THE SELF EFFICACY SCALE FOR EMERGING TECHNOLOGIES: TURKISH ADAPTATION, VALIDITY AND RELIABILITY

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Abstract

This study was conducted to adapt the "modified Computer Self-Efficacy Scale", developed by Laver and colleagues, to Turkish culture in the context of emerging technologies and to conduct validity and reliability analyses. The study employed a quantitative research model and a cross-sectional survey design. Data were collected from different groups of university students for the linguistic equivalence (n = 184), exploratory and confirmatory factor analyses (n = 428), and test-retest (n = 65) phases. The analyses conducted revealed that converting the scale's original 10-item structure into an 8-item single-factor structure was more suitable for the Turkish sample. The results from the confirmatory factor analysis showed that the single-dimensional model fit the data perfectly. Additionally, the scale demonstrated high internal consistency (Cronbach's alpha = 0.916; McDonald's omega = 0.917; CR = 0.915) and acceptable stability over time (Pearson r = 0.623). In addition, measurement invariance up to the scalar level has been established for the gender variable. The findings indicate that the "Self-Efficacy Scale for Emerging Technologies" is a valid and reliable tool for measuring university students' perceptions of self-efficacy regarding new technologies.

Keywords: New Technologies Attitude Scale, Scale Adaptation, Self-Efficacy.

1 INTRODUCTION

The concept of self-efficacy, introduced by Bandura [1] as part of social cognitive theory, describes an individual's belief in their capability to successfully execute a specific task within a given context. An individual's perceived capacity mediates what they can do and what they do [1]. Young people's belief in their personal competence to manage rapidly changing social conditions helps them cope with these challenges, such as adapting to new technologies and navigating social media platforms [2]. The earliest examples of self-efficacy studies related to information and communication technologies (ICT) began with computer self-efficacy [3], and the literature shows that numerous self-efficacy studies have been conducted regarding the Internet, Web, mobile phones, online technologies, tablet computers, social media, Web 2.0 applications, etc.

Today, self-competencies related to emerging technologies being developed in many fields - such as virtual reality, cloud technologies, artificial intelligence, the Internet of Things, educational technology, and health technology - are gaining importance. The time it takes for new ICTs to emerge is becoming shorter with each passing day, and individuals may encounter them in both their professional and personal lives. Prensky [4] introduced the term "digital native" in 2001 to refer to individuals born after 1980, during the Information Age. He claims that digital natives possess a unique ability to quickly and comfortably locate, consume, and share digital information across various electronic devices and platforms. However, research conducted in subsequent years has shown that the technological proficiency of younger generations - often referred to as "digital natives" and categorized by birth year as Millennials, Generation Z, and Generation Alpha - is not as high as previously assumed or predicted, indicating that they may struggle with certain digital skills that are essential in today's daily life or job market [5], [6], [7], [8], [9]. These studies indicate that age is not the sole factor influencing digital competence; rather, experience, education, and culture play a more significant role regarding technology self-efficacy. Multitasking has a detrimental effect on cognitive abilities, and even those labeled as "digital natives" are not immune to its consequences. Regarding university students, such distractions can lead to decreased academic performance and hinder the effective use of digital tools for learning, particularly when students encounter

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competing tasks and interruptions. There is considerable variation in technology usage and proficiency levels among K-12 and higher education students, which results in differing levels of self-efficacy. To enhance their self-efficacy, pedagogical support is essential for assisting students in effectively employing digital tools in academic environments. This support can provide strategies to manage multitasking and improve focus, ultimately leading to better academic performance.

In this context, it becomes necessary to assess the self-efficacy of university students - whose self-efficacy regarding existing technologies may not even be sufficient - in utilising emerging technologies. This study focuses on adapting the modified Computer Self-Efficacy Scale (mCSES) by Laver et al. [10] to Turkish culture in the context of emerging technologies rather than computers and examines its psychometric properties. The aim of the Self-Efficacy Scale for Emerging Technologies (SESET) is to measure how competent individuals perceive themselves to be in handling a technology they have never encountered before - or one that may not even exist currently.

