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Research Article

Development and Psychometric Evaluation of E-Learning Assessment Scale in Higher Education

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Abstract: E-learning is a fairly recent and fleetly expanding trend of education that increased particularly during the COVID-19 epidemic. Thus, assessing learning with were estimated using descriptive statistics, explanatory and Confirmational Factor Analysis (CFA), Pearson correlation analysis, t-test for dependent variables, and Cronbach alpha coefficient. The content validity index of this scale, calculated according to experts‟ opinions, ranged between 0.84-1.00. According to the explanatory factor analysis, two factors had an eigenvalue> 1. These two factors accounted for 68.6 of the total variance. CFA showed favourable results for Chi forecourt/ degrees of freedom (χ2/df), comparative fit indicator (CFI) and root mean square error of approximation (RMSEA). The Cronbach alpha of the scale was 0.96. The Cronbach alpha measure of the sub-dimensions are 0.94 and 0.93 independently. The E-Learning Assessment Scale had strong test-retest reliability. In conclusion, the 18-item E-Learning Assessment Scale was a valid and reliable tool for assessing e-learning. The scale enables students to assess the e-learning process.

Keywords: E-learning, E-Learning assessment scale, Higher education, Higher education students

1. Introduction

The developments in science and technology in recent years bring along constant improvement and change in the field of education. Over the last decade, contrary to traditional face-to-face education, there has been an increase in the interest and need for alternative education and teaching methods (Sáiz-Manzanares et al., 2020).

During the pandemic, many universities were temporarily shut down, and education continued from a distance, namely as e-learning (Sahu, 2020). While some schools chose to transfer the spring semester to the following year, others started to continue education by selecting systems supporting distance education (Viner et al., 2020).

1.1. Advantages and disadvantages of E-Learning

E-learning differs from traditional methods in that it offers learning environments where students, regardless of time and space, can utilise various Information and Communication Technologies (ICT) (Saritepeci & Çakir, 2015). E-learning also offers students opportunities to improve such skills as learning, creativity, imagination, critical thinking, and cognitive skills by employing certain materials (video simulation, multimedia course books, and simultaneous group discussions). Online learning saves both time and financial costs (accommodation and travel). The advantage of online learning compared to traditional methods is that it provides the opportunity to work both online and offline. Combining various tools, videos, computer simulations, multimedia textbooks, online group discussions, and other learning methods, it allows students to develop their learning, imagination, creativity, and

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critical and logical thinking skills (Kuriplachova et al., 2019). However, apart from its many advantages, e-learning also has various disadvantages. As it is not carried out on a face-to-face platform, such troubles as lack of interaction and communication, problems with e-learning infrastructure and technology, and internet outages may affect learning outcomes (Kürtüncü & Kurt, 2020). Information technologies and internet access require a certain level of computer network infrastructure, computer literacy, and technical skills. E-learning may also fall short in fields that require clinical practice. Also, teachers need to have professional and technical training for online education. There is a need for adequate supportive technical and organisational structures for students, and tools such as computers or mobile phones and internet access (Kuriplachova et al., 2019).

The COVID-19 pandemic creates more uncertainty, especially in theory- and practice-based departments such as nursing. Traditionally, nursing education uses cognitive, affective, and psychomotor learning domains through structured healthcare education. Nursing students, whose participation in face-to-face learning opportunities and clinical experiences have been restricted during the pandemic, are in danger of failing to progress in their academic studies and completing their degrees. Remarkably, the COVID-19 pandemic caused traditional teaching methods to fall behind the current needs (Nashwan, 2020). For this reason, it is necessary to use new technologies such as online learning, blended learning, and simulation use in this process of nursing education. Online learning is a method that uses the technical and socio-psychological way of conducting the teaching process in teacher and student relations, using web-based and information technologies (Čepelová et al., 2011).

In the study, 32 articles were evaluated to emphasise the advantages and disadvantages of online education in the health care teaching process, and it is stated that online learning allows students to be independent and flexible in education and develop technical skills, critical thinking, and cognitive skills. As a result of this study, the authors stated that empowering teachers to create personal and professional development and technical skills can be more effective when combined with direct contact between the student and teacher (Kuriplachova et al., 2019). In the study conducted with 516 students studying in the nursing department of a state university in the Western Black Sea Region, most students stated that they thought both theory and practical courses would be insufficient with distance education. They expresseed the problems they experienced in this process as "problems in the infrastructure of distance education", "the lack of face-to-face education", " limited opportunities", "the mood brought by the pandemic", and "exam anxiety" (Kürtüncü and Kurt, 2020).

