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The Development of the Decoding Skills Scale in Information and Communication Technologies and an Investigation of Preservice Teachers in This Framework

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Decoding skills of individuals can be observed in different fields, one of which is information and communication technologies (ICT). Within the scope of the current study decoding skills are a new concept. There is no measurement tool available in the literature. At this point, the researchers aimed (1) to develop the ICT-Decoding Skills Scale and to conduct a validity and reliability study and (2) to identify undergraduate preservice teachers' level of ICT-Decoding skills, studying in faculties of education. The participants of the study involved a total of 1580 faculty of education students studying in 59 different universities in Turkey. The ICT-Decoding Skills Scale is a 4-factor, 5-point Likert-type scale comprising of 23 items. CFA results showed that model fit indices were calculated as the following: [$\chi2$=897.841; df=219; $\chi2$/df=4.100 p<.001; GFI=.873; AGFI=.840; CFI=.938; NFI=.920; NNFI(TLI)=.928; RMSEA=.070; RMR=.068; SRMR=.060]. When the internal consistencies were analyzed, Cronbach's Alpha value for the overall scale was (α=.94). As to address the second aim of the study, the ICT-decoding skills of preservice teachers were examined. Preservice teachers' ICT-decoding skills were found to be at a high level in the overall scale. However, in the subscales, they were observed to have medium and low levels of skills. Similarly, low levels of sensemaking, debugging and problem-solving skills were observed in their Coding Skills. At this point, preservice teachers are suggested to be supported in advanced technical skills, safety and social skills in digital environment and coding skills in addition to basic digital skills.

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Introduction

Decoding skills are a cyclical mental process that involves adapting to the new situation by combining existing knowledge and adapting to the new situation by detecting and solving the faulty situation in case this adaptation cannot be achieved (Akgül, 2021). It was developed based on the schemas approach mentioned in Piaget's cognitive development theory (Phillips, 1975; Piaget, 1965; Wadsworth, 1989). Being able to perform a behavior, being able to tell what a living thing or an object is and being able to solve a problem indicate the existence of schemas (Wadsworth, 1989).

According to Piaget's approach, schemas are mental structures that are inherited at birth, begin with reflexes, and are formed, develop, and change throughout life through experiences (Piaget, 1965). Such that, behaviors such as recognition, understanding, knowing, problem solving can be realized through schemas. For these behaviors to be displayed, the schemas need to be allowed to grow and develop through adaptation and organization to become a structure consisting of more numerous and complex networks (Wadsworth, 1989). The transformation of sensory-motor schemas from childhood into cognitive schemas in adulthood is related to individuals' adaptation to the environment they live in.

When schemas are examined from a theoretical perspective, it is pointed out that in the adaptation process that eliminates the state of disequilibrium, human beings seek balance by nature. For this reason, it is emphasized that achieving equilibrium is achieved by creating a new schema or organizing the old one. Restoring equilibrium is also a natural process, which may also be possible for children with the stimulation of an adult intervening from outside (Piaget, 1965). However, researchers have accessed limited information about an adult individual's self-awareness of the discrepancy and his/her ability to identify and resolve the erroneous situation. From this perspective, how individuals intervene and organize their schemas was of interest. At this point, the researchers estimated and visualized the cyclical process of decoding in the light of the literature as shown in Figure 2.

Decoding Skills

To understand decoding skills, it is necessary to be aware of the indicators of sensemaking, debugging, and problem solving. These indicators work together to form the decoding process. The relationship between the indicators and the cyclical process of decoding is given in Figure 2.

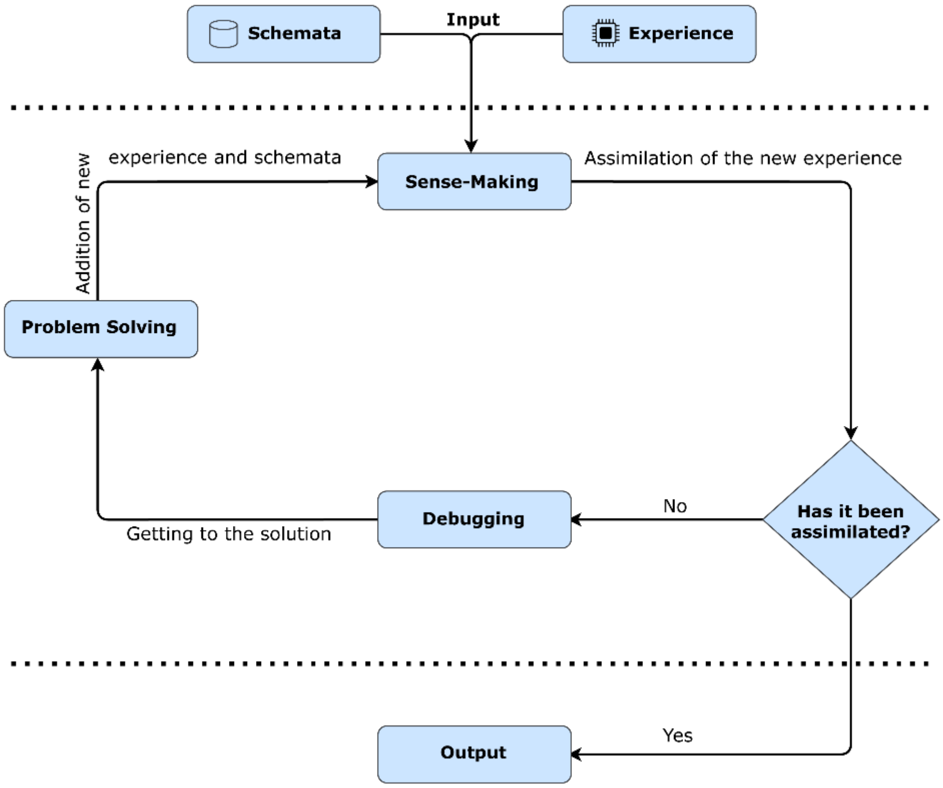

Figure 1. Cyclical Process of Decoding (Akgül, 2021).

