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Investigating Pre-service Elementary School Teachers' Metacognitive Science Learning Orientations

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ABSTRACT This study describes the adaptation and validation of the Self-Efficacy and Metacognition Learning Inventory—Science (SEMLI-S) to examine pre-service elementary school teachers' metacognitive science learning orientations. In addition, pre-service teachers' metacognitive science learning orientations were examined in terms of gender. 193 pre-service elementary school teachers participated in the study. Exploratory and confirmatory factor analyses were performed. Exploratory factor analysis (EFA) showed that there were 4 factors explaining the 54% of the total variance of the scores. In addition to the EFA, confirmatory factor analysis (CFA) was performed to confirm the factor structure of the adapted SEMLI-S. Results of the CFA showed that the four-factor model of the adapted SEMLI-S fit well to the data. It could be concluded that the Turkish version of the SEMLI-S instrument is a valid and reliable instrument serving as a useful tool to understand learners' metacognitive science learning orientations.

1. INTRODUCTION

During the last three decades metacogniton has become one of the major fields of cognitive development. Historical roots of metacognition go far beyond to Plato and Aristotle. The pioneering studies on metacognition were conducted in the area of developmental psychology in 1970s. The term "metacognition" was first introduced by John Flavell based on his study of metamemory in the early 1970s (Flavell 1971). According to Flavell (1971), metacognition refers to "the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects" (p. 232). Flavell (1979) defined metacognition as "knowledge and cognition about cognitive phenomena" (p. 906). Building on Flavell's study, Kluwe (1987) adverted two features of metacognition: "declarative knowledge about cognition, for example the own cognitive activities and abilities, and procedural knowledge, processes directed at the control and regulation of one's own thinking" (p.31). Kluwe (1987) used the term "cognitive knowledge" for declarative knowledge including factual knowledge and "executive decision" for procedural knowledge involving monitoring and regulation of thought. Similarly, Paris and Winograd (1990) asserted two attributes of metacognition: self-appraisal of cognition and self-management of cognition. They defined "self-appraisal" as one's judgments about her/his own cognitive abilities and "self-management" as regulation of cognitive aspects for problem solving. Paris and Winograd (1990) emphasized that self-appraisal of cognition and self-management of cognition involved cognitive and motivational aspects. Also, Brown (1987) indicated the components of metacognition in the area of psychology. She stated that "knowledge about cognition" and "regulation of cognition" were the two essential components of metacognition.