2 METHODOLOGY

2.1 Research Model

In this study, a quantitative research model was utilized, employing a cross-sectional survey design to adapt the modified Computer Self-Efficacy Scale (mCSES). This design measures variables only once [11] and was used to assess undergraduates' self-efficacy levels regarding emerging technologies based on their responses to the scale items.

2.2 Participants

The study employed distinct participant groups for linguistic equivalence, exploratory and descriptive factor analysis, and test - retest phases. The demographic characteristics of the participants across the three different phases of the study are presented in Table 1.

Table 1. Participants of the study.

Phase	***n***	***Female***		***Male***	
		n	***%***	***n***	***%***
Linguistic equivalence	184	147	79.9	37	20.1
Explorative and descriptive factor analysis	428*	258	60.3	166	38.8
Test – retest	65	58	89.2	7	10.8

**Four participants in the explorative and descriptive factor analysis phase preferred not to disclose their gender.*

While the overall sample of 677 university students represented 15 different universities and a wide range of disciplines, with a significant portion of the factor analysis group from engineering and architecture (47%). The test-retest phase primarily consisted of social science students (92.3%). Approximately 63% of the total sample across all phases were first and second-year students.

2.3 Data Collection Tool

The data for the study were collected using SESET, the Turkish equivalent of the mCSES developed by Laver et al. [10]. In the original study, a total of 10 items is categorized into two distinct dimensions: "using the technology alone" (items 1, 2, 3, 7, 8, and 10) and "using the technology with the support of others" (items 4, 5, 6, and 9). A 10-point Likert scale was used for assessment. A higher score indicates that the respondent has a greater level of self-efficacy regarding emerging technology. The results of the exploratory factor analysis in the original article demonstrate that the two-dimensional items account for 66% of the variance, and Cronbach’s alpha coefficient was computed as .94. Prior to commencing the language equivalence studies for the scale, the requisite permission was secured from the corresponding author.

2.4 Research Procedure

For the cultural adaptation, validity, and reliability study of the SESET, permission was first obtained via email from the survey’s original developers. The university's ethics committee also granted approval for the project, which encompasses this study. For the cultural adaptation, validity, and reliability study of the SESET, permission was first obtained via email from the survey's original developers. After ensuring linguistic equivalence, exploratory factor analysis was conducted to determine the presence of a two-factor structure. Based on the findings, confirmatory factor analysis was then performed. Finally, validity and reliability analyses were conducted as the final part of the study.

2.5 Data Analysis

2.5.1 Analyses of Linguistic Equivalence

Data was gathered from 184 participants for linguistic validity research. Participants were instructed to evaluate 10 items using a scale where 1 indicated "Not at all confident for me" and 10 meant "Completely confident." In the data collection phase, a control item was incorporated into the scale, and participants were instructed to choose the third option for that item. All participants accurately chose the third option for this item.

For linguistic equivalence, two faculty members with PhDs and one PhD candidate translated the scale from English to Turkish. Subsequently, a research sub-team qualified to teach in English reviewed these translations, reached a consensus on each item, and produced the initial Turkish draft. The Turkish draft was back-translated into English by two English-proficient academics with PhDs and one PhD candidate. The research team subsequently compared the back-translated items with the original scale to evaluate the extent to which the semantic meaning of the items had been maintained. The draft was further reviewed by a Turkish language expert for linguistic accuracy, followed by a final evaluation by a native English-speaking faculty member. This expert confirmed the equivalence between the Turkish draft and the original scale, finalizing the linguistic validation process.

The Solomon four-group model was utilized for the linguistic equivalence study to eliminate the pre-test effect in groups that completed the scale in both languages. Group 1 received the English scale first, followed by the Turkish scale three weeks later. Group 2 had the Turkish scale first, then the English scale after three weeks. Group 3 only took the Turkish scale, while Group 4 only took the English scale. Each group consisted of around 30 students majoring in English Language Education. In the study, the statistical analysis includes results from the second administration for Groups 1 and 2, as well as those from Groups 3 and 4.

