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A Valid and Reliable Scale for Education 4.0 Competency Determination (E4CD)

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Abstract. The purpose of this study is to develop a valid and reliable "Education 4.0 Competency Determination" scale. The study was conducted in two sessions: In the first session, exploratory factor analysis was applied to 308 students, and then a confirmatory factor analysis was applied to another group and conducted with 172 students. As a result, a scale consisting of 21 items and three- factors was obtained. The internal consistency coefficient of the first factor, which is mastery of digital technology, was α = .925 using the Cronbach's Alpha formula and .921 using the Guttman's Split-half method; the internal consistency coefficient of the second factor, which is information management, was α = .880 and .884 according to Guttman's Split-half method while the internal consistency coefficient of the third factor, which is active participation in the process, was α = .802 according to the Cronbach's Alpha formula and .783 according to the Guttman's Split-half method.

Keywords: Education 4.0, competence determination scale, scale development.

1. Introduction

In today's world, digitalization has gained importance as an essential part of our lives, as well as getting closely integrated into the field of education. These circumstances, as a result, have led to a digital transformation process. In this transformation process, in which the transition from the industrial age to the digital age is taking place, the digital transformation, especially in the education sector, urgently needs to be initiated and placed on a continuously expandable basis. In this context, it is known that educational institutions are rapidly transforming their traditional methods of education into digital forms (Durakbasa *et al.,*2018). Assuming that teaching environments of the future will be based entirely on digital environments and devices, the effective use of digital learning environments is just as important as the knowledge and skills of teachers about digital technologies, as digitalization is an unavoidable process. The study by Qureshi *et al.*

(2021) found that teachers are reluctant to integrate digital technologies into the learning process, while students are willing to learn new technologies. The same study emphasizes that individuals and organizations are also reluctant to integrate new educational technologies and digitalization into their learning processes. In this context, to achieve the goals expected of education systems, it is necessary to increase the quality of education of teacher candidates who train future teachers, familiarize teacher candidates with technology, develop innovative products with them or provide environments that allow them to develop their technology using skills. Especially concerning learning processes, in which Industry 4.0 is integrated into Education 4.0, it is necessary to determine the competencies of teacher candidates for Education 4.0 to uncover possible shortcomings in their education and analyze their current situation. In this context, it is important to develop a measurement tool that can help to show the competencies of teacher candidates for Education 4.0.

1.1. *Education 4.0 and Industry 4.0*

To understand Education 4.0, it is necessary to internalize the concept of Industry 4.0 and the digital transformation process in societies. To better understand the fourth industrial revolution, it is necessary to look at the industrial revolutions preceding this process. The first industrialization movement (Industry 1.0) began with the limited production structure of the industry along with the use of oil and steam engines as a source of energy. The second industrial movement (Industry 2.0) continued with the invention of electricity, in the form of mass production. The third industrial movement (Industry 3.0) is based on the integration of electronic components and information technology into the industry to automate production tasks. The effect of this change has survived until today, thanks to the permanent integration of advanced technologies (Artificial Intelligence, Cloud Computing, IoT, Big Data, robotics, etc.) that support the development of the fourth industrial movement (Industry 4.0) with automation and digitalization of production processes driving the development of smart industrial systems (Davies *et al.*, 2017). Moreover, Industry 4.0 has moved beyond mass production or service delivery leading the society towards customized products and services based on individual customer needs (Vaidya *et al.*, 2018). All industrialization movements have brought some changes in education, as in all areas of society, and educational institutions have been renewed based on these changes. The changes in the education system have gradually evolved into Education 1.0 focusing on narration and memorizing, Education 2.0 focusing on computers and the Internet, Education 3.0 focusing on information production, and Education 4.0 focusing on innovation and production (Diwan, 2017). All of these processes of change and transformation in the educational world have attracted attention and have been studied in depth by researchers (Fisk, 2017; Koantakool, 2016; Jeschke, 2014; Puncreobutr, 2016; Sinlarat, 2016; Wallner *et al.*, 2016). The Education 1.0 period, the beginning of change and transformation, was characterized by knowledge transfer from the teacher to the learner with an emphasis placed on narration and memorizing. In the Education 2.0 period, teaching how to learn became the goal, according to the needs of the industrial society, and a computer and Internet-oriented teaching process was initiated (Gueye & Exposito, 2020). By addressing the needs of the technology society, Education 3.0 aimed to empower students not only to consume knowledge but also to produce it (Öztemel, 2018). During this time, the focus shifted to interactive learning using digital media and social media as teaching tools. Education was structured under new open and online education models (Massive Online Open Courses or MOOC, Corporate Online Open Course or COOC and Small Private Online Courses or SPOC) with no time, place, or location restrictions. Thus, our way of learning and teaching became generally accessible to everyone. Education 4.0, which is more than an education, is expected to help the student develop the ability to apply new technologies, which help to adapt to the changes in society (Gueye & Exposito, 2020). Furthermore, it is emphasized that Education 4.0 enables learners not only to be able to read but also to grow with knowledge and skills throughout their lives (Sinlarat, 2016). In this direction, Education 4.0 was geared towards general innovations and changes in education and pedagogy and the integration of technologies brought to education by Industry 4.0 (Gueye & Exposito, 2020).