Metacognition was called as "fuzzy" concept by researchers (Brown 1987; Flavell 1981; Hacker 1998) because of the vagueness of its definition, characteristics and lots of different historical roots. There are various definitions for metacognition in the literature. According to Flavell (1971), metacognition refers to "the active monitoring and consequent regulation and orchestration of these processes in relation to the cognitive objects" (p. 232). Flavell (1979) defined metacognition as "knowledge and cognition about cognitive phenomena" (p. 906). Brown (1987) defined metacognition as "one's knowledge and control of own cognitive system" (p. 66). White (1988) explained metacognition as "inner awareness or process, not an overt behavior (p. 73). Due to multidimensional character of metacognition, many researchers proposed different categorizations of the components of metacognition (Chi 1987; Flavell 1979; Pintrich et al. 2000; Schraw and Moshman 1995). Flavell (1979) proposed that metacognition consisted of the components of "metacognitive knowledge" and "metacognitive experience". Chi (1987) identified three types of metaknowledge: meta-declarative knowledge, meta-procedural knowledge, and meta-strategies. In line with Flavell's (1979) categorization of metacognition, Schraw (2001) and Schraw and Moshman (1995) made a distinction between two components of metacognition: knowledge of cognition and regulation of cognition. Schraw defined "knowledge of cognition" as the knowledge of a learner about her/his own cognition and described "regulation of cognition" as the activities that a learner used to control her/his own learning. Pintrich et al. (2000) proposed a categorization for metacognition which is different than other categorizations in that they considered metacognitive judgments and monitoring as an additional component to the commonly accepted components of metacognition which were metacognitive knowledge and metacognitive regulation. Their categorization includes three components of metacognition: metacognitive knowledge, metacognitive judgments and monitoring, and self-regulation and control of cognition. However, researchers commonly elaborated on three components of metacognition: metacognitive knowledge/awareness, metacognitive monitoring and evaluation, and metacognitive regulation (for example Flavell 1979; Pintrich et al. 2000; Schraw 2001; Schraw and Moshman 1995). Metacognitive knowledge was divided into three components: person, task, and strategy (Flavell 1979) or declarative, procedural, and conditional knowledge (Pintrich et al. 2000; Schraw 2001; Schraw and Moshman 1995). There are also other reasons for the fuzziness of metacognition. Many "metas" emerged in the literature such as metaaffection, metalearning, metareading, metacomprehension, and metalanguage (Flavell 1971; Kluwe 1987). Researchers emphasized the difficulty of the distinction between "meta" and "cognitive" (Brown 1987; Flavell 1979, 1987). Yet, Flavell (Flavell 1979, 1987) provided definitions for "cognitive strategies" and "metacognitive strategies". He stated that "cognitive strategy" was related to enhancing knowledge, while "metacognitive knowledge" was related to controlling and monitoring the cognitive progress. Measuring metacognition is another obscurity resulted from its own characteristic- it is an inner awareness, not an overt behavior. Several assessment techniques could be used to assess metacognition such as interviews (Zimmerman and Martinez-Pons 1990), questionnaires (Thomas 2003), thinking-aloud protocols (Afflerbach 2000), and observations (Veenman and Spaans 2005). All these assessment methods have their pros and cons. Therefore, there is need for empirical instruments for metacognition. Although many obscurities exist related to metacognition as mentioned above, the importance of it in learning is not questioned. Flavell (1979) indicated the important role of metacognition in oral communication skills, reading comprehension, writing, attention, memory, problem solving, social cognition, and various types of self-control and self-instruction. Following this study, Flavell (1987) suggested that "good schools should be hotbeds of metacognitive development" (p. 27). Metacognition is widely believed to make students responsible for their learning, hence more actively involved in the learning process, and there is growing literature advocating positive impact of metacognitive activity on student thinking skills and conceptual understanding (Hennessey 1999; Hewson et al. 1998; Saribas et al. 2013;Vosniadou 2008).

This study describes the adaptation and validation of the Self-Efficacy and Metacognition Learning Inventory—Science (SEMLI-S) developed by Thomas et al. (2008) to examine pre-service elementary school teachers' metacognitive science learning orientations. The adaptation of this instrument would provide researchers to draw on conclusions in different international contexts and shed light on students' metacognition and self-efficacy in national context.

Within the context given above, the researchers have adapted the SEMLI-S and the following research questions were addressed in this paper.

- Does the adapted SEMLI-S help us to collect valid and reliable data?
- Is there a significant mean difference between male and female pre-service teachers' metacognitive science learning orientations?

2. MATERIAL AND METHODS

2.1 Translation and Item Modifications

In the original version of the SEMLI-S, there were 30 items and five sub-factors as follows:

seven items for Constructivist Connectivity (CC), nine items for Monitoring, Evaluation and Planning (MEP), six items for Science Learning Self-efficacy (SE), five items for Learning Risks Awareness (AW), and three items for Control of Concentration (CO). The researchers followed the steps given below at the process of adaptation of the SEMLI-S to Turkish.

(1) Initial Translation with Language Experts: At this step three language experts translated and ensured the correctness of these translations. Two of the experts were English language experts who are native Turkish speakers. One of the expert translated English items into Turkish. The other one translated these items back to English. Then, this was compared with the original items to see if these items were compatible to each other. This process showed that the translation of the items into Turkish was error free. The third expert was Turkish language expert. This one checked all of the translated items to see if there are any grammatical or semantic errors. At this stage, the items were modified once more to ensure their correctness.

(2) Revision of the Items by the Researchers: At this step, the researchers checked the compatibility of each item with the original ones. Here, it was seen that several phrases could be misunderstood by the students. These were learning task, science class, out-of-class science activities, field trip, and science visit. The translations of these items were reviewed to ensure if they expressed the intended meaning. For example, "science visit" is not a common word in Turkish context. If we used direct translation of this phrase, most probably, the students would not understand what we meant with it. Moreover, several specific phrases were worded to have more general meanings. For example, at the original items there was a phrase like "this course". This was changed as "science courses". With the use of "science course" term, this instrument can be used at any courses related to science. After these revisions, the very first version of the adapted SEMLI-S was ready to be implemented.

