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The Reliability and Validity Study of the STEM Identity Instrument

***Güney Hacıömeroğlu**

Abstract. The purpose of this study was to establish cross-cultural reliability and validity of the STEM identity instrument for pre-service teachers in Turkey. The translated instrument was administered to 211 elementary pre-service teachers at a public university in Turkey. For the adaptation of the instrument, both exploratory factor analysis and confirmatory factor analysis furnished evidence to support the reliability and factorial validity of the Turkish version of the STEM identity instrument. Findings revealed that adapted instrument consists of two sub-scales: STEM interest and STEM recognition. Cronbach's alpha for the whole instrument calculated as .88. For the sub-scales STEM interest and STEM recognition, the reliability value was found as .83 and .87, respectively. The original and adapted instrument were equivalent. The results of the study revealed that adapted instrument is valid and reliable to use for pre-service teachers.

Keywords. STEM identity, elementary pre-service teacher, STEM education.

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Recent educational reforms emphasize the vital role of Science, Technology, Engineering and Mathematics [STEM] education to raise the next generation of STEM professionals (e.g., engineers, health care workers, statisticians). The most influential STEM professional of all, elementary teachers should be prepared to become effective STEM teachers. Nevertheless, many of the elementary teachers feels less comfortable about teaching STEM in comparison to other subjects (Adams, Miller, Saul & Pegg, 2014). Many teacher educators focus on ways to improve the preparation of pre-service teachers majoring in mathematics, science, chemistry by incorporating STEM disciplines into their instructions (e.g., Adams, Miller, Saul & Pegg, 2014; Aslan-Tutak, Akaygün & Tezsezen, 2017; Yıldırım & Altun, 2015; Özkızılcık & Cebesoy, 2020; Tarkın-Çelikıran & Aydın-Günbatar, 2017). When they become classroom teachers, they would be able to incorporate STEM education into their teaching and help students engage in activities involving STEM disciplines.

In grades K-12, elementary grades are a critical time for developing students' STEM career interest (Conderman & Woods, 2008; DeJarnette, 2012). As the students' progress through the elementary grades, their interest and achievement in science and mathematics declines (Pell & Jarvis; 2001; Suna, Tanberkan & Ozer, 2020). In order to reverse this cycle, as a teacher educator, we need to focus on how the most influential STEM professional of all, elementary teachers should be prepared (Griffin, 2015). Elementary pre-service teachers are trained as generalist meaning they are expected to teach subjects such as mathematics, science, learning and writing (Li, 2008; Schwartz & Gess-Newsome, 2008). Research emphasized that pre-service teachers often begin teacher education programs with lack of confidence and interest in teaching STEM subjects (Weiss, Banilower, McMahon, & Smith, 2001). Their current and past experiences within these subjects shapes their teaching approaches. In order to address the declining interest of the students in STEM subjects, new learning and teaching approaches should be used to engage pre-service teachers in elementary teacher education programs. This way, teacher education programs would support pre-service teachers to develop their confidence and intentions to teach STEM (Adams, et al., 2014).

Identity is defined as a way of how one defines him-/herself along with the way other people (e.g., teacher, parents, friends, classmates) define him/her (Heffernan & Newton, 2019). Positive identity in relation to mathematics requires imagining one's self as a math learner and continuance of studying math (Boaler & Greeno, 2000). Mathematics identity described as a positive relationship with mathematics (Heffernan & Newton, 2019). Negative identity is related to seeing mathematics as irrelevant (Anderson, 2007), meaningless, and repetitive subject (Boaler & Greeno,

2000). Also, a person with negative identity feels as if he/she does not have the natural talent to succeed in mathematics (Blackwell, Trzesniewski, & Dweck, 2007). Having negative self-perceptions and beliefs influence engagement and achievement in mathematics (Pajares & Schunk, 2001). Feldhaus (2014) emphasized one's mathematical disposition are formed early as a student and it is very difficult to alter later in life. Science identity defines as whether a person see him/herself and are recognized by others as science person (Hazari, Sonnert, Sadler & Shanahan, 2010). Research on both mathematics and science identity has been tied to students' aspirations and persistence in studying these subjects. 'Being recognized' and 'growing interest' are core features for constructing a science and mathematics identity (Bleeker & Jacobs, 2004; Cribbs, Hazari, Sonnert, & Sadler, 2015; Hazari et al., 2010; Smith & Hausafus, 1998). Math and science identity, like all identities can be altered at any time (Bikner-Ahsbahs, 2003; Dou, Hazari, Dabney, Sonnert & Sadler, 2019). Thus, the teacher education programs need to provide opportunities for positive identity formation both as a student and teacher (Beauchamp & Thomas, 2009; Bikner-Ahsbahs, 2003; Chong & Low, 2009; Horn, Nolen, Ward & Campbell, 2008). This way, pre-service teachers would develop positive STEM identities and see STEM subjects as sensible, useful, and worthwhile. Also, it would positively influence their future students' learning of mathematics. However, research studies are lacking in illustrating how pre-service teachers promote positive mathematics identity in themselves or how teacher education programs help transition pre-service teachers' identity to being positive. This brings the need for an instrument to measure pre-service teachers' STEM identities.