1.2. *Education 4.0 in Learning Environments*

Education 4.0, which enables learners to structure their learning with flexible, dynamic, and adaptive learning pathways by harnessing the potential of digital technologies, is shaping the future of education. The concept of Education 4.0, which emerged as a natural consequence of Industry 4.0, is an important process to align education with Industry 4.0 and integrate technological developments into the learning and teaching process (Halili, 2019). In this context, digital transformation incorporates technology into the learning process as a learning tool that supports the development of new innovative learning methods, intelligent and adaptive learning environments (Gueye & Exposito, 2020). To succeed in digital transformation, education and higher education institutions today need to use 3D printing, augmented reality, virtual reality, cloud computing, hologram, biometrics, multi-touch LCD, Internet of Things, artificial intelligence, Big Data, QR codes in education (Halili, 2019); closely follow technological developments such as learning management systems, mobile learning, virtual learning assistants, intelligent and adaptive learning environments, sensors that can integrate interaction and fun into the learning process (Gueye &Exposito, 2020) and to effectively and efficiently integrate these technologies into learning environments. In addition, Fisk (2017) noted that nine trends should be included in the learning process. These are learning in different times and places, personalization of learning, adaptive and dynamic learning processes, Project-based learning, field experience, data interpretation, formative assessment, student ownership, and the mentoring system, as mentioned in the literature.

Intelitek's (2018) report on Education 4.0 learning systems states that education must be based on the core principles of Education 4.0, such as personalization of learning paths, mentoring and diversity of different learner profiles, and formative assessment. In addition to emphasizing student-centered learning methods and technologies with Education 4.0, it also included the need for flexible learning environments (Saxena *et al.*, 2017). Similarly, it is evident that the role of MOOC in higher education is becoming increasingly important (Altbach *et al.*, 2009; Fondation Telecom, 2014; Taşkıran, 2017; Vassiliou & McAleese, 2014). In this context, to keep pace with Education 4.0, institutions need to shift from process-oriented, technology-enhanced non-formal education systems to a new method of teaching that values individualized learning (Saxena *et al.*, 2017). Looking at Education 4.0 studies intended for educators (Goldie, 2016; Hussin, 2018; Mourtzis *et al.*, 2018), we see that they welcome the concept of Education 4.0 and support its transfer to educational life. In addition, Hussin (2018) emphasized the need to integrate current technologies into education, citing the need for instructors to be more creative in designing their courses, and the importance of student participation and rewarding creativity in the process, as well as the importance of activity-based learning. In studies on Education 4.0 conducted from the learner's perspective (Ciolacu *et al.*, 2017; Eichinger *et al.*, 2017; Hussin, 2018; Mourtzis *et al.*, 2018), students provided positive feedback on Education 4.0 and learned faster and earlier in the process. They indicated that the process increased their employment opportunities.

Unlike Education 1.0, 2.0, and 3.0; Education 4.0 is structured in line with the general innovation and amendments in education as well as the integration of new generation technologies into education. During such an integration process, students are expected to possess such skills as realizing and making the most of the potential of digital technologies as well as constructing their learning experience in light of this potential (Saxena *et al.*, 2017). In this context, with the rapid changes brought by the digital age, it is important to identify the competencies of teacher candidates at universities that train future teachers and what they should focus on, and how they should be trained to support the digital education process. In this way, deficits can be eliminated, changes on a national and international level can be introduced, and teachers can be empowered to lead the digital age. Furthermore, today, when MOOCs are commonly used to support lifelong learning, the use of Education 4.0 scales to determine users' competencies before using these environments can allow MOOC systems to be designed according to individual competencies. Furthermore, an examination of the scales in the literature developed for Education 4.0 shows that a limited number of scales have been created for the relevant field. (Karaman *et al.*,2020). It was noted that this scale was created to determine the perceptions and attitudes of teacher candidates. Today, however, it is clear that persons trained by teachers are the representatives of the digital generation and that teachers must have certain qualifications to properly educate this generation. In this context, the aim was to develop a valid and reliable "Education 4.0 Competency Determination (E4CD)" scale to indicate the competencies of teacher candidates for Education 4.0. This allows us to determine whether future teacher candidates can achieve the goals established in the teacher education program using the appropriate scale. In addition, it is anticipated that the relevant scale will assist both educators and program developers in organizing training to achieve the program's intended learning outcomes.

2. Methodology

This study, aiming to develop a scale to determine teacher candidates' competencies for Education 4.0, used a mixed method that combined qualitative and quantitative research techniques. The exploratory sequential design was used for purposes of this study, which is one of the mixed research methods. The exploratory sequential design model was preferred because it met the assumptions about the subject of the study, such as the lack of an existing measurement instrument and the uncertainty of the forms of the concept (Creswell & Clark, 2015). The exploratory sequential pattern research is about quantitatively testing the findings, established based on a qualitative design (Creswell, 2007). Accordingly, qualitative data were collected by interviewing both computer science teachers working in public or private schools and graduates of computer science departments of the Faculty of Education working as computer science specialists or R&D staff in the private sector concerning digital technologies that have gained importance with the introduction of Education 4.0, the process of using these technologies and the management of related technologies. The aim was to obtain quantitative results with the item pool obtained as a result of the experts' feedback using the Davis technique according to the opinions of public and private sector employees.