1.2. Measurement tool for E-Learning

As in many countries, the interest and need for e-learning have also increased in Türkiye during the COVID-19 pandemic. Although there are studies that investigate students' attitudes towards e-learning (Amir et al., 2020; Klibanov et al., 2018), the impact of this method on intended learning outcomes is still unknown. Moreover, when e-learning-specific scales in literature are examined, it is obvious that there are scales that evaluate the experience (Deshwal et al., 2017), quality of e-learning (Chaney et al., 2007), perception (Özutku & Başboğaoğlu, 2022), and attitude toward e-learning (Guillasper et al., 2020; Kisanga & Ireson, 2016). With the scale we have developed, there are items for evaluating e-learning in higher education. Psychometric evaluation of e-learning in higher education has been conducted with this scale. Although there are some scales for assessing distance education in the literature, our scale is a measurement tool developed for evaluating e-learning (Guillasper et al., 2020; Kisanga & Ireson, 2016; Deshwal et al., 2017). There is also e-learning readiness (Yurdugül & Sırakaya, 2013) and self-efficacy scales (Yavuzalp & Bahcivan, 2020) in the literature. However, a measurement tool for the assessment of e-learning is unavailable. Therefore, this study aims to develop an e-learning assessment scale for university students. Accordingly, the generated research questions are as follows:

1. Is this scale valid for university students?
2. Is this scale reliable for university students?

2. Method

2.1. Research model

This study is a methodological study to develop a valid and reliable e-learning assessment scale for university students.

2.2 Creation of the item pool and content validity

In forming items, three researchers initially conducted a literature review while constructing the items related to e-learning assessment for university students. Thus, an item pool of 82 was formed. Using 68 items considered to be suitable for the pool, a draft scale was prepared. The scale particulars were rated on a 5- point likert- type scale (1, I don't agree at all; 2, I don't agree; 3, I'm undecided; 4, I agree; and 5, I agree entirely). To determine content validity, opinions related to the scale should be entered from at least three and at most 20 experts in the applicable field of wisdom with the capacity to prepare the questions on the scale (Esin, 2014).

A group of 10 experts (a specialist in measurement and evaluation and nine specialists in nursing education and with experience in e-learning) were asked to examine the 68-item scale. The experts analyzed whether the items measured students' attitudes towards e-learning together with a linguistic analysis of the items; consequently, they made suggestions. They were asked to rate every item on a 4-point scale as follows: 'veritably applicable' (4 points), 'applicable but needs minor changes' (3 points), 'item needs to be put into an applicable form' (2 points), or 'not applicable' (1 point). Ratings of the ten experts were evaluated using the Davis technique. According to experts' suggestions, 36 items were neglected, and two items were added. The Content Validity Index (CVI) for each item is recommended to be ≥0.80 (Hayran & Hayran, 2011). The CVI of the 68-item scale was 0.95 and ranged between 0.84-1.00 for each item. Following the first disquisition, some details were modified in line with the suggestions in terms of clarity, judgment structure, applicability to the topic and re-evaluation of situations that should be measured independently in some details. Therefore, the final interpretation of the 34-item scale was created.

2.3 Participants

The study population consisted of students at Gazi University in Türkiye, who had no difficulty in communication. Although opinions differed regarding the optimal sample size required to perform factor analysis in scale development studies, the collective assumption of the sample size turned out to be 5-10 times the number of items in the scale (Grove et al., 2013). The study anticipated participation of 340 students, equal to 10 times the number of items (340). The study was completed with 434 voluntary students.

2.4 Data collection

The study was performed from October 2020 to December 2021 with 434 students in Türkiye. In data collection, after the literature review, a descriptive information form that consisted of 8 questions regarding students' sociodemographic characteristics and a draft form including 34 items were used.

Six students (3 male - 3 female) were subject to pre-administration to determine the comprehensibility of the scale items following the expert opinions. The students answered on a 5-category rating scale that ranked between 'totally agree' (5) and 'totally disagree' (1). No feedback connoting 'incomprehensibility of the items' in the draft form was received from participants.