(3) One to One implementation: Two pre-service teachers were asked to complete this version of the instrument. Moreover, the researchers wanted them to read and think aloud during this process. These two sessions were video-taped. These videos then were revived by the researchers. The main reason to do that was to see if the pre-service teachers understand what we wish to mean.

(4) Final Modifications: According to the results of the one to one implementations, the researchers decided to remove two of the items of the Constructivist Connectivity sub-factor (Items CC2 and CC7).

(5) Expert Opinions: After the final modifications, the final version of the SEMLI-S was sent to two experts with the PhD degree in the field of science education. At this step, they were asked to review the items with respect to the purpose of the instrument. Moreover, the presentations of the items were also checked by the experts. The feedback from the experts showed that the items did not need any further modification. However, it was suggested to give an explanation for the phrases which are "learning task" and "out-of-class science activities" in the scale. Therefore, the final version of the adapted SEMLI-S included the explanations of these two phrases.

(6) Data Collection: In order to collect the data, the researchers decided to use an online platform. Therefore, the online version of the adapted SEMLI-S was prepared with the use of an online survey application. The reason behind this was to minimizing coding errors and saving time to export the data.

(7) Data Analysis: In order to check construct validity of the SEMLI-S, the exploratory factor analysis (EFA) and the confirmatory factor analysis (CFA) was carried out.

2.2 Sample of the Study

The sample of the study consisted of 193 pre-service elementary teachers from a public university located in a small city at inner west region of the Anatolia. The female pre-service teachers were the 77% of the sample (N=147) whereas the male pre-service teachers were only 23% of the all (N=46).

3. RESULTS

3.1 Exploratory Factor Analysis

In order to validate the factor structure of adapted SEMLI-S, the EFA with maximum likelihood estimation was employed. The analysis was carried out with principal component as the extraction method and varimax as the rotation.

Prior to interpreting the results of the EFA, we first checked measure of sampling adequacy and Barlett test of sphericity to test if we have an interpretable data set. The KMO measure of sampling adequacy was found to be 0.91 which was an acceptable value. Moreover, Barlett test of sphericity was significant (BTS value = 2872, p <0.05) showing that the correlation matrix is not an identity matrix. Therefore, it was appropriate to conduct the EFA. The EFA proposed five factors that accounts for 61.25% of the variance of the data. The five-factor solution emerged from the EFA supported the factor structure of the original SEMLI-S. However, when the component matrix was examined, it was seen that several items were conceptually at odds clustered in several factors (See Table 1).

Table 1: Component matrix

Item #	*Component*				
	1	2	3	4	5
Item 21	0 .846				
Item 15	0 .831				
Item 24	0 .821				
Item 25*	0 .587				
Item 4	0 .574				
Item 11	0 .441				
Item 17*					
Item 22		0 .743			
Item 13		0 .729			
Item 3		0 .712			
Item 18		0 .703			
Item 26	0 .408	0 .701			
Item 2*					
Item 10			0 .857		
Item 1			0 .794		
Item 19			0 .723		
Item 28		0 .441	0 .656		
Item 8*		0 .442	0 .530		
Item 14*		0 .418	0 .480		
Item 12				0 .751	
Item 20				0 .649	
Item 23				0 .624	
Item 16				0 .524	
Item 27*				0 .439	
Item 5					0 .703
Item 6*					0 .696
Item 9*					0 .602
Item 7*					0 .587

*These items were conceptually at odds clustered in different factors

Note. The item loadings lower than 0.40 were excluded.

Therefore, the researchers excluded 9 items (Item 2, 6, 7, 8, 9, 14, 17, 25, and 27) and repeated the EFA. The KMO measure of sampling adequacy was found to be 0.88 which was an acceptable value. Moreover, Barlett test of sphericity was significant (BTS value = 1737, p<0.05) showing that the correlation matrix is not an identity matrix. Therefore, it was appropriate to conduct the EFA. The EFA proposed four factors that accounts for 54% of the variance of the data. The new component matrix is shown in Table 2. When this table is examined, it could be said that these 19 items fit well to the factors proposed by the SEMLI-S except items of the Control of Concentration factor. At the original version of the SEMLI-S, this factor had three items. However, in the adapted SEMLI-S we had to remove the items in this factor.