3. Research Group

The study involved 508 teacher candidates studying at higher educational institutions in the Black Sea region. The data collected in two different sessions, after the incorrect or incomplete ones were eliminated after the first examination, were retrieved from a total of 499 undergraduate students and used in the analysis process. The data were analyzed concerning the normality assumption and 19 records with extreme values for some items were deleted; the remaining 480 records were used in the study. 27% (130) of the students participating in the research were male, while 73% (350) were female. For healthier results, confirmatory factor analysis (CFA) after EFA was performed in the same study year at the same university but in a second session (N = 172) (Table 1). While some studies in the literature defend having a sample size 5 times the number of items for a 5-point Likert scale (Child, 2006; Tabachnick & Fidell, 2007), others sup-

Table 1
Distribution of Students Constituting the Research Group

	Analysis	N	Female		Male	
			N	%	N	%
I.Session	EFA	308	224	64	84	65
II.Session	CFA	172	126	36	46	35
Total		480	350	100	130	100

port having a sample size between 7–10 times, or at least 5 times greater than the number of items (Floyd & Widaman, 1995). From this point of view, it is possible to say that the number of participants in the EFA research group (N = 308) and CFA research group (N = 172) seems to be adequate.

4. Development of the Data Collection Tool

Looking at the sources that provide information about the scale development process, they have characterized this process in three steps:

- Pre-application.
- Application.
- Post-application.

This process is demonstrated in Fig. 1.

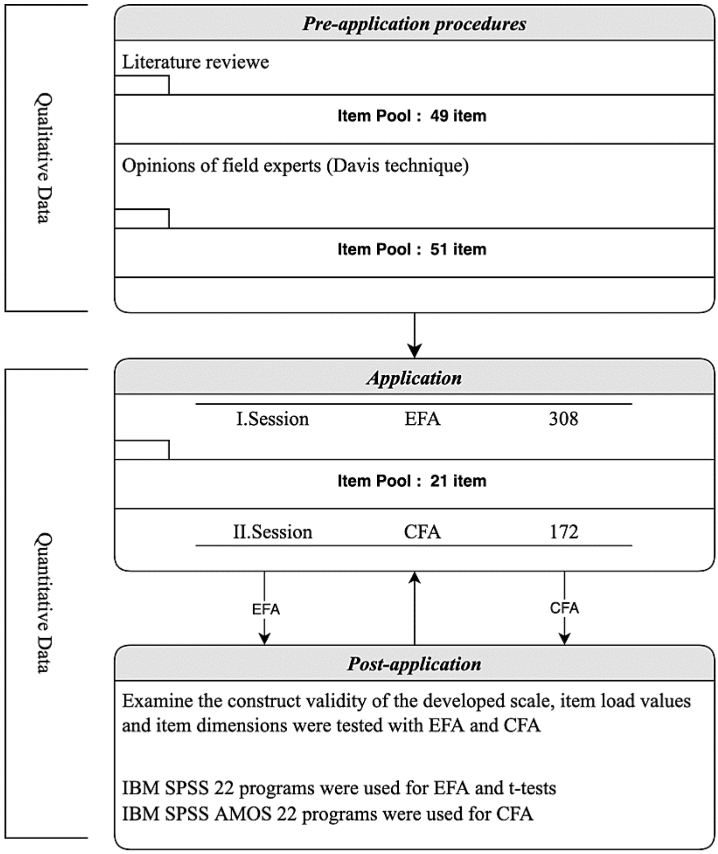

Fig. 1. The scale development process.

4.1. *Pre-application*

To determine the items to be included in the Education 4.0 Competency Determination Scale (E4CD), the literature was reviewed, initially (Ciolacu *et al.*, 2017; Demir *et al.*, 2019; Grinshkun & Osipovskaya, 2020; Gueye & Exposito, 2020; Eichinger *et al.*, 2017; Hussin, 2018; İlhan *et al.*, 2019; Karaman *et al.*, 2020; Mourtzis *et al.*, 2018; Öztemel, 2018; Puncreobutr, 2016; Qureshi *et al.*, 2021; Wallner *et al.*, 2016). In light of subjects on the Education 4.0 process covered by the literature, qualitative data were collected by interviewing both computer science teachers working in public or private schools and graduates of computer science departments in the Faculty of Education who worked as computer scientists or R&D staff in the private sector. According to the qualitative data, together with the literature, an attempt was made to put together items related to the competencies of teacher candidates concerning Education 4.0. As a result of the assessments, an item pool of expressions was created to measure the Education 4.0 qualifications/competencies of undergraduate students in the Department of Education. This pool, created with 49 items, was redesigned to include 51 items according to the opinions of field experts.

An expert opinion was sought before application to ensure content and face validity. Expert opinions were used to ensure content validity (Kline, 2011). For this purpose, the items of the draft scale were sent to five experts in the field of computer and instructional technologies who analyzed them using the Davis technique and were rated on a scale of four options (A = not appropriate, B = item should be seriously reviewed, C = item should be slightly revised, D = appropriate). According to the Davis technique, the sum of all A and B scores in all expert evaluation forms for the candidate item in the scale is divided by the total number of experts (NE) to obtain the content validity indices (CVI) (CVI = A + B/NE). If the CVI index is greater than .80, the item is good enough for content validity. Items with low CVI are removed from the scale (Davis, 1992). According to expert opinions, the draft items were rearranged, and the content validity of the scale was found good enough according to the calculated content validity index (CVI = .97 > .80) (Davis, 1992). The 51 items scale was examined by a linguist in terms of readability and intelligibility. When writing the items, care was taken to keep them short, clear, and understandable; however, the applicability and understandability of the scale were tested with five undergraduate students in parallel with the target audience. As a result of the applications, it was decided that the scale would consist of 51 items and a 5-point Likert-type scoring method would be used to evaluate these items.