As seen in Figure 2, decoding skills consist of three main processes: sensemaking, debugging, and problem solving. Sensemaking is the stage in which the new experience is associated with the schemas of the past. When a new experience is encountered, similar situations are searched for in past experiences through sensemaking. Two results emerge according to the presence or absence of a cognitive, affective, or psychomotor schema appropriate to the new experience in past experiences. The first is the realization of the action by finding the appropriate schema for the new experience. The second is to understand and correct the discrepancy in the absence of the appropriate schema. First, the debugging process in which the causes of incongruence are examined, comes into play (Akın et al., 2007; Ekici & Balım, 2013). In debugging, all possibilities related to the discrepancy at hand are cognitively determined. Solving the identified reasons is handled in the problem-solving phase. It may not always be possible to reach a definite solution in the problem-solving phase. At this point, the fact that human beings also learn from their failures and realize new learnings should be taken into consideration (Bauer, 2006). Thus, it does not matter whether problem solving results in success or failure. In both cases, it is possible to mention the formation of a schema appropriate to the new experience or a change in the existing schemas. Schematic innovations are added to the process and the sensemaking phase is repeated. If the discrepancy regarding the new experience is eliminated, the action is performed. Otherwise, the process repeats until the discrepancy is resolved. Thus, the action is cyclically realized by finding the appropriate schema for the new experience.

The concept of "experience" mentioned here is considered as experiences that require cognitive, affective, and psychomotor skills. In the literature, some of the areas where decoding skills can be used include the following examples.

- decoding in reading a written text (e.g., Algozzine, Mcquiston, O'shea, & McCollin, 2008; Apel & Swank, 1999; Kirby, 2018; Parrila et al., 2023; Pritchard, Coltheart, Marinus, & Castles, 2016; Swank & Catts, 1994),
- decoding in communication (verbal and non-verbal) and human relations (Burgoon & Bacue, 2003; Carton et al., 1999; Lee et al., 1980; Shannon, 1948; Swank & Catts, 1994),
- neural decoding in neural activities (e.g., Shi, 2010)
- decoding in humor orientation (e.g., Merolla, 2006)
- decoding in music perception (e.g., Corcoran, Stupacher & Vuust, 2022)

However, it is also seen that the expression of decoding differs in each study and is included in more than one discipline. Since this situation will prevent the understanding and generalizability of the concept of decoding, decoding processes in different disciplines need to be specificized. Decoding skills can be structured specifically for disciplinary areas. Thus, it will be easier to teach and measure decoding skills specific to disciplinary areas.

Based on this idea, the presence of decoding in information and communication technologies was studied in the context of this study. The fact that individuals make sense of the message passing between them and a digital technology, examine the causes of the digital error they encounter, and achieve successful or unsuccessful results by trying the solutions that come to mind shows the relationship with decoding skills in information and communication technologies (ICT-decoding skills).

Decoding Skills in Information and Communication Technologies

The spread of the Internet and mass media after the 1990s at a rapid speed have given rise to new needs in daily life. ICT is used as a tool to meet these needs (Nascimento & Franco, 2017). The Organization for Economic Cooperation and Development [OECD] (2021) reports show that over the years, there has been a substantial rise in ICT access and data consumption by households and people across the entire globe. This increase is predicted to bring about digital information requirements and digital problems in the future. From this perspective, the predicted problems will need to be solved by individuals. This situation shows us that decoding skills can also be handled under the scope of ICT. Based on this, an ICT-decoding skills structure was created. The structure is given in Figure 3.

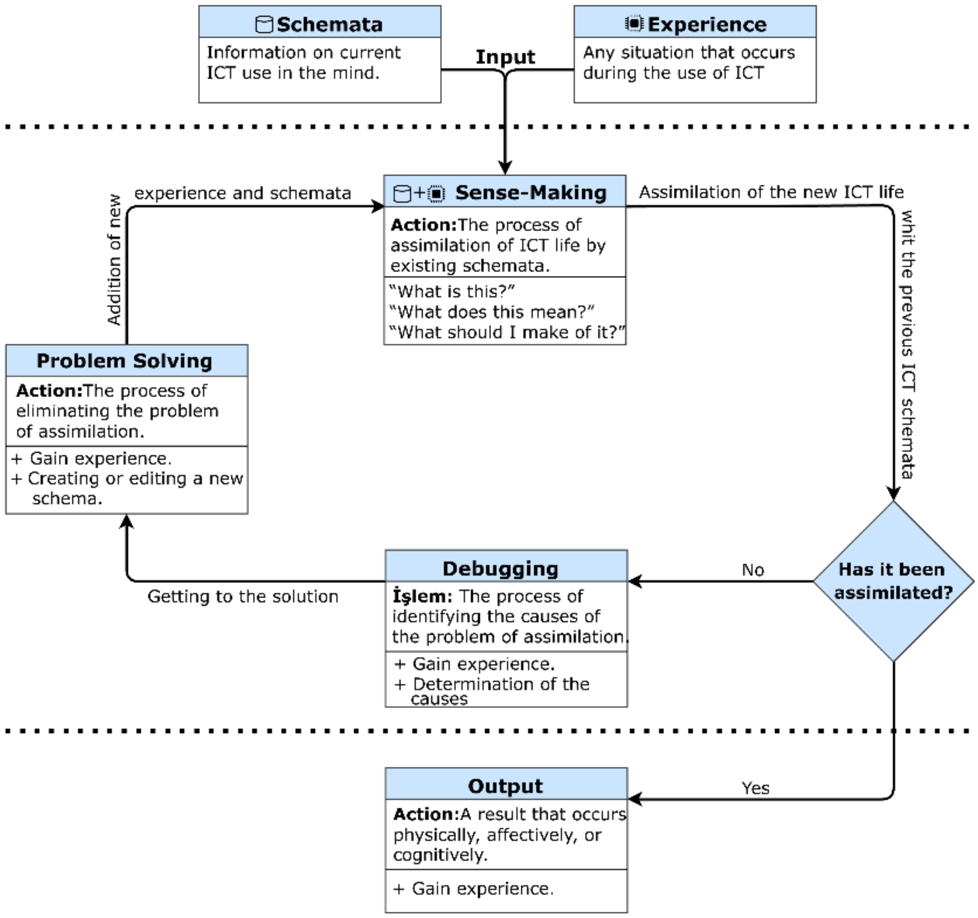

Figure 2. ICT-Decoding Skills Structure (Akgül, 2021)