Table 2: Component matrix after exclusion

Item #	*Component*				
	1	2	3	4	5
Item 22	0 .749				
Item 13	0 .746				
Item 18	0 .737				
Item 3	0 .715				
Item 26	0 .711	0 .401			
Item 21		0 .860			
Item 15		0 .844			
Item 24		0 .812			
Item 4		0 .643			
Item 11		0 .489			
Item 10			0 .872		
Item 1			0 .799		
Item 19			0 .743		
Item 28	0 .447		0 .675		
Item 12				0 .762	
Item 20				0 .668	
Item 5				0 .621	
Item 16				0 .587	
Item 23				0 .579	

Note. The item loadings lower than 0.40 were excluded.

3.2 Confirmatory Factor Analysis

The results of the EFA showed that, we have four-factor model instead of five-factor model. We tested this four-factor model with the CFA using diagonally weighted least squares (DWLS) estimation (Flora and Curran 2004) with LISREL 8.8 software (Jöreskog and Sörbom 2006). The four factor-model of the adapted SEMLI-S can be seen in Figure 1.

In order to test if this model fit or not, the researchers considered following fit indices: Standardized χ^2, Comparative Fit Index (CFI; Bentler 1990), Normed Fit Index (NFI; Bentler and Bonett 1980), and Root-Mean-Square Error

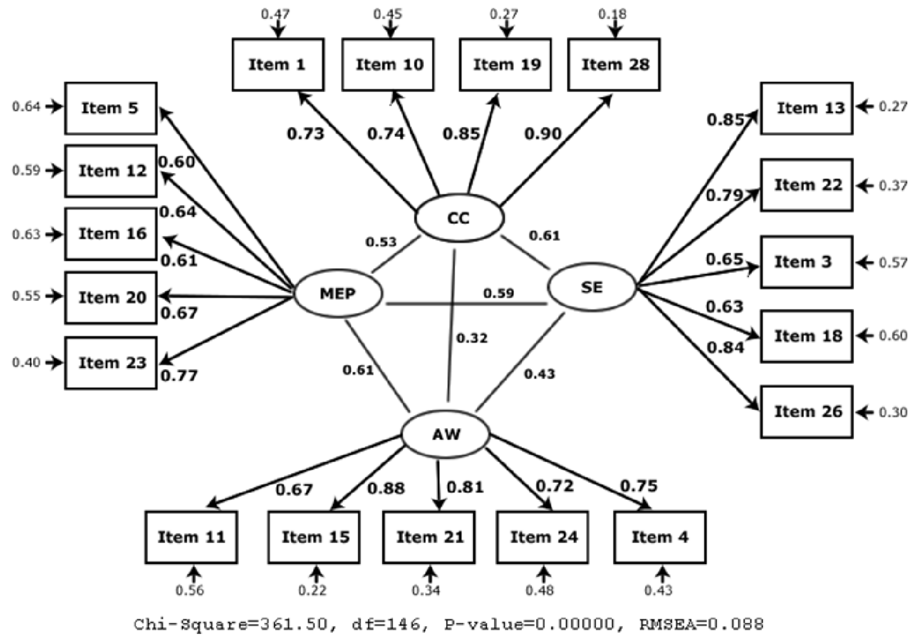

Fig. 1. Standardized coefficients for the four-factor model of the adapted SEMLI-S

of Approximation (RMSEA; Steiger 1990). In a good model, CFI and NFI values should be over 0.90 (Kline 1998). Moreover, RMSEA values less than 0.05 indicate close fit and models with values greater than 0.10 shows that the model cannot be defended (Browne and Cudeck 1992).

In this study, CFI and NFI were found to be 0.99 and 0.96, respectively. The RMSEA value was 0.088 (90% Confidence Interval for RMSEA = 0.0764 ; 0.0991). With respect to these values, it could be said that the four-factor model of the adapted SEMLI-S fit well to data. In other words, the results of the CFA show us that this instrument help us to collect valid data in our context.