Importance of the Study

Although the questionnaires for pre-service teachers' views on STEM education (e.g., self-efficacy, teaching intentions , knowledge and attitudes, etc.) have been developed, translated, cross-validated, and used in research studies (Derin, Aydın & Kırkıç, 2017; Gelen, Akçay, Tiryaki & Benek, 2019; Hacıömeroğlu & Bulut, 2016; Yaman, Özdemir, Akar & Vural, 2018; Yıldırım & Topalcengiz, 2018), no research has involved a translation of pre-service teachers' STEM identity instrument into the Turkish language. This study filled the gap by validating the instrument.

Purpose

The purpose of this study was to establish cross-cultural reliability and validity of the STEM identity instrument for pre-service teachers in Turkey.

This study will therefore address the following research question:

- Is a translated Turkish version of the STEM identity instrument valid and reliable when used with pre-service teachers in Turkey?

Method

Research Model

This quantitative study aims at adapting the STEM Identity Instrument developed by Dou et al. (2019) to Turkish language and culture. For this reason, survey method approach (Karasar, 2010) was utilized to examine validity and reliability study of the instrument.

Study Group

Data were collected from 211 fourth-year pre-service teachers majoring in elementary teacher education program at a public university in Turkey. Elementary pre-service teachers are prepared as a generalist to teach subjects such as mathematics, science, and social studies. Therefore, they are appropriate to be a part of this study group. Towards the end of the semester, the researcher met with the pre-service teachers and explained the purpose of this research study. Pre-service teachers who volunteered to participate in this research study filled out the survey. Of the 218 pre-service teachers, 27 (12.8%) were males, and 184 (87.2%) were females.

Data Collection Tools

STEM identity instrument. This instrument developed by Dou et al. (2019) designed to measure students' own self-perceptions related to competence and performance that directly affects their STEM identity. It includes 7-items on a 6-point Likert type scale (i.e., strongly disagree to strongly agree). The STEM instrument consists of two sub-scales: STEM interest and STEM recognition. The instrument intents to examine the students' self-perceptions of their interest and recognition in STEM fields. Since seeing oneself as a STEM person is related to their STEM identity development. Cronbach's alpha for the whole instrument calculated as .97, respectively (See Appendix 1).

Translation procedure of the instruments. Cross-cultural research requires the following certain protocols so that linguistically equivalent instrument can be provided. Three procedures, the back translation, the committee approach, and a combination of the first two approaches were utilized to establish linguistic equivalence (Brislin, 1970; Cohen, Manion & Morrison, 2018; Matsumoto & Yoo, 2003). First approach, back translation involves translation of the instrument from English language to Turkish language. The researcher who is fluent in both languages

translated the instrument back to the original language. This procedure was repeated until the end product was semantically equivalent to the original instrument in English language (Brislin, 1970, 1993). The second, the committee approach involves bilingual experts in science education, mathematics education, and assessment and testing collectively translated the instrument by using research protocol into a target language of Turkish. By following these protocols, the translation committee tried, debated, and compared the various words and phrases that can be used in Turkish language. Results of this process is the Turkish version of the instrument that involved agreement of the experts. The third approach involves combinations of the first and second approaches. In other words, translations of the instrument provided by both the researcher and translation committee compared and contrasted, and then agreed-upon translations were determined. The final version was the Turkish version of the STEM identity instrument (See Appendix 2).

Process

Data were gathered from fourth-year pre-service teachers majoring in elementary teacher education program. First, pre-service teachers were informed about STEM identity Instrument and adaptation process of the research study. Then, the instrument was administered to the pre-service teachers who volunteered to participate.

Data Analysis

Both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were performed to examine the best factor structure of the instrument. SPSS version 22 was utilized to perform EFA. In order to determine the data was appropriate for factor analysis Kaiser-Myer-Olkin (KMO test) and Bartlett's test of sphericity was used. For the measure of sampling adequacy, Bartlett's test of sphericity should be statistically significant ($p<0.05$) and KMO index should be greater than or equal to 0.6. Test-retest reliability was measured with a test-retest correlation. This test was conducted with group of participants to measure the instrument consistency. The Cronbach's alpha reliability coefficients were calculated for each measure. CFA was utilized to examine the factorial structure from EFA using Lisrel 8.53 (Jöreskog & Sörbom, 2002).