During the process of solving digital problems or understanding digital information, individuals will need a few cognitive skills. First, the individual needs to make sense of a digital experience. At this stage, the individual should establish a connection between his/her past ICT experiences and the new experience, which is sensemaking. Whether the new experience creates a problem or not should be decided, which could be a digital error message or a disagreement arising from the individual's incomplete ICT knowledge. Then, the possibilities that could cause this problem should be considered, which is debugging. Thereafter, efforts should be made to solve one of the identified possibilities in the phase of problem-solving. Then, it should be reconsidered whether the situation at hand is still a problem, which is re-sensemaking. If it is clear that the problem at hand has been solved, i.e., assimilation has taken place, action can be taken. However, at this point, it may also be decided that the steps taken to solve the digital problem are not sufficient because solution attempts may not always be sufficient. This is where the cyclical process comes into play. If the situation specified as a problem persists, the cyclical process continues until the possibilities of the problem are depleted or resolved. Whenever the problem is solved, the process ends with output. As can be seen, sensemaking, debugging, and problem solving, which are indicators of decoding skills, are also applicable to this discipline (Akgül, 2021).

ICT-decoding's overall goal is to attempt to comprehend an ICT experience using prior knowledge. If the experience cannot be understood, it is necessary to pinpoint potential error causes and to give the experience meaning with the aid of problem-solving techniques (Akgül, 2021). Individuals' ICT-decoding processes have been explained within the scope of cognitive skills. However, no valid and reliable instrument exists to measure individuals' ICT-decoding processes.

The Study's Aim

The purpose of this study is to develop the ICT-Decoding Skills Scale, carry out a validity and reliability analysis, and identify the ICT-decoding skills of undergraduate preservice teachers studying in the faculty of education.

Method

This section entails information on the present study's design, population and sample, data collection tools, and processes for data collection and analysis.

Participants

The study involved a total of four groups of participants. The members of each group had similar characteristics with each other. All participants were preservice teachers studying at the undergraduate level in universities' faculty of education. The groups, the number of participants pertaining to each group, and the participants' demographic information are presented in Figure 4.

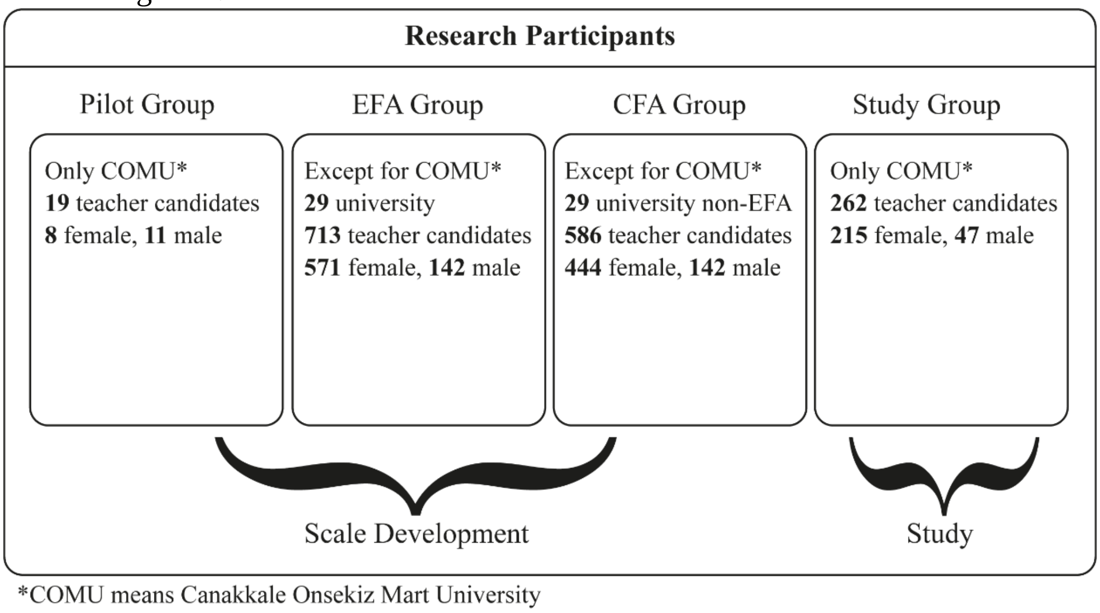

Figure 3. Participants of the study

A number of 19 preservice teachers at Çanakkale Onsekiz Mart University (COMU) of Türkiye Faculty of Education, who were enrolled in different departments, voluntarily participated in the pilot project. In the pilot study, there were eight female preservice teachers and 11 male preservice teachers. They ranged in age from 18 to 40.

The preservice teachers who took part in the Exploratory Factor Analysis (EFA) study were enrolled in the Faculty of Education at 29 different Turkish universities. The volunteers who agreed to take part in the study provided a total of 868 responses. The data from 155 participants were not included in the study because of the control items that were part of the data collection form. The dataset containing the responses of 713 participants included the

EFA group's data after the omitted items. There were 142 male participants and 571 female participants, the ages of whom varied from 18 to 42.

With the voluntary participation of 586 preservice teachers from the Faculties of Education of additional 29 universities outside of the EFA group in Turkey, the Confirmatory Factor Analysis (CFA) study was carried out. The participants who responded provided a total of 690 responses. Data from 104 individuals were not included in the study because they were excluded as a result of the control items that were added to the data collection form. The dataset with the responses of 586 participants contained the CFA Group's data after the omitted responses. There were 444 female participants and 142 male participants. They ranged in age from 18 to 49.