Data was collected using an online survey link. On the first page of the survey link, there is an informed consent form and the questions became only visible after students marked the option that showed they accepted participating in the research. No identity information was asked of students. The students' answers are anonymous and the researchers do not know whom the answers belonged to. The time

between the test and retest was short enough for actors to flash back their answers and not long enough to change significantly in terms of the characteristic measured by the scale. Therefore, it was recommended to administer the tests in 1-2 week intervals (Polit &Yang, 2016). Students were asked to input their e-mail addresses to perform the test-retest analysis of the scale. For the test-retest analysis, the scale was re-administered to 30 randomly selected students from the first group 2 weeks after the first administration.

2.5 Data analysis

The data collected at the end of the study was uploaded to a computer using LISREL 8.80 and SPSS 24.0 software package and the scale was tested to check whether it is a valid and reliable tool. To analyse the data, the following tests were used:

The study used the CVI to evaluate the content validity. Also, Confirmatory Factor Analysis (CFA) and Explanatory Factor Analysis (EFA) were used to determine the content validity of the scale. The suitability of the data set for EFA was determined using Kaiser- Meyer- Olkin (KMO) and Bartlett sphericity test. CFA was performed to test the conformity of the structure revealed by EFA. CFA was performed to detect the correlation between the variables and factors, check the correlation between EFA, and find out whether the model is sufficient to define the factors. The CFA included $\chi 2$/degrees of freedom (df), including the chi-square ($\chi 2$) goodness of fit, Normed Fit Index (NFI), Non-normed Fit Index (NNFI), Root Mean Square Error of Approximation (RMSEA), Adjusted Goodness of Fit Index (AGFI), Comparative Fit Index (CFI), and Goodness of Fit Index (GFI) to analyse and evaluate the accuracy of the model. The Cronbach alpha and Pearson correlation coefficients were calculated to analyse the scale's reliability.

2.6 Ethical aspect of the study

Confirmation was acquired from the Gazi University Ethics Committee (2020-526) to implement the study. Before the start of the study, a written permit was obtained from the institution where the study was going to be conducted. Also, with the informed consent form on the first page of the survey link, confirmation was acquired from students. The students were informed that the data obtained from the study would only be used for exploration and that they had the right to withdraw from the study at any time. The researchers ensured data security in a computer only used by the researchers.

3. Results

Of the students, 77.6 % are female and 22.4% are male. Fifty-six percent of the students lived longest in the city centre. Those who participated in the research study were at the Faculty of Dentistry, Faculty of Pharmacy, Faculty of Science, Faculty of Education, Faculty of Architecture, Faculty of Engineering, Faculty of Health Sciences, Faculty of Sports Sciences, and Faculty of Technology and Vocational School of Higher Education. Of the students, 96.6% are in their first eight terms and have taken online classes at least once via the E-learning Centre of the University. Studentsstated they used tablet (88.2%), phone (85.3%), and computer (75.8) , respectively, to participate in online classes. The results regarding the validity and reliability of the scale are explained as construct validity (item analysis, EFA, CFA, and reliability (internal consistency reliability-Cronbach alpha coefficient, consistency of the scale over time-Pearson correlation coefficient).

3.1 Construct validity

3.1.1. Exploratory Factor Analysis (EFA)

To check whether the sample size is sufficient and the data is suitable for factor analysis, the Kaiser-Meyer-Olkin (KMO) coefficient was calculated, and the Barttlet Sphericity test was performed. The KMO value is recommended to be >0.6 for factor analysis (Pallant 2001). Considering the KMO coefficient as

0.96 and the Barttlet Sphericity Test value as (x2= 6942.54, df=153, p < 0.001) statistically significant, it was determined that the scale is suitable for Exploratory Factor Analysis.

To reveal independent dimensions of the scale, the Varimax technique of vertical rotation was performed and factor load values were examined. In determining the factor structures, a common factor eigenvalue >1.0 (Lee and Wang 2014) and factor loading >0.30 (Costello and Osborne 2005) were taken into consideration.Factor analysis revealed four factors that had an eigenvalue of ≥1.0. Items that loaded more than one factor and had load values of less than 0.10 were individually omitted, and EFA was repeated. Consequently, a total of 16 items in the scale were omitted. It was found that the remaining 18 items on the scale were gathered under two factors. Also, it was seen that the factor load values of the rest 18 items ranked between 0.30 and 0.86. The explained variances of two factors and their factor loads are shown in Table 1. The sub-dimensions (factors) are named based on results as follows; 'E-learning Infrastructure' and 'Impact of E-learning on Students' (Table 1).