The scores obtained by the groups on the SESET were initially evaluated for normal distribution assumptions using the Shapiro-Wilk test, along with skewness and kurtosis values and histograms. After confirming that the normality assumptions were met, a MANOVA analysis was performed. The results of the MANOVA, which examined the mean total and subscale scores from the groups on the SESET, revealed no significant differences among the groups. This suggested that the English and Turkish versions of the scale are linguistically equivalent.

2.5.2 Exploratory Factor Analysis (EFA)

In the investigation of the mCSES scale, initial evaluations indicated a two-factor structure; however, this was challenged upon reviewing the original article, revealing that items were predominantly clustered under a single factor. The presence of two items in the proposed second factor raised concerns, as literature necessitates a minimum of three items for factor validity and reliability [12], [13], [14]. In pursuit of clarity, the corresponding author was contacted, but no response was received, prompting a series of exploratory factor analyses (EFA) to reassess the structure.

The first EFA, utilizing direct oblimin rotation, identified a two-factor structure with Items 1 and 2 within the second factor. The KMO value was recorded at 0.912, with Bartlett's test showing significance (χ^2 = 2307.205; $p < 0.005$). This analysis explained a total variance of 68.712%, with the first factor accounting for 56.043% and the second for 12.668%, suggesting the scale might be unidimensional. Consequently, a second EFA was performed, excluding Item 2, resulting in 9 items consolidated under a single factor, a KMO value of 0.928, and a significant Bartlett test (χ^2=1958.758; $p<0.005$). However, explained variance decreased to 58.599%.

A third EFA was conducted following the removal of both Items 1 and 2, leading to an eight-item single-factor structure, with an explained variance of 63.166, KMO value of 0.930, and significant Bartlett's test (χ^2=1840.906; $p<0.005$). The findings from all three analyses supported that the eight-item single-factor structure represents a more reliable and valid scale framework. A confirmatory factor analysis was thus proposed to utilize this optimized eight-item scale.

2.5.3 Confirmatory Factor Analysis (CFA)

The analysis's requirements and assumptions were verified prior to conducting the CFA. In the initial stage, both single and multiple outliers were assessed. When examining the standardized z-scores, the ±4.00 range [15] was considered. Two data points (-5.52; -4.84) that fell outside this range were removed from the dataset. To identify multiple outliers, it was observed that Cook's distances (0.000) were less than 1.00. Mahalanobis distances were then calculated. The resulting values ranged from 0.570 to 91.200. The chi-square value for these data, with df=10 and α=0.001, is 29.588. Accordingly, the data from 29 participants were excluded from the dataset because their Mahalanobis distance exceeded 29.588. The analysis continued with 397 participants.

In the second stage, univariate and multivariate normality tests were conducted. It was observed that the skewness values ranged from -1.553 to -0.502, while the kurtosis values ranged from -0.358 to 2.738. Since the skewness) and kurtosis values were below the specified limits, univariate normality was established [16], [13]. In the third stage, a linearity analysis was conducted; upon examining the scatter plots for Item 1 (–0.552) and Item 6 (–1.553), which had skewness values at the extremes, it was concluded that the linearity condition was met. Finally, the VIF (1.983–2.719) and tolerance values (0.368–0.504) were examined for multicollinearity. Since the VIF (<3) and tolerance (>0.10) values were within the specified ranges, no multicollinearity issue was observed [17].

To evaluate the model's fit with the data in the CFA of the eight-item single-factor structure, we examined several fit indices, including chi-square/degrees of freedom, CFI, NFI, TLI, RMSEA, and SRMR [18], [13]. Additionally, we obtained a path diagram that corresponds to the model.

2.5.4 Reliability Analysis

To demonstrate the reliability of the scale, Cronbach's α, McDonald's ω, test-retest reliability, and composite reliability (CR) were calculated. A value greater than 0.70 was accepted as the criterion for reliability coefficients [19].