After the scale development process was complete, the Implementation Group was established with the voluntary participation of preservice teachers studying at the Faculty of Education at the COMU. This group was used in an attempt to provide an answer to the question "at what level are the ICT-decoding skills of preservice teachers?" A number of 331 volunteers who agreed to take part in the study provided the data. The data of 69 individuals were not included in the study because they were removed as a result of the control items added to the data collection form. The dataset containing the responses of 262 participants included the data from the implementation group after the omitted data items. There were 215 female participants and 47 male participants in this phase, ages of whom varied from 18 to 34.

Procedure

All Turkish higher education institutions offered their courses online throughout the data gathering phase due to the Covid-19 pandemic. This process remained this way for 2 years. Therefore, the research data were collected completely remotely. In obtaining the data for EFA and CFA processes, 58 universities with faculties of education in Turkey were identified. These universities were randomly divided into two groups. These two groups were randomly named as EFA Group and CFA Group. The e-mail addresses of 6560 faculty members working in faculties of education were gathered from the system “akademik.yok.gov.tr” in order to contact the preservice teachers in these groups. After the e-mails were collected, approximately 2800 e-mails were sent. First, data were collected to calculate construct validity and scale reliability. In this process, faculty members working in 29 universities in the EFA Group were reached via e-mail. In the e-mail, the scale link and ethics committee approval were sent. It was requested that the faculty members pass along the scale link to their education faculty students. For a period of 14 days, EFA data were gathered. After the data was collected, several items from the scale were eliminated, the factor structure was established, and the reliability coefficient was calculated.

Following the EFA procedure, the form comprising the scale items for the CFA procedure was developed. A new 14-day data gathering procedure was then initiated. Emails were sent to academic staff members at the other 29 universities in the CFA group as part of the new procedure. The creation of a valid and trustworthy scale concluded when the CFA procedures were finished.

The Faculty of Education at COMU was not included in the participant group during the development of the ICT-Decoding Skills Scale (EFA and CFA processes). Following the development of the scale, it was distributed by e-mail to faculty members at COMU’s Faculty of Education in order to assess pre-service teachers' ICT-decoding skills. Consequently, the research data were gathered.

Development of the ICT-Decoding Skills Scale

A Likert-type scale was developed to measure ICT-decoding skills. At this stage, the scale development process proposed by DeVellis (2012) was taken as a basis (see Figure 5).

Figure 5. Scale development steps (DeVellis, 2012)

The stages depicted in Figure 5 were carried out during the scale development phase. The creation of the item pool marked the beginning of the study.

Formation of the Item Pool

Deductive and inductive methods were used together to create the item pool (Hinkin, 1998). A literature review was conducted with the deductive method. First, the scope of ICT was determined. Then, the scale items that were theoretically similar to the draft scale were collected from the literature. In the inductive method, the items were derived by resorting to the opinions of researchers and experts in the field. There were three steps involved in creating the item pool.

A literature review was done in the first step to identify the scope of ICT. Based on the scope of ICT as defined by Kaarakainen et al. (2017) and the experiences of the researchers, topics related to ICT were identified. Thirteen subheadings were added to the 3-factor structure determined by Kaarakainen et al (2017). The obtained ICT scope is given in Table 1.

Table 1. Categories and Headings in the Scope of ICT

Category	**Heading**
Basic Digital Skills	• The use of office programs • Digital communication • Searching for information, reaching correct information • The use of Web 2.0 tools • Basic use of computer (computer, printer, scanner, video camera, photograph camera, smart technologies, etc.) • Image, video, and audio editing (content editing)
Advanced Technical Skills	• Installation of operating systems • Purchasing, installing, running, updating software • Information security • Basic coding, issuing a command, creating algorithms
Professional ICT Skills	• The use of digital technology and knowledge in different disciplines • The use of datasets • All sorts of programming including web, desktop, and mobile

The items that can meet the decoding skills from the literature and developed measurement tools were taken directly, edited, or reconstructed to create a list. In the resulting list, studies containing the following keywords were found.

- internet/technology use (Aşkar & Mazman, 2013; Güven, 2004),
- digital trade (Kuş et al., 2017),
- digital security (Doğanç & Korucu, 2020; Güldüren, 2015),
- computational thinking (Brennan & Resnick, 2012; Gülbahar, Kert, & Kalelioglu, 2019; Jang, Choi, Kim & Kim, 2023; Korkmaz et al., 2015, 2017; Standl, 2017),
- decoding in communication (Buluş et al., 2017; Carton et al., 1999; Coursen & Thomas, 1989; Ersanlı & Balcı, 1998; Merolla, 2006; Mill, 1984; Ruben et al,)
- decoding in reading (Allen, 1985; Apel & Swank, 1999; Ehri & Wilce, 1982; Glenn & Hurley, 1993; Hickman et al., 2008; Kirby, 2018; Masuck et al., 2008; Parrila et al., 2023; Plourde et al., 2015; Standl, 2017),
- decoding in programming (Altun & Mazman, 2012; Kasalak, 2017),
- decoding in hardware (Günbatar, 2014; Kuş et al., 2017),
- problem solving (Akın et al., 2007; Ekici & Balım, 2013; Gülbahar, Kert, & Kalelioğlu, 2019; Semerci, 2016; Tuğsal, 2019),
- ICT use (Açıkgül Fırat & Özden, 2015; Erdem & Koçyiğit, 2019; Şimşek & Yazar, 2016)

The scale items and definitions in the literature were scrutinized. At the end of the examination, the items that were deemed to reflect decoding skills were included in the draft pool. New items were derived from this pool by the researchers. The items were prepared to cover the 13 ICT topics determined in the first step and the sensemaking, debugging, and problem-solving processes of decoding skills. A number of 32 items was written for 13 topics. After the item pool had been created, assessments of the content validity were made by experts.