The first factor (Qualities of the infrastructure used in e-learning) consists of 10 items (4, 9, 10, 11, 12, 13, 14, 15, 19, 22), and factor load values range between 0.30 and 0.86. Factor explains 40.3% of the total variance, and factor eigenvalue is 7.36.

Item load values in the second factor (Impact of E-learning on Students) range between 0.64 and 0.78. The second factor consists of 8 items (1, 2, 25, 27, 29, 30, 31, 32). The eigenvalue of the second factor is 5.63, which explains 28.3% of the total variance. Two of the 18 items (4 and 29) are reverse items.

Table 1

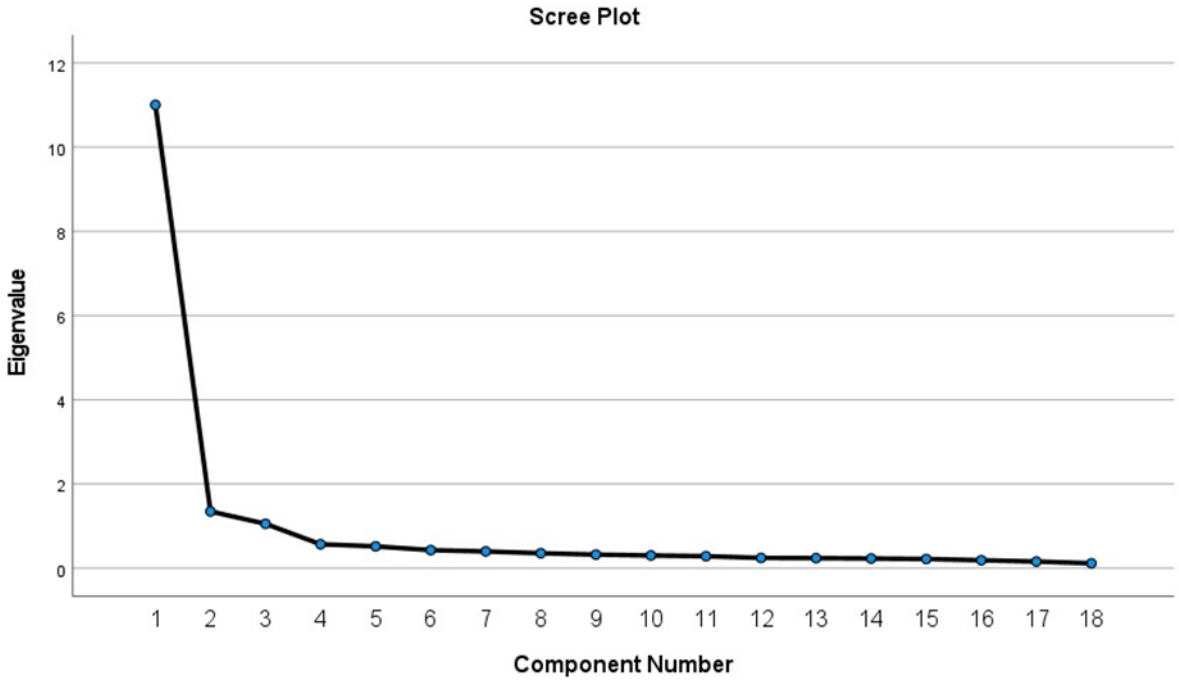
Exploratory Factor Analysis of the E-Learning Assessment Scale (n=434)