Final version of the adapted SEMLI-S had 19 items: four items at Constructivist Connectivity (items 1, 10, 19, and 28), five items at Monitoring, Evaluation and Planning (MEP) (items 5, 12, 16, 20, and 23), five items at Science Learning Self-efficacy (SE) (items 3, 13, 18, 22, and 26), and five items at Learning Risks Awareness (AW) (items 4, 11, 15, 21, and 24) factors.

3.3 Descriptive Statistics

At the first step, item analysis was carried out to check if the items in the adapted SEMLI-S were functioning well. Moreover, Cronbach alpha coefficient, which is one of the measures of the reliability, was calculated at this step. It was seen that this value is 0.90 which indicates high reliability of the data collected with this instrument. Moreover, you can see the item-scale correlations and item means in Table 3. If the

Table 3: Item analysis results of the adapted SEMLI-S

Item #	*Mean*	*Item-scale correlation*
1	3.585	0.564
3	3.135	0.529
4	3.938	0.565
5	3.415	0.549
10	3.777	0.548
11	3.850	0.539
12	3.658	0.552
13	3.534	0.677
15	4.098	0.596
16	3.762	0.500
18	3.363	0.514
19	3.751	0.632
20	3.554	0.598
21	4.078	0.556
22	3.373	0.607
23	3.606	0.636
24	4.083	0.534
26	3.674	0.704
28	3.606	0.690

item-scale correlation value is greater than 0.40, we can say that the item is functioning quite satisfactorily (Crocker and Algina 1986: 315). Here, the minimum item-scale correlation is 0.50, which indicates that all of the items in the adapted SEMLI-S are functioning well. Cronbach alpha coefficient was also calculated for each factor. It was found to be 0.86 for the CC, 0.76 for the MEP, 0.84 for the SE, and 0.84 for the AW.

The possible minimum and maximum scores for the adapted SEMLI-S are 19 and 95 respectively. In Table 4, you can see the descriptive statistics of the adapted SEMLI-S scores. There is no missing value in this study since the web-based survey system was informing the pre-service teachers if they pass an item without answering it. The mean, median, and mode value of the scores is 69.84, 71, and 70, respectively. Here, all these three values are close to each other. In a normal distribution, these values are the same. However, in this study, since these values are not fluctuating much, it could be said that the distribution is normal. Moreover, when we check the skewness and kurtosis values we see that this distribution is negatively skewed and leptokurtic. Therefore, it could be concluded that this distribution deviates from the normality. Because of that, the results of non-parametric alternative of independent samples of t-test was also reported in Section 3.4.

Table 4: Descriptive statistics for the scores of the SEMLI-S

Statistics		
N	Valid	193
	Missing	0
Mean		69.84
Median		71
Mode		70
Std. deviation		10.8934
Skewness		-1.321
Std. error of skewness	0 .175	
Kurtosis		3.367
Std. error of kurtosis	0 .348	
Minimum		27
Maximum		94

Distribution of the scores can be clearly seen in the histogram given in Figure 2. As stated above, this distribution is negatively skewed.

3.4 Inferential Statistics

The second research question of the study was “Is there a significant mean difference between male and female pre-service teachers’ metacognitive science learning orientations?” In order to answer this question, an indepen-