Obtaining Expert Opinions

In the expert opinion form, information on decoding skills and ICT scope was added. The created item pool's content validity and conformance to the item writing criteria were to be evaluated by experts. Online forms were used to solicit the opinions of 8 experts in Computer and Instructional Technologies and 1 expert in Measurement and Evaluation.

The experts were given 3 options for each item: “appropriate”, “partially appropriate”, “inappropriate”. Suggestions were received for the items marked as partially appropriate and inappropriate. After receiving the expert opinions, corrections and changes were made on the items. Each item was structured to measure a single feature. Technical terms were simplified. Explanations were added to the items. Thus, the number of scale items increased to 39. After this process, the researchers reviewed all the items together. They critically examined all the items, presented and discussed their opinions in case of disagreement and finally reached a consensus. The ICT-Decoding Skills Scale's content and face validity were thus confirmed.

Pilot Application Process

A lesser number of preservice teachers participated in the pilot implementation than in the full implementation. The purpose of the pilot study was to identify the items that preservice teachers struggled with, the average duration of time it took to complete the scale, and their recommendations.

Demographic information of the participants was obtained in the pilot application form. This was followed by 39 scale items and the second section, which included the statement “Is ‘Item X’ clear and understandable? (If not, write the reason in the ‘other’ option)” for each item. In the third section, the average response times and whether there were any items or statements that were not generally understood were obtained. Finally, the respondents were asked to write down their general opinions and suggestions.

Looking at the response times reported by the participants, it was determined that the scale was completed in an average of 12 minutes. In addition, explanations were added to the relevant items for the expression “Database query”, which was not sufficiently understood. Thus, the pilot implementation process was completed.

Findings and Conclusions

The findings pertaining to the scale validity and reliability of the scale development process are reported in this section. Processes for exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) as well as their findings are provided. Finally, the study's findings regarding preservice teachers' ICT decoding skills are presented.

Findings Related to EFA Process

By assembling moderately or strongly related items into factors, factor analysis is an appropriate technique for reducing the number of variables (Fraenkel et al., 2012: 337). According to the literature, a sample size of 200 or more (Kline, 2016) or 5-10 participants per item or 300 participants in total (Kass & Tinsley, 1979) is viewed sufficient for factor analysis. The presence of 713 participants in the EFA group of the study was considered sufficient for factor analysis. Kaiser-Meyer-Olkin (KMO) and the Bartlett sphericity test are used to determine whether the data are suitable for factor analysis (Büyüköztürk, 2013). KMO value should be .60 or higher in order to perform factor analysis, and Bartlett's test of sphericity has to be significant (Büyüköztürk, 2013). Table 2 provides the KMO value and Bartlett's test of sphericity findings for this scale development study.

Table 2. KMO and Bartlett’s Sphericity Test Values in Testing the Suitability of Factor Analysis

Test		**Result**
Kaiser-Meyer-Olkin (KMO) Value		.945
Bartlett Sphericity Test	Chi-square value	24246.852
	SD	741
	p	.000*

*p<.001

The KMO value of .945 in Table 2 indicates that the sample size is sufficient (Büyüköztürk, 2013). The fact that Bartlett’s test of sphericity yielded significant results ($\chi 2$=24246.85, p=.000<.001) indicates that the items are interrelated, and the data meet the normality prerequisites (Tabachnick & Fidell, 2013). Accordingly, the necessary prerequisites for EFA were met.

The factor structure is typically determined using principal component analysis (Büyüköztürk, 2013). Principal components analysis was carried out using the Verimax rotation technique, one of the orthogonal rotation methods, in the factor analysis employed for the construct validity of the scale. Communalities were examined at after the analysis. Items with values less than .40 were eliminated from the scale. The analysis was renewed until all the items had a value above .40 (Costello & Osborne, 2005). Subsequently, the items with loadings distributed across different factors were analyzed. The items with loadings less than .10 between two factors were considered overlapping and removed from the scale (Büyüköztürk, 2013). The process of deletion and reanalysis continued until the communality value for all items was above .40 and there were no overlapping items. A total of 16 items, including m5, m25, m34, m35, m36, m2, m4, m10, m11, m12, m31, m32, m33, m37, m38, m39, were removed from the scale because they did not meet the communality value. At the end of this process, 23 items remained in the scale. The final KMO value was .921, and Bartlett's Test of Sphericity values were $\chi2=13222.62$; $p=.000<.001$; sd=253.

After the Varimax rotation technique, factor loadings ranged between .501 and .907. Factor loadings of .45 and above indicate that the contribution of the items to the scale is at a sufficient level (Büyüköztürk, 2013).

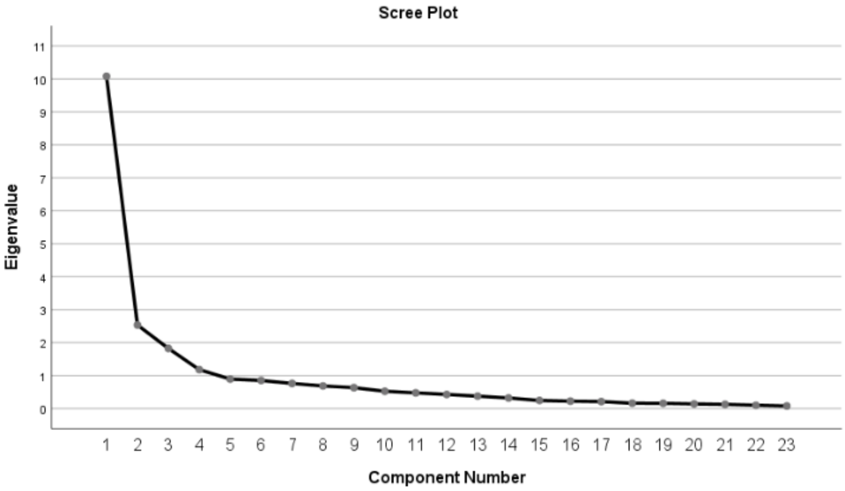

Figure 4. Line chart of factor analysis (scree plot)

In determining how many factors the scale consists of, Kaiser criterion eigenvalues above 1 (see Figure 6) were taken into consideration (Can, 2013). Thus, it was seen that the scale was structured under four factors. Then, according to the items under the factors, the factor names were respectively determined as "Basic Digital Skills", "Advanced Technical Skills", "Safety and Social Skills in Digital Environment", and "Coding Skills". Table 3 shows the factor structure, internal consistency coefficients, and variance explained values of the ICT-Decoding Skills Scale as a result of EFA.