	Items*	**Items**	**Factor 1**	**Factor 2**
Qualities of the infrastructure used in e-learning	I4	The infrastructure used for e-learning was insufficient.	**.30**	
	I9	E-learning offered a wide range of learning activities.	**.78**	
	I10	In e-learning. I have reached the target information.	**.76**	
	I11	The technological methods applied in e-learning were sufficient.	**.82**	
	I12	The assessment scales used in e-learning were suitable.	**.83**	
	I13	The teaching methods applied in e-learning were effective.	**.86**	
	I14	E-learning was encouraging for students to participate in classes.	**.69**	
	I15	The methods applied in e-learning enhanced my creativity.	**.73**	
	I19	The teaching materials used in e-learning were encouraging for students.	**.76**	
	I22	The measurement tools used in e-learning were eligible.	**.80**	
Impact of E-learning on Students	I1	To me. e-learning provides equal opportunities in education.		**.72**
	I2	E-learning was beneficial.		**.64**
	I25	Compared with face-to-face education. E-learning facilitated better learning.		**.78**
	I27	The use of technology in e-learning increased students' interest in classes.		**.68**
	I29	E-learning negatively affected students' sense of belonging to schools.		**.72**
	I30	E-learning encouraged students' readiness for classes.		**.65**
	I31	E-learning helped students to feel valuable.		**.72**
	I32	E-learning increased students' confidence.		**.70**
		Eigenvalue	**7.26**	**5.09**
		% of varience	**40.3**	**28.3**
		Explained total variance	**68.6**	

* The items that load more than one factor are not included in the table.

Figure 1

Scree Plot Diagram



3.1.2. Confirmatory Factor Analysis (CFA)

To confirm the 18-item and 2-factor structure that occurred as a result of EFA, CFA was performed on the Lisrel 8.80 structural equation program. At the end of CFA, it was found that the scale-specific Ki-square value was significant, and the data was sufficient for the model (X2=617.31, df=134, X2/df=4.60, $p < 0.001$). The model fit indices were as follows: $\chi 2/df = 4.60$, NFI=0.97, NNFI=0.98, CFI=0.99, AGFI=0.87, GFI=0.90, and RMSEA=007. All of the items significantly loaded onto the factors (Preacher and Yaremych, 2023). (Figure 1).