These were:

1 I cannot at all
2 I may not
3 I can/cannot do partially
4 I can
5 I definitely can

4.2. *Application*

The finalized scale was created with three interfaces in the digital environment; in the first interface, participants were asked to read and approve the voluntary consent form, in addition to general information about the work and permissions. Demographic information was recorded in the second interface, and the scale's responses to items were recorded in the last interface. After obtaining regulatory approvals, academic advisors were contacted and students were asked to digitally submit the scale link. All of these studies were volunteer-based. The data from the first data collection at the beginning of the second semester of the academic year were used for the EFA, the second data collection was performed two months later according to the analyses, and the data obtained were used for CFA.

4.3. *Post-application*

Construct validity analyses were first conducted on the data obtained during the implementation stage. Construct validity refers to the extent to which the measurement instrument is related to the characteristics it seeks to measure (Hinkin, 1995). Therefore, construct validity is a process that requires testing the relationships between data for the items (or subscales) of the measurement instrument developed (Gable, 1986). Factor analysis techniques are commonly used to test the construct validity of scales developed in social sciences (Büyüköztürk, 2011; Gable, 1986).

The two main methods used in factor analysis are EFA and CFA.

EFA aims to discover the main structures and factors in the measurement instrument (Kline, 1994).

CFA is intended to test the hypothesis or theory regarding the structure formed from the relationship between variables with more complex and higher-level analyses (Albright & Park, 2009; Büyüköztürk, 2011; Kline, 1994; Mueller & Hancock, 2001; Pallant, 2020; Schreiber *et al.*, 2006; Tabachnick & Fidell, 2007).

To examine the construct validity of the developed scale, item load values and item factors were tested with EFA and CFA, and item discrimination levels were tested at the .05 level with the unrelated t-test.

5. Data Analysis

The data obtained during the research were transferred to the computer environment and IBM SPSS Statistics 22 program was used for EFA and t-tests, and IBM SPSS AMOS 22 program was used for CFA. Before processing EFA and CFA, it was determined if there were missing, incorrect, and extreme data in the datasets. During the initial examinations, erroneous and missing data were found in both data sets; accordingly, 9 data sets were excluded from the analysis. To determine the extreme values, the BoxPlot graph of each item in the data sets was examined and 19 data sets were excluded from the analysis according to the values outside the rows of the graph.

Before EFA, the correlation matrix between items was examined to test for overlap among scale items, and accordingly, it was found that the correlation coefficients between items were above .30 in all cases, and these values did not exceed .90. Therefore, it can be said that there is no problem of multicollinearity between items (Field, 2009; Tabachnick & Fidell, 2007).

Normality analyses of items were examined with skewness and kurtosis values, and 8 items (M1, M2, M3, M7, M12, M26, M30, M50) that showed extreme deviations from the normal distribution (> ±1) were removed from the scale before analysis (George & Mallery, 2010). For the remaining 43 items, the results of the Kaiser-Meyer-Olkin (KMO) and Barlett sphericity tests were examined to test the sampling adequacy of the dataset, and it was determined that the dataset was suitable for factor analysis (KMO = .945; X^2 = 8533.251; sd = 903: p = .000).

6. Findings

This section provides details of the validity and reliability studies of the scale and discusses the results of the analyses.

6.1. *Exploratory Factor Analysis*

In this factor analysis, how 43 items were factored in was examined. The principal component analysis is used frequently in this review. The main purpose here is to determine the minimum number of factors that can best represent the relationships in the set of variables (Pallant, 2007). Factor analysis used the direct oblimin oblique rotation technique. Due to the nature of the factor analysis process, the possibility of a relationship between factors (r ≥ .32) is high, so it was preferred to start with the oblique rotation method in factor analysis (Tabachnick & Fidell, 2007). Kaiser criterion (>= 1 eigenvalue), slope chart, component matrix, common factor variance, explained variance ratio, and representation indicators of the theoretical structure being measured are widely used in the literature to determine the number of factors (Brayman & Cramer, 2011). In line with the analyzes made in this context, it was seen that there were four-factors with an eigenvalue above 1 for 43 items that were taken as a basis (1^{st} factor 10.653; 2^{nd} factor 2.044; 3^{rd} factor 1.477; and 4^{th} factor 1.186). The contribution of these factors to the total variance is 61.44% (1^{st} factor 42.62; 2^{nd} factor 8.17; 3^{rd} factor 5.91; and 4^{th} factor 4.74). Evaluating these four factors in the context of the importance of their contribution to the total variance explained, the contribution of any one factor is less than 5% (Tabachnick & Fidell, 2007), and looking at the slope chart, the horizontal slope, forming after the third factor, speaks to this decision about the three-factor structure of the scale. In the analysis, when the acceptance levels of the items, overlaps, and factor loading values were examined, it was found that 8 items (M34, M31, M35, M16, M36, M9, M51, M28) yielded a loading value below .32 (Field, 2009) and 14 items (M29, M49, M14, M37, M38, M48, M27, M41, M39, M40, M42, M13, M10, M11) were items with high loading scores (overlapping) in more than one factor. The item factor loading values and common factor variances obtained as a result of excluding the said items from the analysis are presented in Table 2.