Results

Exploratory Factor Analysis

The 7 items of the STEM Identity Instrument were subjected to explarotory analysis (EFA) using SPSS version 22. Prior to conducting EFA, the suitability of data for factor analysis was

assessed. Inspection of the correlation matrix revealed the presence of the coefficients of .3 and above. The Kaiser- Meyer-Olkin value was .854, exceeding the recommended value of .6 (Cohen, Manion & Morrison, 2018) and the Bartlett's Test of Sphericity (Bartlett 1954) reached statistical significance ($X^2_{(21)}$ =869.095, p=.000 p<.01), supporting the factorability of the correlation matrix. The result of the analysis revealed that the data was adequate for factor analysis to explore the component structure underlying the instrument. EFA revealed the presence of two components with eigenvalues exceeding 1, explaining 74.9%, of the variance respectively. Varimax rotation was performed for the interpretation of the component. The rotated solution revealed all variables loading substantially on two components. The 7-item total correlations were calculated, and the values were greater than .20 (Klein, 1986). In this study, factor loadings were between .646 and .905. The final instrument with two sub-scales consisted of 7 items. The results in Table 1 indicated that internal consistency reliability was .88 for the STEM Identity Instrument. Cronbach's alpha for the sub-scales, STEM interest and STEM recognition was calculated as .83 and .87 respectively. These values are considered to be acceptable (Field, 2005).

Table 1.

Principal Components Analysis Results for Two-Factor Varimax Rotation

Factor loadings			
Item	**STEM Interest**	**STEM Recognition**	
5		.896	
7		.882	
4		.783	
6		.646	
3	.905		
1	.799		
2	.750		
Cronbach's alpha	.83	.87	.88

Test-Retest Reliability

STEM Identity Instrument was administered to 56 pre-service teachers twice in one month apart. Pearson correlation coefficients, mean, and standard deviation scores were calculated to examine the relationship between two measurements. The mean and standard deviations were calculated as 3.61±.41 and 3.52±.62 respectively. Results of the analysis revealed the test-retest reliability coefficient was reported acceptable (r= .806).

Confirmatory Factor Analysis

Confirmatory factor analysis was applied to test the stability of the scores from two-factor and 7-item. A two-factor model tested whether the STEM Identity Instrument measures one overall factor. The chi-square statistic, x^2/df ratios were calculated for the model. The radios ranging below 5 considered to represent acceptable model (Sümer, 2000). The goodness of fit index (GFI ≥ .90), the adjusted goodness of fit index (AGFI ≥ .90) (Hooper, Coughlan & Mullen, 2008; Schumacker & Lomax, 1996; Sümer, 2000), the standardized root mean square residual index (SRMR≤.03), the root mean square residual index (RMR≤.03), (Brown, 2015), the root mean square error of approximation (RMSEA ≤ .08) (Brown, 2015), the non-normed fit index (NNFI ≥ .90), the normed fit index (NFI ≥ .90) (Hu & Bentley, 1999; Sümer, 2000; Tabachinck & Fidell, 2007), and the comparative fit index (CFI ≥ .90) were calculated (Jöreskog & Sorböm, 2002). As a result, all fit indices had a satisfactory goodness of fit: x^2 = 44.28, *df* = 13, *p* < .00, x^2/df = 3.4; GFI = .97 (≥.90); AGFI = .94; ((≥.90); RMR = .03 (≤.05); SRMR = .03 (≤.05); RMSEA = .0071 (≤.08); NNFI = .98 (≥.90); NFI = .98 ((≥.90); CFI = .99 (≥.90). Results of the CFA analysis revealed that the model for the STEM identity instrument is best represented by two-dimensional construct (See Figure 1).