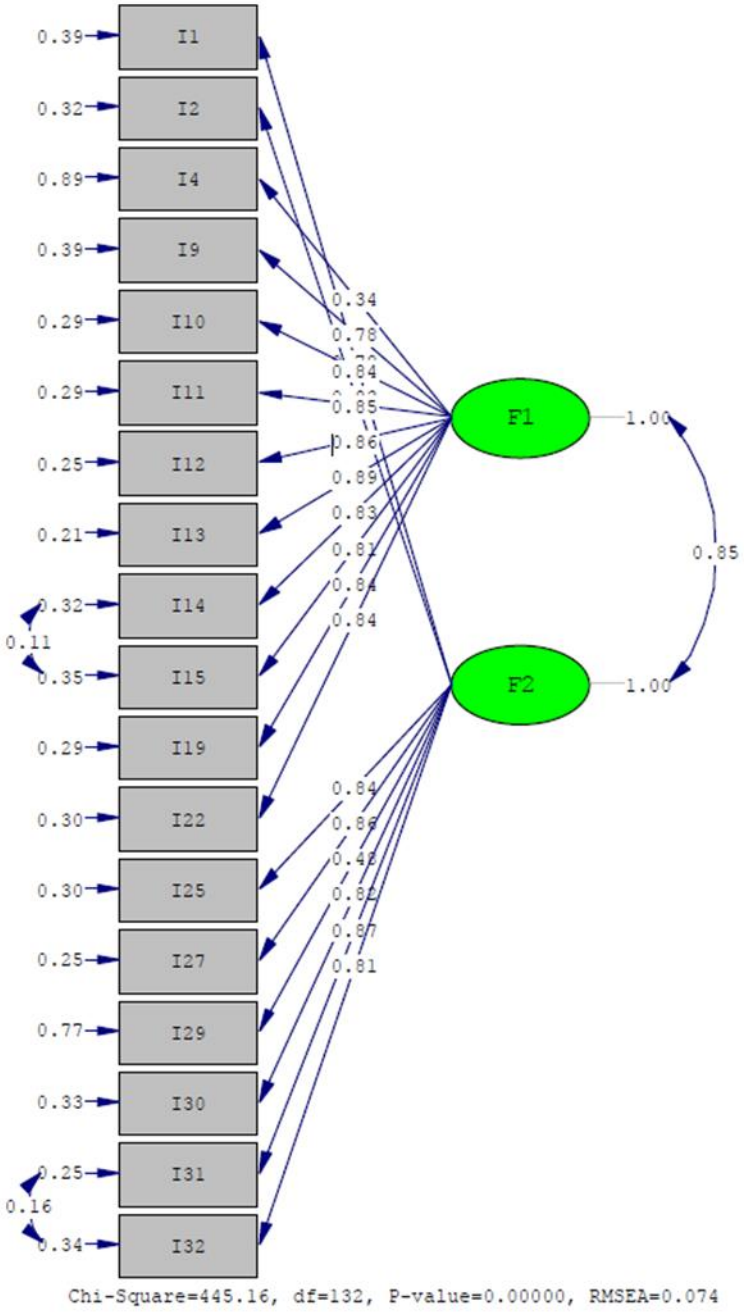


Figure 2. *Two-factor E-Learning Assessment Scale CFA model "Factor 1: '' Qualities of the infrastructure used in e-learning'' and Factor 2: ''Impact of E-learning on Students.''*

3.2 Reliability

3.2.1. Internal consistency reliability/Cronbach alpha coefficient

A Cronbach alpha coefficient of 0.80-1.00 indicates that 'the scale is largely dependable'; a measure of 0.60-0.79 indicates that 'the scale is relatively dependable'; a bar of 0.40-0.59 indicates that ‘ the scale is less dependable ' and a measure of 0.00-0.39 showed that ' the scale is unreliable'(Alpar, 2010). In our study, the scale and its sub-dimensions had high-reliability coefficients. The Cronbach alpha coefficient of the scale was 0.96. The Cronbach alpha coefficient of factor 1 was 0.94, and factor 2 was 0.93 (Table 2).

3.2.2. Consistency of scale over time/Pearson correlation coefficients

The scale was performed on 32 participants in 15-day intervals to determine the internal consistency,.Test–retest analysis was performed using Pearson's correlation coefficient (n = 32) to determine the consistency of the scale over time. If the correlation coefficient is closer to 1, the correlation is stronger. For assessment of correlation, classification is recommended: 0.50 < | r |< 0.99 strong correlation, 0.30 < | r | < 0.50 moderate correlation, and 0.10 < | r | < 0.30 weak correlation (Cohen 1988). In this study, the correlation coefficient for the total scale was r = 0.82 (p < 0.001), and that of the sub-dimensions was 0.77-0.83 (Table 2).

Table 2

Internal Consistency Reliability and Test-Retest Reliability

	Items	**Cronbach alpha**	**Correlation coefficient**
Qualities of the infrastructure used in e-learning	10	0.94	0.77
Impact of E-learning on Students	8	0.93	0.83
Total scale	18	0.96	0.81

4. Discussion and Conclusion

Over the last few years, apart from face-to-face education, different education methods have become a current issue (Sáiz-Manzanares et al., 2020). E-learning is a learning method conducted in specific fields and supports autonomous learning by offering different paths; its content is based on individual learners and is backed up with various methods and tools. E-learning can be assessed with multiple scales. Current scales more frequently assess attitudes towards e-learning, readiness, and obstacles in e-learning (Dray et al., 2011; Demir & Horzum, 2013; Ozturk et al., 2022; Smith et al., 2003). This study developed an assessment scale for e-learning, the validity and the reliability results of which are discussed in the following.

A recently developed assessment scale is supposed to have two characteristics: validity and reliability. In order to determine whether the sample size is sufficient and the data is suitable for factor analysis, the KMO coefficient was calculated, and the Barttlet Sphericity Test was performed. The KMO value is recommended to be >0.6 for factor analysis (Buyukozturk, 2020). In this study, it was found that the KMO coefficient of 0.96 and the Barttlet Sphericity Test value (x2= 6942.54, df=153, p<0.001) are statistically significant. Besides, the KMO value demonstrates that the sample size is sufficient.

The EFA technique was used to statistically determine the construct validity of the scale. The factor load value coefficient, which helps to comprehend the correlation between items and factors is taken into consideration while omitting the item from the scale (Buyukozturk, 2020). In revealing the independent dimensions of the scale, the Varimax technique of vertical rotation was performed, and factor load values were examined. Factor load values have to be between 0.30-1.0 (Costello & Osborne, 2005; Lee & Wang, 2014). Factor item loads were examined, and those that did not have suitable values (16 items) were omitted. After the second EFA, the rest 18 items formed two factors. The factor load values of the remaining 18 items range between 0.300-0.869. It is stated that the more the total variance rate increases, the stronger the scale is, and the ideal variance values are between 40% and 60% (Ozdamar, 2016). The factors in the scope of the scale explain 68.6% of the total variance. The two sub-scales were named "E-learning Infrastructure" and "Impact of E-Learning on Students". The first factor, which consists of 10 items, explains 40.3% of the total variance, and the factor eigenvalue was found to be 7.36. The eigenvalue of the second factor, on the other hand, is 5.63, explaining 28.3% of the total variance.