Table 3. Values Regarding the Factors of the ICT-Decoding Skills Scale

Item	Variance Explained (%)	Cronbach's Alpha (α)	F1[a]	F2[b]	F3[c]	F4[d]
m13			0.766			
m14			0.763			
m15			0.751			
m16	43,823	α=.92	0.749			
m18			0.738			
m17			0.731			
m3			0.659			
m1			0.659			

m21	11,019	α=.93		0.825		
m20				0.798		
m19				0.765		
m23				0.765		
m24				0.754		
m22				0.729		
m27	7,929	α=.79			0.740	
m6					0.730	
m9					0.717	
m8					0.619	
m7					0.585	
m26					0.501	
m29	5,129	α=.95				0.907
m30						0.890
m28						0.877
Total	**67,899**	**α=.94**				

[a]: Basic Digital Skills
[b]: Advanced Technical Skills
[c]: Safety and Social Skills in Digital Environment
[d]: Coding Skills

According to Table 3, the total explained variance value is 67.90%. This value is quite good for social sciences research (Çokluk et al., 2014; Henson & Roberts, 2006; Scherer et al., 1988). Cronbach's Alpha internal consistency coefficients between .70 and .90 are interpreted as high reliability, while .91 and 1.00 are interpreted as excellent reliability (Hinton et al., 2014). In this context, it can be said that the internal consistency coefficients for the scale have excellent reliability for Basic Digital Skills (α=.92), Advanced Technical Skills (α=.93), and Coding Skills (α=.95). On the other hand, the internal consistency coefficient in the high reliability range was found in the subscale of Safety and Social Skills in Digital Environment (α=.79).

Findings Related to the CFA Process

Confirmatory Factor Analysis (CFA) is used to investigate causal relationships between latent and observed variables in predetermined models, which is an analysis method among structural equation modeling techniques (Mueller & Hancock, 2001). In the study, CFA was utilized to measure the validity of the factor structure obtained with EFA in a different group of preservice teachers. The literature suggests that 5-10 participants per item (Bagozzi, 2010) or 200 participants in total (Hair et al., 2011) are sufficient for CFA. The fact that the number of participants in the CFA Group was 586 indicates that a dataset with sufficient participants was used for the analysis. The model structure consisting of 23 items and 4 factors was analyzed with the "Maximum Likelihood (ML)" statistic.

In the first analysis, the results of the analysis without correction do not meet the model fit values. At this point, Modification Indices were taken into consideration. Modification Indices provide information about the definition of the model and the degrees of freedom of the variables. In social sciences, it is not possible for variables to be completely free. For this reason, it is recommended to create covariance by considering the correction values between variables (Yaşlıoğlu, 2017). The corrections made with the covariances will bring the model fit indices to acceptable levels (Diamantopoulos & Siguaw, 2000; Hooper et al., 2008). Although there is no definite statement about the number of covariances, it is recommended to be theoretically reasonable (Diamantopoulos & Siguaw, 2000) and to be done in moderation (Hooper et al., 2008).

In this context, Adjustment Indices were analyzed. Since the recommendations between e1-e2, e7-e8, e12-e13-e14 are theoretically reasonable, covariance was created between them. Thus, the model fit indices were brought to an acceptable level. The model obtained as a result of CFA after the procedure is given in Figure 7.

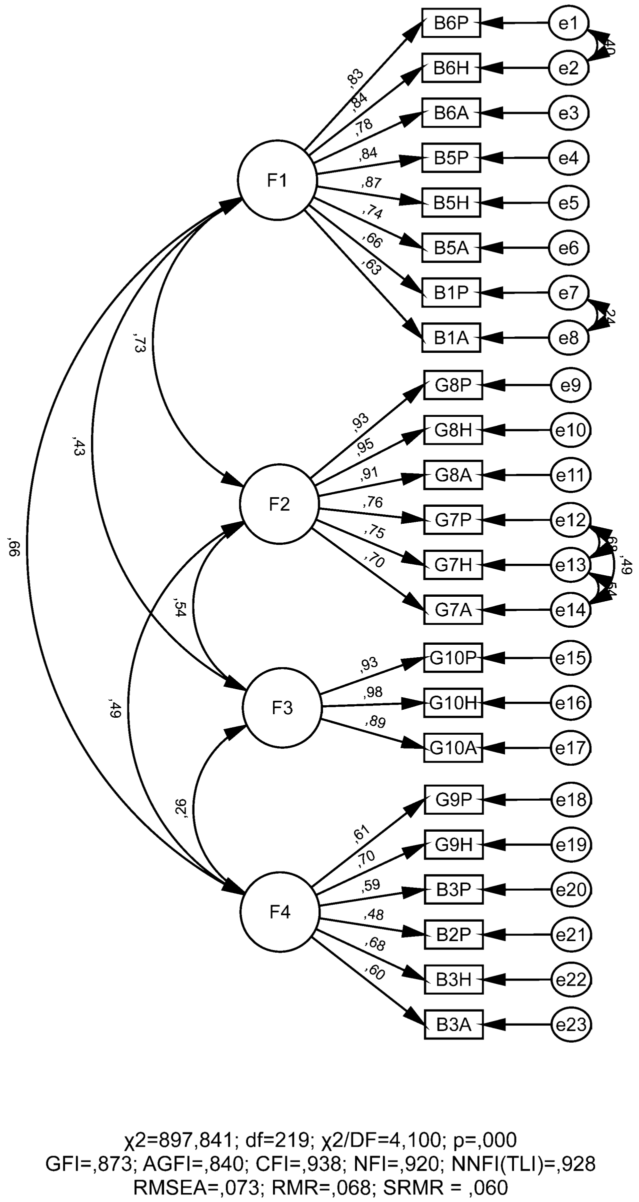

Figure 5. ICT-Decoding Skills Scale's CFA Model (Standardized path diagram)

The *t* values, standardized factor loadings, error variances, squares of multiple correlation (R2), which is a validity indicator, and Cronbach's alpha internal consistency coefficients of the factors obtained according to CFA are given in Table 4.