Examination of the table revealed a three-factor structure consisting of 21 items, 10 in the first factor, 5 in the second factor, and 6 in the third factor. Item load values were found to vary from .543 to .839 for the first factor, from .781 to .807 for the second factor, and from .523 to .815 for the third factor. All 21 items in the scale explain 60.20% of the variance (1st factor 43.98%, 2nd factor 9.30%, 3rd factor 6.92%). For multifactorial scales in social sciences, this rate is expected to be between 40% and 60%. In this context, it can be stated that the contribution of the three-factor structure to the total variance is sufficient. Reliability calculations were also done for this structure before CFA. Accordingly, the internal consistency coefficient of the first 10 item factor was α = .925 using the Cronbach's Alpha formula and .921 using the Guttman's Split-half

Table 2

Factor structure of the Education Competency Assessment Scale

Template Item	Common Variance	Components			Item-Total Correlation
		Factor 1	Factor 2	Factor 3	
M24	.659	**.839**	.025	-.090	.735**
M23	.701	**.830**	.032	-.019	.775**
M20	.628	**.814**	-.054	.008	.723**
M33	.658	**.781**	.084	-.030	.762**
M18	.672	**.762**	.001	.108	.779**
M19	.681	**.744**	.097	.053	.792**
M22	.564	**.743**	-.069	.078	.695**
M32	.493	**.725**	-.029	-.019	.647**
M21	.567	**.586**	.180	.102	.741**
M25	.510	**.543**	.237	.039	.697**
M45	.687	.033	**.807**	.034	.652**
M47	.682	.055	**.802**	-.018	.628**
M43	.620	-.015	**.784**	.095	.635**
M44	.707	-.033	**.783**	.043	.582**
M46	.676	.129	**.781**	-.050	.655**
M8	.596	-.113	.012	**.815**	.484**
M6	.570	.051	-.018	**.737**	.557**
M15	.490	-.122	.154	**.673**	.480**
M4	.475	.105	.011	**.626**	.546**
M5	.510	.304	-.136	**.586**	.595**
M17	.498	.162	.114	**.523**	.623**
Variance Source		Factor 1	Factor 2	Factor 3	Total
Explained Variance		43.98%	9.30%	6.92%	60.20%
Cronbach Alpha		.925	.880	.802	
Guttman's Split-half method		.921	.844	.783	

** Correlation is significant at the 0.01 level

Table 3
E4QD Factors Correlation Matrix

	Total	Factor 1	Factor 2	Factor 3
Total	1			
Factor 1	.931**	1		
Factor 2	.766**	.557**	1	
Factor 3	.774**	.577**	.555**	1

** Correlation is significant at the 0.01 level

method. The internal consistency coefficient of the second 5 item factor was α = .880 using the Cronbach alpha formula and .844 using Guttman's Split-half method. The internal consistency coefficient of the third 6 item factor was α = .802 using the Cronbach's Alpha formula and .783 using Guttman's Split-half method. In addition, the adjusted item-total correlation coefficients calculated for the scale yielded high values between .774 and .618 for the 1st factor, Between .750 and .668 for the 2nd factor, and between .598 and .515 for the 3rd factor. Based on these data, it can be argued that reliable measurements with sufficient sensitivity can be obtained using the 21 items in this three-factor model. The items distributed among the factors were examined by two field experts as well as the researchers, and the items under factor 1 were named "mastery of digital technology", items under factor 2 were "information management", and items under factor 3 were "active participation in the process".

The relationship between the correlation values of the components with each other and the total scale score is shown in Table 3. Looking at the table, all components of the Education 4.0 Competency Determination Scale show a high and significant positive correlation with the overall scale score. When looking at the relevance level, the variable with the highest correlation to the E4QD scale score is the Factor 1 component at .931. The fact that all components have a highly positive correlation supports the construct validity of the Education 4.0 Competency Determination Scale.

6.2. *Confirmatory Factor Analysis*

To verify the three-factors structure obtained by EFA, CFA was performed on a different data set of 172 individuals. As a result of the first analysis, acceptable fit values were obtained for some indices. To achieve better fit values, the modifications proposed by the AMOS program were examined. As a result of the examinations, suggestions were taken into account that if the error covariances were correlated between the M23 and M24 items and the M46 and M47 items in the scale, these fit values would increase significantly. After correlating the error covariances between the named items, it was observed that the standardized load values for the items in the model varied between .72 and .91, as a result of repeated confirmatory factor analyses. The path diagram showing the standardized load values of the model is shown in Fig. 2.