The total variance indicates that the scale is comprehensive enough for students to assess the e-learning experiences.

The scale and sub-scales have high coefficients of reliability. The general Cronbach alpha coefficient of the scale is 0.96. The Cronbach alpha coefficient of factor 1 is 0.94, while that of Factor 2 is 0.93. The fact that Cronbach α coefficient is between 0-0.40 demonstrates that the scale is unreliable; the one between 0.40-0.60 shows low reliability; the one between 0.60-0.80 shows complete reliability, and the one between 0.80-1.00 indicates high reliability (Tavşancil, 2018). The values in our study signify a high level of reliability.

For test-retest analysis, the test should be performed on at least 30 individuals after 2-6 weeks (Tavşancil, 2018). Moreover, the literature suggests that in scale development, validity and reliability studies, the analyses of invariance according to time illustrate that there is no constant time interval between two practices, but they generally vary in 2-4 weeks (Acaroğlu, 2014). In the test-retest assessment, the total correlation coefficient of the scale is $r=0.82(p<0.001)$, and the correlation coefficient of sub-dimensions is 0.77-0.83. Accordingly, it was found that the test-retest reliability coefficients of both the whole scale and the sub-dimensions are relatively high, and the scale and the sub-dimensions are reliable and invariant according to time.

In developing a new scale after EFA, CFA is another step that checks whether the constructed structure works in a new sample (Yemez, 2016). As a result of the confirmatory factor analysis in our study, the model suitability indexes appeared as follows: $\chi 2/df = 4.60$, CFI = 0.98, NFI = 0.98, NNFI = 0.98, AGFI = 0.87, GFI= 0.90, and RMSEA= 0.074. The fit values calculated in CFA must be within acceptable limits for the construct validity of a scale (Esin, 2014). Our study revealed that the values of CFI, NFI, and NNFI are suitable.

The analyses carried out to illustrate the significant distribution of the developed items of the scale demonstrated the scale consisted of 18 items with 2 sub-dimensions of 'Qualities of the infrastructure used in e-learning' and 'Impact of E-Learning on Students'. The adequacy of infrastructure in e-learning is essential for both students and the institution that offers education (Celen et al., 2011). What is more, the process of e-learning has various impacts on students. While some can fruitfully acquire knowledge, others may opt for face-to-face education. Thus, in e-learning, the virtual classes and discussion platforms must be organised in a way to promote learning (Horzum et al., 2015; Simuth & Sarmany-Schuller, 2010). It is also essential to facilitate students' use of the scale.

Consequently, the e-learning assessment scale was determined to be a valid and reliable measurement tool in Türkiye. The scale enables students to assess the e-learning process. Therefore, it was found that the scale may become of significant use for further studies in the future. It is thought that the studies that benefit from this scale in different groups may contribute to the subject matter. It is recommended that the scale be used in other groups.

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Declaration of interest statement

The authors declare no conflict of interest.

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5. Appendix

Table 3

E-Learning Assessment Scale

	1-I do not agree at all	2-I do not agree	3-I am undecided	4-I agree	5-I completely agree
1. The infrastructure used for e-learning was insufficient.					
2. E-learning offered a wide range of learning activities.					
3. In e-learning, I have reached the target information.					
4. The technological methods applied in e-learning were sufficient.					
5. The assessment scales used in e-learning were suitable.					
6. The teaching methods applied in e-learning were effective.					
7. E-learning was encouraging for students to participate in classes.					
8. The methods applied in e-learning enhanced my creativity.					
9. The teaching materials used in e-learning were encouraging for students.					
10. The measurement tools used in e-learning were eligible.					
11. To me, e-learning provides equal opportunities in education.					
12. E-learning was beneficial.					
13. Compared with face-to-face education, e-learning facilitated better learning.					
14. The use of technology in e-learning increased students' interest in classes.					
15. E-learning negatively affected students' sense of belonging to schools.					
16. E-learning encouraged students' readiness for classes.					
17. E-learning helped students to feel valuable.					
18. E-learning increased students' confidence.					