Test-retest reliability involved 154 participants in the first administration, but only 63 completed it again three weeks later. Two participants were identified as outliers after data review. The analysis then proceeded with 61 participants, and it was determined that the distributions for both administrations were normal. The scatter plot of scores from the first and second administrations indicated a linear relationship, leading to the decision to use the Pearson correlation coefficient. Additionally, based on discussions in the literature [20], [21], [22], [23], the test-retest reliability was also calculated using the intraclass correlation coefficient. For this calculation, the closeness of the means and standard deviations was verified [23]. The means (74.44 for the first administration and 73.36 for the second administration) and standard deviations (11.509 and 10.826, respectively) indicated no significant change in participants' scores over time. The "two-way mixed effects, absolute fit, single-measurement model" was employed for the coefficient calculation [22].

2.5.5 Convergent Validity Analyses

In the study, evidence of the scale's construct validity was also examined. Given that the scale demonstrated a unidimensional structure, a divergent validity analysis to differentiate between dimensions was not performed [19]; instead, only a convergent validity analysis was conducted. The analysis accepted an Average Variance Extracted (AVE) value greater than 0.50, along with a composite reliability coefficient exceeding 0.70, as criteria for establishing convergent validity [24], [19].

2.5.6 Analyses Related to Measurement Invariance

Measurement invariance studies were conducted to assess whether the construct measured by the scale holds the same meaning across different gender groups (women/men). Analyses utilized the multi-group confirmatory factor analysis method [18]. Configurational, metric, scalar, and strict invariance were tested sequentially; fit indices (chi-square and degrees of freedom, RMSEA, CFI, SRMR) were calculated at each stage, and inter-model difference statistics (ΔRMSEA, ΔCFI, ΔSRMR) were evaluated to determine whether to proceed to the next stage [18]. The following criteria were considered in decision-making based on these difference statistics: ΔCFI ≤ -0.010, ΔRMSEA ≤ 0.015, ΔSRMR ≤ 0.03 for metric invariance, and ΔSRMR ≤ 0.015 for scalar and strict invariance [25], [26].

3 RESULTS

3.1 Findings of Confirmatory Factor Analysis

To confirm the unifactorial structure of the ESSET, a first-order CFA was conducted using the maximum likelihood estimation (MLM) method. The results for the first model showed that most of the indices were in excellent or acceptable range, but the RMSEA (0.082) was slightly higher than the usual threshold of 0.08. Consequently, modification indices were examined, revealing high covariance between the error terms of Item 3 ("I can make use of emerging technologies if I have a relevant manual for reference") and Item 4 ("I can make use of emerging technologies if I have seen someone else using it before"), which share a common theoretical focus on external guidance. Maintaining the same MLM estimation method, a covariance term was added between these error variances to refine the model. The fit indices obtained from this initial and modified analysis, along with the standard criteria, are presented in Table 2.

Table 2. Fit indices initial and modified CFA Model

Indices	Initial Model	Modified Model	Excellent Fit Criteria	Acceptable Fit Criteria
χ^2/sd	72.630/20 = 3.632	57,567/19 = 3,030	≤3.00	≤ 5.00
SRMR	0.0308	0,0276	≤0.05	0.05 ≤ SRMR ≤ 0.08
RMSEA	0.082	0,072	≤0.05	0.05 ≤ RMSEA ≤ 0.08
CFI	0.971	0,979	≥0.95	0.90 ≤ CFI ≤ 0.95
NFI	0.961	0,969	≥0.95	0.90 ≤ NFI ≤ 0.95

The modified model column in Table 2 demonstrates that this refinement led to an excellent fit, significantly enhancing the RMSEA to 0.072. The chi-square/df value of 3.030 is now close to the threshold for an excellent fit. Additionally, the values for SRMR (0.0276), CFI (0.979), and NFI (0.969) also indicate an excellent fit. Through this modification process, the model fit has improved, and the model has been validated in terms of first-order DFA, as reflected in these metrics. The model obtained regarding the scale's single-factor structure is presented in Figure 1.