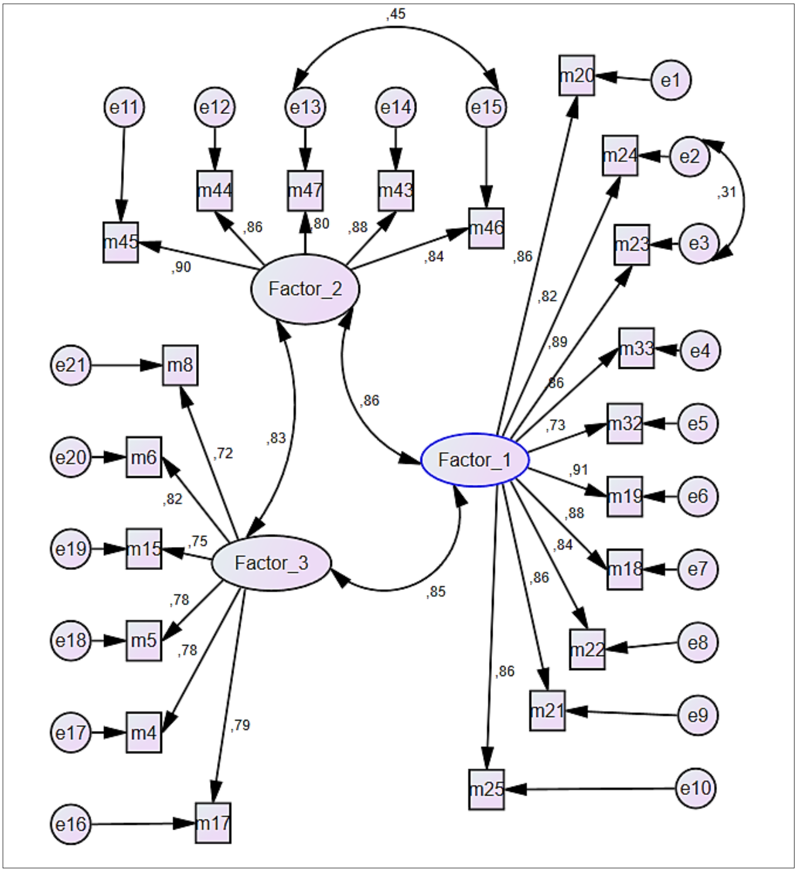

Fig. 2. Standardized Load Values of CFA.

When the fit values regarding the significance of the model are examined [$\chi^{2/sd}$ = 1.619; RMR = .042; GFI = .964; CFI = .967; NFI = .918; RMSEA = .060]. When Table 4 is examined, it can be said that the triple factor structure of the scale consisting of 21 items is confirmed.

Table 4.
CFA Analysis Fit Measurements Value Table

Fit Measurements	Good Fit Value	Acceptable Fit Values	Competency Assessment Scale	Fit Measurements
$\chi^{2/sd}$	$0 \leq \chi2/sd \leq 2$	$2 \leq \chi2/sd \leq 3$	1.619	Good Fit
RMSEA	0.00 < RMSEA < 0.05	0.05 < RMSA < 0.10	0.060	Acceptable
RMR	0.00 ≤ RMR < 0.05	0.05 < RMR ≤ 0.10	0.042	Good Fit
GFI	0.95 < GFI < 1.00	0.90 < GFI < 0.95	0.964	Good Fit
NFI	0.95 < NFI < 1.00	0.90 < NFI < 0.95	0.918	Acceptable
CFI	0.95 < CFI < 1.00	0.90 < CFI < 0.95	0.967	Good Fit

Based on the values obtained from the CFA, the average variance extracted (AVE) values and the composite reliability (CR) coefficients for reliability were examined to test the convergent validity of the structure. AVE value was .72 for the first factor, .73 for the second factor, and .71 for the third factor; and these values were greater than .50; CR coefficients were .96 for the first factor, .93 for the second factor, and .90 for the third factor. It can be argued that three-factors provide convergent validity and reliability as these values are greater than .70 (Fornell & Larker, 1981).

6.3. *Findings Regarding the Reliability of the Scale*

In addition to the reliability analyses performed after CFA, the reliability Cronbach Alpha internal consistency coefficient of the three-factor final model, Guttman's Split-half reliability coefficients, the corrected item-total correlations (Corrected Item-Total Correlation), and the t-values for the comparison of the 27% lower and upper group averages were calculated and tested. In this context, the second study group set was used for reliability analyses in terms of internal consistency. These calculations are presented in Table 5.

Table 5

Item-Total Correlation and Comparison of 27% Lower and Upper Groups for Scale Items.

Factors/ Items	DMTK (n = 172)	Upper Group (n = 46)		Lower Group (n = 46)		df	t	p	Cohen d
		M	Sd	M	Sd				
1. Factor (Cronbach's Alpha = .978 , Guttman's Split-half coefficient =.974)									
M18	.911	4.65	.640	1.78	.593	90	22.305	.000	4.65
M19	.927	4.89	.315	2.26	.648	90	24.779	.000	5.16
M20	.898	4.57	.807	1.70	.553	90	19.900	.000	4.15
M21	.905	4.91	.285	2.72	.584	90	22.931	.000	4.77
M22	.894	4.52	.809	1.57	.655	90	19.259	.000	4.01
M23	.930	4.72	.544	1.96	.515	90	25.003	.000	5.21
M24	.903	4.30	.785	1.52	.505	90	20.216	.000	4.21
M25	.874	4.74	.535	2.65	.640	90	16.971	.000	3.54
M32	.833	3.98	1.043	1.41	.541	90	14.807	.000	3.09
M33	.915	4.74	.535	1.89	.640	90	23.150	.000	4.83
2. Factor (Cronbach's Alpha = .971 , Guttman's Split-half coefficient =.931)									
M43	.910	4.87	.341	2.72	.584	90	21.604	.000	4.50
M44	.910	4.98	.147	2.93	.574	90	23.403	.000	4.89
M45	.934	4.93	.250	2.65	.526	90	26.603	.000	5.54
M46	.925	4.96	.206	2.96	.515	90	24.472	.000	5.10
M47	.917	4.91	.285	3.07	.490	90	22.111	.000	4.59
3. Factor (Cronbach's Alpha = .947, Guttman's Split-half coefficient =.956)									
M4	.822	4.96	.206	3.41	.686	90	14.622	.000	3.06
M5	.847	4.85	.363	3.07	.574	90	17.809	.000	3.71