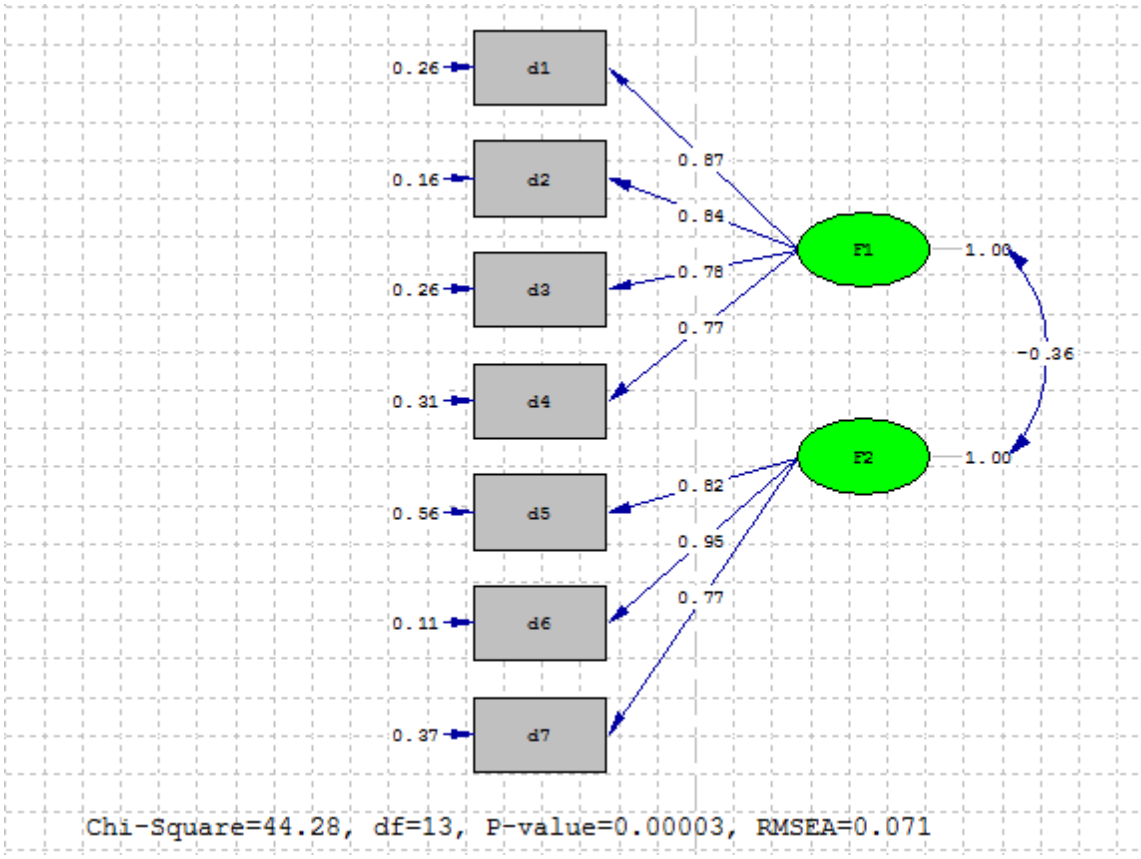

Figure 1. Path Model.

Discussion and Conclusion

In this study, STEM identity instrument developed by Dou et al. (2019) was adapted to Turkish for pre-service teachers. The adapted STEM identity instrument intents to examine pre-service teachers' self-perceptions related to competence and performance that directly affects their STEM identity. Results of the exploratory and confirmatory factor analysis revealed that the adapted instrument includes two sub-scales: STEM interest and STEM recognition. STEM interest sub-scale aims at measuring pre-service teachers' interest in learning more about STEM. STEM recognition sub-scale focuses on exploring pre-service teachers' self-perceptions of their recognition as a STEM person. The original and adapted instrument were equivalent. Cronbach's alpha for the whole instrument calculated as .88. Both original ve adapted instrument had strong reliability values. For the sub-scales, STEM interest and STEM recognition reliability coefficients were calculated as .83 and .87, respectively. The results of the study revealed that adapted instrument is valid and reliable to use for measuring pre-service teachers' STEM identity.

Recommendations

Further research should focus on adapting the STEM identity instrument for in-service teachers (e.g., mathematics, science, chemistry, physics, biology). Also, research studies should be conducted with pre-service teachers to examine reliability and validity of the instrument for both STEAM and STEM into social studies.

About Authors

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Conflict of Interest

It has been reported by the authors that there is no conflict of interest.

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Ethical Standards

I have carried out the research within the framework of the Helsinki Declaration. The consent forms were utilized. The participants were informed about the study and volunteered to participate.

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Appendix 1. *Original STEM Identity Instrument*

STEM Identity Instrument
STEM Interest
1. I am interested in learning more about STEM
2. Topics in STEM excite my curiosity
3. I enjoy learning about STEM
STEM Recognition
4. My STEM teacher sees me as a STEM person
5. My family sees me as a STEM person
6. Others ask me for help in STEM
7. My friends/classmates see me as a STEM person

Appendix 2. *Turkish STEM Identity Instrument*

FeTeMM Kimlik Ölçeği
FeTeMM İlgi
1. FeTeMM hakkında daha fazla öğrenmek isterim.
2. FeTeMM'deki konular merakımı uyandırıyor
3. FeTeMM hakkında öğrenmek hoşuma gidiyor
FeTeMM Tanınırlık
4. FeTeMM öğretmenim beni STEM kişisi olarak görür.
5. Ailem beni FeTeMM kişisi olarak görür.
6. Diğer insanlar beni FeTeMM kişisi olarak görür.
7. Arkadaşlarım/sınıf arkadaşlarım benim FeTeMM kişisi olarak görür.