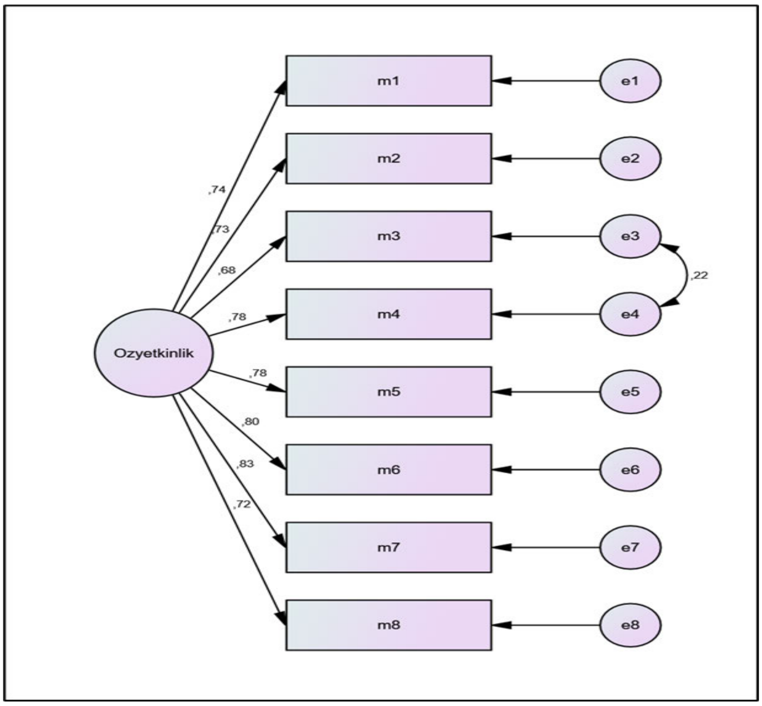

Figure 1. Path diagram for ESSET.

As shown in Figure 1, the model obtained for the scale's single-factor structure. In the model, the standardized estimated coefficients range from 0.68 to 0.83. It was determined that all t-values for the estimated coefficients were greater than 1.96. Based on this finding, it can be concluded that all relationships between the items and factors are significant ($p < 0.05$). In the model, a low positive correlation (0.22) is observed between the error terms of Item 3 and Item 4. This finding indicates that there is no relationship between the two items strong enough to disrupt the model's structure; rather, they simply share a small amount of common variance.

3.2 Findings Related to Reliability

The reliability findings indicate that the scale has high internal consistency. While the Cronbach alpha reliability coefficient, calculated under the assumption that factor loadings are equal, is 0.916, the omega coefficient, calculated under the assumption that factor loadings are unequal, is also very close (0.917). Furthermore, the composite reliability coefficient, which accounts for the possibility that factor loadings may differ, is also very close to and high compared to the alpha and omega coefficients (0.915). The Pearson correlation coefficient ($r = 0.623$) and the intraclass correlation coefficient (0.622) calculated for test-retest reliability indicate that the scale demonstrates moderate stability over time.

3.3 Findings Related to Convergent Validity

To demonstrate convergent validity - which indicates the degree of agreement among scale items - both the factor loadings and significance of the items were examined, and the average variance explained (AVE) value, which indicates the proportion of variance in the items explained by the factor, was compared with the composite reliability coefficient (CR).

In the analysis, the factor loadings for the eight-item scale were calculated as 0.742; 0.730; 0.682; 0.780; 0.783; 0.799; 0.830; and 0.717, respectively. The factor loadings for all items were found to be significant ($p < 0.05$). The AVE was calculated as 0.576. The CR was 0.915. Based on these findings, it was determined that the criteria of CR > AVE; CR > 0.70; and AVE > 0.50 [24], [19] were met. These findings indicate that the scale meets the criteria for convergent validity.

3.4 Findings Regarding Measurement Invariance

The fit indices obtained for key steps of the ESSET's measurement invariance analysis by gender (female/male) are presented in Table 3.