Continued on next page

Table 5 – continued from previous page

Factors/ Items	DMTK (n = 172)	Upper Group (n = 46)		Lower Group (n = 46)		df	t	p	Cohen d
		M	Sd	M	Sd				
M8	.798	4.67	.560	3.24	.524	90	12.686	.000	2.64
M15	.828	4.98	.147	3.37	.610	90	17.399	.000	3.63
M17	.824	4.87	.341	3.15	.595	90	16.989	.000	3.55

Since there are 21 questions on the competency assessment scale, the lowest score that can be obtained from the test is 21 and the highest score is 105. The lowest and the highest score obtained from the scale were 44 and 105, respectively. In the independent samples t-test analysis performed for the significance of the difference between the means of the lower 27% and upper 27% groups, the first 46 individuals with the highest scores (27%) were included in the upper group and the last 46 individuals with the lowest scores (27%) were included in the lower group, to form two groups. It was seen that the mean of the lower group was 54.8 and the mean of the upper group was 100. The t-test showed that the p-value was less than .05 (p = .000) for all questions and there was a significant difference between the lower group and the upper group. When the t-values were examined, it was found that there was no item with a low t-value. It was determined that the items of the scale were highly discriminating.

7. Discussion

This study aimed at developing a valid, reliable, and useful measurement tool to identify teacher candidates' competencies for Education 4.0. Today, as traditional education inevitably transforms into digital education (Durakbasa *et al.*, 2018), prospective teachers who are to train future teachers are expected to develop their knowledge and skills related to digital technologies as well as their ability to apply these new technologies in the learning environment (Gueye & Exposito, 2020). In other words, in line with Education 4.0, the learners are expected not only to be a technology reader but also to self-improve with knowledge and skills throughout their lives and construct their learning strategies (Saxeno & Balat, 2017). Accordingly, in order to determine the competencies of candidates for Education 4.0, in the qualitative dimension, the existing studies in the relevant literature were reviewed and, taking into account the scale development stages indicated in the literature (Devellis & Thorpe, 2021), the items of the scale were identified, expert opinions on the items were obtained, the feedback and the items were analyzed using the Davis technique (Davis, 1992), content validity was ensured, and the scale was created.

The items of the developed "E4CD" scale were applied to the teacher candidates and the data obtained were analyzed using quantitative analysis. As a result of the exploratory factor analysis (EFA), it was found that the scale consisting of three-factors had a good variance explanation rate (60.20%), high factor loading values (.543–.839), and item overall correlation coefficients (r = .480 – .792). As a result, the items distributed in three-factors with an eigenvalue greater than 1 were obtained, and these items were examined and the factors were named mastery of digital technology, information management, and active participation in the process. It is known that the dimension of learning and innovation skills, one of the 21st-century skills based on the relationship of the 21st-century learning framework with innovative learning technologies, directly affects communication and collaboration, critical thinking, and creativity (P21, 2013). In this process, learners also need new skills such as organizing, analyzing and accessing information using technology (Abdüsselam & Turan-Güntepe, 2017). Similarly, Education 4.0 highlights the importance of student participation, creativity, and activity-based learning, as well as acquiring the ability to apply new technologies to the learning environment in light of developments in society (Gueye & Exposito, 2020), structure their learning with flexible, dynamic, and adaptable learning methods (Halili, 2019; Hussuin, 2018). In this context, the following factors come to the fore: "mastery of digital technology" in terms of recognizing the potential of digital technologies and making use of this potential; "information management" in terms of structuring one's learning in light of this potential, and "active participation in the process" in terms of increasing student participation. Besides, skills such as 'Analytical thinking and innovation', 'Active learning and learning strategies', 'Creativity, originality and initiative', Technology design and programming, 'Critical thinking and analysis', 'Complex problem-solving', 'Leadership and social influence', 'Emotional intelligence', 'Reasoning, problem-solving and ideation', and 'Systems analysis and evaluation' mentioned in "World Economic Forum Future of Jobs Reports (2022)" shouldn't be ignored during this process as the developments taking place in the field of education are the reflections of the sector. Technology Design and Programming, Systems Analysis, and Evaluation variables are related to the Mastery of Digital Technology factor of the scale; Analytical Thinking and Innovation, Critical Thinking and Analysis, Complex Problem Solving, Leadership and Social Influence, Emotional Intelligence, Reasoning, Problem Solving and Ideation variables are related to the "Information Management" factor while the Active Learning and Learning Strategies variables are related to the "Active Participation in the Process" factor. When all of these variables are examined, it appears that the factors incorporated into the scale are compatible with the variables in the World Economic Forum's Future of Jobs reports. Particularly in unexpected situations such as the Covid19 pandemic, educational institutions have more responsibility than ever to provide students with the skills to structure their education and help them take an active role in the process (Kresta, 2021). Moreover, it is well known that to keep up with Education 4.0, institutions need to shift to a new method of teaching that values process-oriented and individualized learning (Saxena *et al.*, 2017).