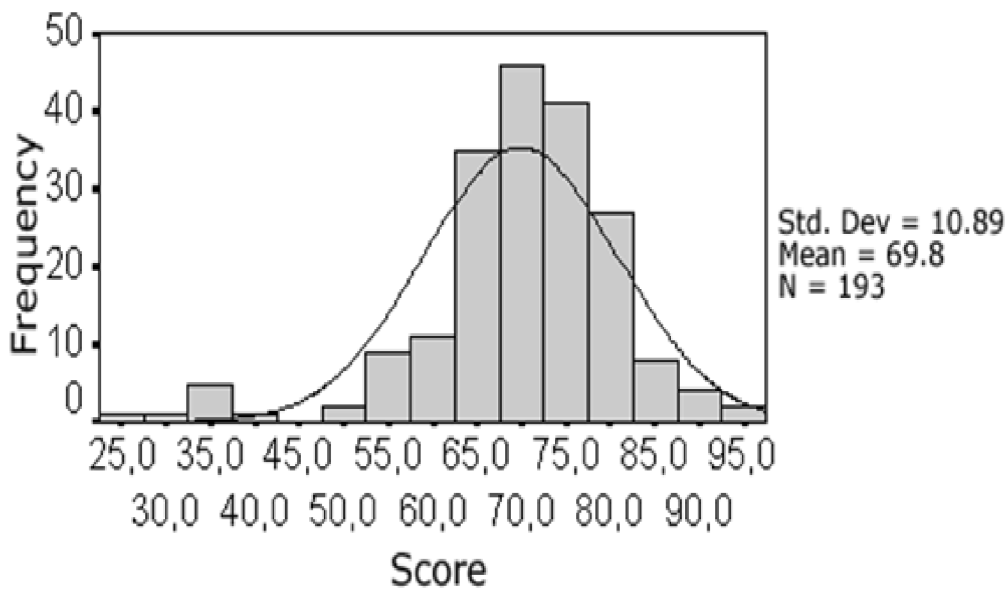

Fig. 2. Distribution of total score

dent sample t-test was carried out. The results of the independent sample t-test ($t(191) = 1.26$, $p > 0.05$) showed that there was not a significant mean difference between male pre-service teachers' metacognitive science learning orientations ($M = 71.61$, $SD = 8.48$) and female pre-service teachers' metacognitive science learning orientations ($M = 69.29$, $SD = 11.51$). As a nonparametric analog to the independent samples t-test, Mann-Whitney U-test was carried out. The results also showed that the two groups did not differ significantly ($U(191) = 3270.00$, $Z = -0.34$, $p > 0.05$). However, one can have some doubts about the power of this result as the numbers of male and female students are not equal (see Section 2.2). This can cause to have insignificant difference even there is actually a significant difference. In this case, the raw scores could be referred to check the difference. The difference is 2.3, which is not high difference to expect a statistically significant mean difference. Moreover, if the group variances are equal, as in this case, unequal group sizes are not fatal to t-test.

4. DISCUSSION

The 19-item SEMLI-S was found to measure the following four factors of pre-service teachers' metacognitive science learning orientations:

- CC (items 1, 10, 19, and 28)
- MEP (items 5, 12, 16, 20, and 23)
- SE (items 3, 13, 18, 22, and 26)
- AW (items 4, 11, 15, 21, and 24)

The CC factor was removed in the adapted version of this instrument. The items loaded in this factor were not conceptually related to each other. Thomas et al. (2008) also emphasized the problematic nature of this factor since the items in this factor could be clustered in different factors. In contrast to their study, there was no statistical support for these items' belonging to a separate factor.

The results of the EFA indicated that each item has a significant contribution to the corresponding factor. In addition, the CFA provided evidence for the four-factor structure of the instrument. In terms of internal consistency, the reliability coefficients for all factors were higher than 0.75. Therefore, it could be concluded that the four-factor model of Turkish version of the SEMLI-S represented a valid and reliable instrument to measure pre-service teachers' metacognitive science learning orientations.

The results showed that the SEMLI-S did not differentiate between females and males in terms of metacognitive learning orientations. There is need for studies to investigate the gender difference in metacognitive learning orientations in different cultural contexts. The results also indicated that pre-service elementary teachers scored high on the scale which is not surprising since research studies documented that older students were more metacognitive (Aydin and Ubuz 2010; Shraw and Dennison 1994).

5. CONCLUSION

It could be concluded that the Turkish version of the SEMLI-S instrument was found as a valid and reliable instrument to measure pre-service teachers' metacognitive science learning orientations. This instrument provides information about pre-service teachers' perceptions of CC, MEP, SE, and AW. Therefore, the SEMLI-S will enable teachers and teacher educators to identify their students' metacognitive learning orientations and the relationship between metacognition and achievement.

6. RECOMMENDATIONS

The adapted version of the SEMLI-S will serve as a valuable tool for teachers and teacher educators to shed light on to their ways while exploring their students' perceptions of metacognitive learning orientations. In this study, the data were obtained from pre-service teachers. The study could be replicated with the students at different ages in order to investigate the changes in the perceptions of metacognitive learning orientations. There could be a relation between students' metacognition and achievement in different cultures and this should be investigated by further studies.

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