Table 3. Statistics on measurement invariance.

Variable	*Steps*	*χ^2 (sd)*	*χ^2/sd*	*RMSEA*	*ΔRMSEA*	*CFI*	*ΔCFI*	*SRMR*	*ΔSRMR*
Gender	Configural	97,8 (40)	2,445	0,08	-	0,97	-	0,03	-
	Metric	102 (47)	2,170	0,07	0,01	0,97	0,00	0,04	-0,01
	Scalar	108 (54)	2,000	0,07	0,00	0,97	0,00	0,04	0,00
	Strict	156 (62)	2,520	0,08	-0,01	0,95	-0,02	0,05	-0,01

Table 3 presents the chi-square-to-degrees-of-freedom ratios for all invariance steps, which range from 2.000 to 2.445, falling within the criteria for excellent fit ($\chi^2/df \leq 3.00$). The RMSEA values were found to be within acceptable fit limits, while the SRMR and CFI values were noted to be within excellent fit limits. These results indicate that the measurement model was validated at each stage of the invariance analysis. When analysing the difference statistics for fit indices related to metric invariance, scalar invariance, and strict invariance, it was found that configural, metric, and scalar invariances were achieved. However, the ΔCFI value exceeded the critical threshold of 0.01 (recorded at 0.02), suggesting that strict invariance was not achieved.

4 CONCLUSIONS

The study's findings indicate that when comparing the original mCSES to the ESSET, Cronbach's alpha values are quite similar, at 0.94 for the mCSES and 0.92 for the ESSET. The exploratory factor analysis (EFA) reveals that the scale items account for 66.2% of the total variance in the mCSES and 58.6% in the ESSET. However, since the original study did not present findings from a confirmatory factor analysis (DFA), a comparison could not be conducted.

The confirmatory factor analysis conducted as part of this study revealed that the one-dimensional model fits the data well. This finding demonstrates that the scale measures attitudes toward new technologies without confounding them with other characteristics; in other words, it possesses construct validity.

Considering the findings regarding reliability, it was determined that Cronbach's alpha, McDonald's omega, and composite reliability coefficients yielded high values that were very close to one another. This finding supports the conclusion that the scale possesses a strong unidimensional structure. Furthermore, this situation can be interpreted as an indication that measurement errors are distributed evenly across the items and that they measure the intended construct with similar success. Although the internal consistency coefficients are high, the fact that the Pearson and intraclass correlation coefficients calculated for test-retest reliability are slightly below 0.70 indicates that while the scale has a strong internal structure, it is sensitive to time. One reason for this discrepancy may be the low number of items in the scale. Another reason could be the possibility that the measured variable (attitude toward emerging technologies) itself has changed over the time between the two administrations. It is possible to state that the scale provides measurements that are stable at an acceptable level over time.

In the study on convergent validity, the finding that the factor loadings for the items were high and statistically significant, along with the confirmation that the criteria related to AVE and CR were satisfied, demonstrates that the relationship between all items and the measured construct - attitude toward emerging technologies - is not coincidental. This indicates that the items effectively represent the construct.

In the analysis of measurement invariance, structural, metric, and scalar invariance were confirmed for the gender variable; however, strict invariance could not be established. This finding suggests that female and male participants interpret and react to scale items similarly, with their responses originating from the same baseline. The inability to attain strict invariance signifies that the error variances across groups are dissimilar, and in practice, fulfilling this criterion can be challenging. The establishment of measurement invariance up to the scalar invariance stage confirms the absence of gender bias in the measurement model, indicating that the scale can be utilized without apprehension regarding measurement bias in studies examining attitudes toward new technologies by gender.

In this study, we focused on examining measurement invariance concerning gender; however, it would also be valuable to investigate measurement invariance for other demographic and cultural variables, such as age, socioeconomic status, and regional differences within Turkey.

When we evaluate all findings together, ESSET will serve as a measure that demonstrates established reliability and validity for application in Turkish culture.

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