To verify the structure of the scale, confirmatory factor analysis (CFA) and model fit indices were examined and it was found that the factor structure of the scale was compatible with the model. These values indicate an excellent/acceptable fit when X2/sd is less than 3 (X2/sd = 140.520/87 = 1.615); RMSEA being .06 or less (RMSEA = .06); most CFI, GFI, and NFI values being .95 or above (CFI = .980, GFI = .905, NFI = .949) indicate that the developed model and structure are a perfect fit. It can be said that the convergent validity and reliability of the scale items are good enough in the context of average variance extracted values (AVE = .44) and composite reliability coefficients (CR = .00). The coefficients of the internal consistency of the scale calculated according to Cronbach's Alpha (alpha = .444) and Guttman's Split-half (r = .999) also attest to the reliability of the scores from the scale. The minimum and maximum scores on this 5-point Likert-type scale, which consists of a total of 21 items, varying from 21–105; the options respondents could choose from and their score values were "I definitelycan" (5 points), "I can" (4 points), " I can/cannot do partially " (3 points), "I may not" (2 points), and "I can't at all" (1 point). No item must be reverse scored based on the final shape of the scale. Very high scores were in the range of 105.00–88.21, high scores 88.20–71.41, moderate scores 71.40–54.61, low scores 54.60–37.81 and very low scores 37.80–21.00. In this context, this scale, which can be said to be valid and reliable at the expected level, can be used as a data collection tool to assess competency levels for Education 4.0, or for researchers or institutions/organizations to determine individuals' competencies in respect to Education 4.0, which is quick to fill in and practical to use in a print or digital environment.

Teacher candidates of the digital age must take advantage of the benefits that Education 4.0 adds to the learning process, such as learning at different times and places, personalizing learning, adaptive and dynamic learning processes, project-based learning, and mentoring system (Fisk, 2017). Moreover, the fact that teacher candidates can communicate, work collaboratively, and engage in more permanent learning activities in digital environments by actively participating in online environments underscores the concept of Education 4.0 (Karaman *et al.*, 2020). In light of these circumstances, it is possible to support the process by determining the Education 4.0 qualifications of higher education students and organizing conferences, seminars, and extra training in collaboration with higher education institutions so that faculties of education, engineering, and health can keep up with the digital age. Similarly, Lapteva and Efimov (2016) suggest universities increase scientific studies to turn information into reality, provide support for opening high-tech companies within their bodies, coordinate between different fields by forming communication networks and pave the way for innovations. Thus, they can integrate the innovations introduced by Education 4.0 and Industry 4.0 into our lives and raise the pioneers of the digital age from the individuals that are highly skilled and can keep up with the times.

8. Result and Suggestions

Today, the importance of this concept is becoming more and more prominent, as students trained by teachers are the representatives of the digital generation, and Education 4.0 supports the integration of new generation technologies into education to properly educate this generation. This scale, developed for purposes of this study and good validity and reliability, can be applied to all students at a higher education level. In addition, this study confirmed the three-factor structure (mastery of digital technology, information management, active participation in the process) of the E4CD. In creating the three-factor structure, Analytical thinking and innovation, Active learning and learning strategies, Creativity, originality, and initiative, Technology design and programming, Critical thinking and analysis, Complex problem-solving, Leadership and social influence, Emotional intelligence, Reasoning, problem-solving, and ideation, Systems analysis and evaluation skills cited in the "World Economic Forum's Future of Jobs Reports (2022)" were taken as a basis, in addition to the "Learning and innovation skills" dimension, which is based on the relationship of the 21st-century learning framework with innovative learning technologies. Using this developed scale, it will be possible to identify the competencies of teacher candidates for the Education 4.0 process and to create a qualified education system by highlighting the issues that need to be addressed to equip teachers with the right skills. In addition, it is recommended that the outcomes of the scale be used to guide the process of structuring the teaching programs of teacher candidates who are to train the teachers of the future.

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Appendix
Education 4.0 Competency Determination

Factors	Old item no.	New item no.	Scale items	I cannot at all	I may not	I can/cannot do partially	I can	I definitely can
Mastery of dijital technology	I18	I1	I know what cloud technologies are.					
	I19	I2	I know about smart technologies such as wearable technologies and smart glasses.					
	I20	I3	I know what robotic programming is.					
	I21	I4	I know what mobile technologies are.					
	I22	I5	I know what Bitcoin and Blockchain technologies are.					
	I23	I6	I know what three-dimensional (3D) technologies are.					
	I24	I7	I know which software to use to do 3D printing.					
	I25	I8	I know what artificial intelligence is.					
	I32	I9	I can write my own program using code blocks.					
	I33	I10	I know the intended purposes of wearable technologies and smart glasses.					
Information management	I43	I11	I can take security measures while using information and communication technologies.					
	I44	I12	I pay attention to ethical principles when using information and communication technologies.					
	I45	I13	I know what to do when I encounter a security incident while using information and communication technologies.					
	I46	I14	I can question the accuracy of information in digital resources.					
	I47	I15	I can choose the correct information in digital resources.					
Active participation in the process	I4	I16	I can direct my personal training depending on my personal needs.					
	I5	I17	I can participate in project-based studies.					
	I6	I18	I can use my time effectively in the learning process.					
	I8	I19	I can easily solve the problems that I encounter in the learning process.					
	I15	I20	I know from whom to get help when faced with difficulties in the learning process.					
	I17	I21	I can conduct interdisciplinary studies.					