Table 4. Item Statistics of the ICT-Decoding Skills Scale According to CFA

Factor	Item	*t*	Factor Loading	Error Variance	R^2	*p*
Basic Digital Skills (α= .93)	B1A	16.27	0.63	0.47	0.40	.000
	B1P	16.16	0.66	0.58	0.43	.000
	B5A	15.68	0.74	0.36	0.54	.000
	B5H	13.39	0.87	0.24	0.75	.000
	B5P	14.11	0.84	0.29	0.71	.000
	B6A	15.18	0.78	0.36	0.61	.000
	B6H	13.97	0.84	0.28	0.71	.000
	B6P	14.20	0.83	0.30	0.69	.000
Advanced Technical Skills (α= .94)	G7A	16.39	0.70	0.77	0.49	.000
	G7H	16.16	0.75	0.62	0.56	.000
	G7P	16.10	0.76	0.59	0.58	.000
	G8A	13.53	0.91	0.27	0.82	.000
	G8H	9.59	0.95	0.14	0.91	.000
	G8P	12.14	0.93	0.20	0.86	.000
Coding Skills (α= .95)	G10A	14.51	0.89	0.38	0.78	.000
	G10H	3.97	0.98	0.07	0.96	.000
	G10P	12.01	0.93	0.25	0.86	.000
Safety and Social Skills in Digital Environment (α= .78)	B2P	15.93	0.48	0.65	0.23	.000
	B3A	14.97	0.60	0.68	0.36	.000
	B3H	13.83	0.68	0.39	0.46	.000
	B3P	15.07	0.59	0.80	0.34	.000
	G9H	13.31	0.70	0.36	0.49	.000
	G9P	14.78	0.61	0.70	0.37	.000
Overall Scale (α=.94)						

When Table 4 is examined, it is seen that the significance level is p<.05, $t \geq 1.96$ for all items in the scale, and the error variance is between .07-.80 and all of them are below .90. It can be said that these values comply with the limit values stated in the literature (Kline, 2016; Tabachnick & Fidell, 2013). In addition, the ranges for the factor loadings are as follows: .71 and above for excellent, .70 - .63 for very good, .62 - .55 for good, .54 - .45 for good, .44 - .32 for poor (Harrington, 2009). When the obtained results are analyzed, factor loadings greater than .30 and in the range of .48 - .98 indicate that all items have acceptable factor loading values (Harrington, 2009). On the other hand, R2 values ranging between .23 - .96 indicate the amount of variance explained.

Cronbach's Alpha internal consistency coefficients (α) indicate the reliability of the measurement results. Alpha coefficients for the overall scale and each dimension should be .70 and above (Nunnally & Bernstein, 1994). Alpha coefficient can be interpreted as high reliability in the range of .70 - .90 and excellent reliability in the range of .91 - 1.00 (Hinton et al., 2014). When the internal consistencies are examined, it is seen that Cronbach's Alpha values are at excellent level for "Basic Digital Skills" (α=.93), excellent level for "Advanced Technical Skills" (α= .94), excellent level for "Coding Skills" (α=.95), high level for "Safety and Social Skills in Digital Environment" (α=.70), and excellent level for the overall scale (α= .94). In addition, the internal consistency coefficients obtained were consistent with those obtained as a result of EFA.

In this context, CFA findings show that the ICT-Decoding Skills Scale has values consistent with the literature. In addition, the ICT-Decoding Skills Scale has construct validity and is a reliable scale. In addition, another point to be considered is the model fit indices.

There are different opinions regarding the indices to be considered in the evaluation of model fit indices obtained from CFA analysis (İlhan & Çetin, 2014). Gerbing and Anderson (1985) state that the freedom to report model fit indices belongs to the researcher. The values identified as being prevalent in the literature are employed within the context of this study: overall model fit ($\chi2$), overall model fit divided by degrees of freedom ($\chi2/df$), goodness of fit index (GFI), adjusted goodness of fit index (AGFI), comparative fit index (CFI), normed fit index (NFI), non-normed fit index (NNFI-TLI), root mean square error of estimate (RMSEA), root mean square error of the mean (RMR), standardized root mean square error of the mean (SRMR). According to the literature, Table 5 displays the good and acceptable model fit indices.

Table 5. Model Fit Indices

Fit Index	Good Range	Acceptable Range	References
$\chi2$	$0\leq \chi2 \leq 2df$	$2df < \chi2 \leq 3df$	(Çokluk vd., 2014; Tabachnick & Fidell, 2013)
p value	$.05 \leq p \leq 1.00$	$.01 \leq p \leq .05$	
$\chi2/df$	$0 \leq \chi2/df \leq 2$	$2 < \chi2/df < 5$	(Kline, 2016)
GFI	$.95 \leq GFI \leq 1.00$	$.80 \leq GFI \leq .95$	(Forza & Filippini, 1998; Greenspoon & Saklofske, 1998; Hooper vd., 2008)
AGFI	$.95 \leq AGFI \leq 1.00$	$.80 \leq AGFI \leq .95$	(Forza & Filippini, 1998; Greenspoon & Saklofske, 1998; Hooper vd., 2008)
CFI	$.95 \leq CFI \leq 1.00$	$.90 \leq CFI \leq .95$	(Sümer, 2000)
NFI	$.95 \leq NFI \leq 1.00$	$.90 \leq NFI \leq .95$	(Tabachnick & Fidell, 2013)
NNFI (TLI)	$.95 \leq NNFI\ (TLI) \leq 1.00$	$.90 \leq NNFI\ (TLI) < .95$	(Sümer, 2000)
RMSEA	$.00 \leq RMSEA \leq .05$	$.05 \leq RMSEA \leq .08$	(Browne & Cudeck, 1992; Schreiber vd., 2006)
RMR	$.05 < RMR < .10$	$.05 < RMR < .10$	(Brown, 2006; Browne & Cudeck, 1992; Hu & Bentler, 1998)
SRMR	$.00 \leq SRMR \leq .05$	$.05 < SRMR < .10$	(Brown, 2006; Browne & Cudeck, 1992; Hu & Bentler, 1998)

