order CFA**|      |      |       |       |       |
| MA                 |      |      |       |       |       |
| MA1                | 1.000 | 0.000 | <----> | 0.743** | 0.120 | 0.552** |
| MA2                | 0.613 | 0.056 | 10.911** | 0.538** | 0.036 | 0.284** |
| MA3                | 1.015 | 0.063 | 16.197** | 0.777** | 0.090 | 0.604** |
| MA4                | 1.124 | 0.064 | 17.578** | 0.847** | 0.239 | 0.717** |
| MA5                | 1.052 | 0.070 | 15.036** | 0.789** | 0.007 | 0.623** |
| MA6                | 1.370 | 0.123 | 11.177** | 0.987** | 0.537 | 0.974** |
| SA                 |      |      |       |       |       |
| SA1                | 1.000 | 0.000 | <----> | 0.718** | 0.065 | 0.516** |
| SA2                | 0.921 | 0.083 | 11.147** | 0.595** | 0.062 | 0.354** |
| SA3                | 1.256 | 0.092 | 13.597** | 0.739** | 0.152 | 0.546** |
| SA4                | 1.147 | 0.057 | 20.180** | 0.805** | 0.071 | 0.648** |
| SA5                | 1.212 | 0.092 | 13.234** | 0.721** | 0.050 | 0.519** |
| SA6                | 1.229 | 0.088 | 14.024** | 0.777** | 0.205 | 0.603** |
| ET                 |      |      |       |       |       |
| ET1                | 1.000 | 0.000 | <----> | 0.790** | 0.299 | 0.624** |
| ET2                | 0.667 | 0.073 | 9.137** | 0.491** | 0.071 | 0.241** |
| ET3                | 1.138 | 0.072 | 15.808** | 0.825** | 0.293 | 0.681** |
| ET4                | 0.974 | 0.072 | 13.468** | 0.717** | 0.071 | 0.514** |
| ET5                | 0.976 | 0.069 | 14.199** | 0.744** | 0.180 | 0.554** |
| ET6                | 0.843 | 0.070 | 12.063 | 0.647** | 0.091 | 0.418** |
| SK                 |      |      |       |       |       |
| SK1                | 1.000 | 0.000 | <----> | 0.655** | 0.067 | 0.429** |
| SK2                | 1.220 | 0.086 | 14.225** | 0.832** | 0.261 | 0.692** |
| SK3                | 1.090 | 0.092 | 11.695** | 0.686** | 0.107 | 0.470** |
| SK4                | 1.044 | 0.092 | 11.396** | 0.673** | 0.034 | 0.453** |
| SK5                | 0.009 | 0.093 | 10.837** | 0.645** | 0.055 | 0.416** |
| SK6                | 1.119 | 0.091 | 12.341** | 0.698** | 0.122 | 0.487** |
| **Second-order CFA**|      |      |       |       |       |
| MA                 | 1.000 | 0.000 | <----> | 0.596** | 0.030 | 0.355** |
| SA                 | 1.219 | 0.149 | 8.199** | 0.856** | 0.017 | 0.733** |
| ET                 | 1.196 | 0.150 | 7.956** | 0.615** | 0.014 | 0.378** |
| SK                 | 1.085 | 0.155 | 6.988** | 0.800** | 0.032 | 0.640** |

Note: **p<0.01
Figure 2. Conclusion of second-order CFA statistics results for ASTEM

Note: **p<0.01, $\chi^2$=254.650, df=220, p= 0.054, $\chi^2$/df = 1.158, CFI= 0.988, TLI= 0.984, RMSEA=0.020, SRMR=0.045]
7. Discussion
The present research investigated the construct validity of ASTEM. Second-order CFA was used for analyzing data because this statistic is an independence technique whose primary purpose is to define the underlying structure among the variables in the analysis [1][3]. Result of this research reveal that total second-order CFA provided the best fit. It showed that ASTEM can measure the attitudes of STEM and can give the valid information for STEM classroom management. Consistent with previous research of Unfried, Faber, Stanhope, and Wiebe, student’s attitude toward academic subjects that consists of Mathematics Attitude, Sciences Attitude, Engineer/Technology Attitude and closely the 21st Century Skills Attitudes [5]. Therefore ASTEM is the valid research tools. In the future the ASTEM can be used to assess the attitudes toward STEM for enhancing STEM learning outcomes.

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