Model fit indices were as follows as a result of the CFA performed for the model consisting of 4 factors and 23 items: [$\chi2$=897.841; df=219; $\chi2/df$=4.100 $p<.001$; GFI=.873; AGFI=.840; CFI=.938; NFI= .920; NNFI(TLI)=.928; RMSEA= .070; RMR=.068; SRMR=.060]. In large samples, $\chi2$ value may be large and *p* value may be significant. In these cases, $\chi2$ and *p* value can be ignored (Çokluk et al., 2014). Instead, $\chi2/df$ value should be preferred (Hooper et al., 2008; Kline, 2016). Considering the model fit indices provided in Table 5, it is seen that $\chi2$ /df, GFI, AGFI, CFI, NFI, NNFI, RMSEA, RMR, SRMR values are in the “acceptable fit” range (Brown, 2006; Browne & Cudeck, 1992; Forza & Filippini, 1998; Greenspoon & Saklofske, 1998; Hooper et al, 2008; Hu & Bentler, 1998; Kline, 2016; Schreiber et al., 2006; Sümer, 2000; Tabachnick & Fidell, 2013). The model structure, which includes 4 factors and 23 items, is supported by the results.

The 23-item ICT-Decoding Skills Scale uses a 5-point Likert scale. The mean score is used to interpret the scale. The range of 0.80 was chosen as the base value for the 5-point Likert-type scale using the formula (n-1/n). This framework leads to the following interpretation of the scale results: 1-1.80 is very low; 1.81- 2.60 is low; 2.61-3.40 is medium; 3.41- 4.20 is high; 4.21-5.00 is very high ICT-Decoding Skill level.

Findings Regarding the Level of ICT-Decoding Skills of Preservice Teachers

Findings related to preservice teachers' level of ICT-Code solving skills were obtained by using the ICT-Decoding Skills Scale developed within the scope of the research. The findings regarding the preservice teachers' levels of ICT-decoding skills are reported in Table 6. Afterwards, the findings are discussed with the literature.

Table 6. Descriptive Statistics Regarding Preservice Teachers' Level of ICT-Decoding Skills

Dimension	**f**	$\bar{X}$	***SD***	**SM**	SD_{SM}	**DB**	SD_{DB}	**PS**	SD_{PS}
Basic digital skills	262	3.80	.74	4.10	.70	3.65	.87	3.60	.87
Advanced technical skills		3.09	1.08	3.15	1.12	3.04	1.10	3.09	1.15
Safety and social skills in digital environment		4.02	.70	3.89	1.21	4.21	.71	3.95	.89
Coding skills		2.00	1.11	2.09	1.18	1.98	1.15	1.92	1.12
Overall scale	262	3.44	.69	3.51	.71	3.40	.72	3.42	.72

Note. The mean values of the results obtained from the 5-point Likert-type scale are given. SD: Standard deviation, SM: mean of sensemaking, DB: mean of debugging, PS: mean of problem-solving.

Table 6 shows that the preservice teachers' mean scores revealed that they scored well in the Basic Digital Skills dimension, medium in the Advanced Technical Skills dimension, high in the Safety and Social Skills in Digital Environment dimension, and low in the Coding Skills dimension. The overall scale revealed that preservice teachers' ICT-decoding skills were at a high level. Especially in social and security skills, better results were obtained than technical skills. These results confirm Kaarakainen's (2018) claim that circumstances demanding higher technical expertise are more challenging.

On the other hand, when the means for each decoding component are looked at, it turns out that the preservice teachers' decoding skills are present at all three levels: low, medium, and high. The results showed that there were different degrees of sensemaking competence depending on the ICT-decoding sub-skills. Sensemaking was discovered to be at a low level, particularly in Coding Skills. On the other hand, it demonstrates how Safety and Social Skills in Digital Environment and Basic Digital Skills can be effective in creating a connection with prior experiences (Akn et al., 2007; Boyacolu & Aktaş, 2018; Güven, 2004) and associating new information with prior learning (Güven, 2004) when faced with an unfamiliar circumstance. It is also evident that preservice teachers who have low coding skills also exhibit poor debugging and problem-solving skills. According to certain research, those with excellent programming skills have low debugging skills, and debugging skills should be taught separately (Ahmadzadeh et al., 2005; Masuck et al., 2008). Contrary to the literature, it was found in this study that coding and debugging skills displayed levels that were consistent. This is not to suggest, nevertheless, that those with strong coding skills will also have strong debugging skills. Böttcher et al. (2016) contend that debugging encompasses more than just its technical definition and entails learning technical skills in the fields of software and engineering. This view is supported by the higher level of debugging in non-technical sub-dimensions when the debugging levels of the preservice teachers are examined. The highest skills are Safety and Social Skills in Digital Environment, according to the data on problem-solving skills. The lowest skill sets are in coding, as is the case with all sub-skill groups.

Suggestions

In this study, decoding skills and ICT-decoding skills were introduced. Then, a valid and reliable measurement tool was developed to measure ICT-decoding skills. Afterwards, preservice teachers' ICT-decoding skills were analyzed. For academics working in higher education institutions as well as researchers, teachers, and policymakers working in the field of curriculum development, some recommendations are provided in this section.

ICT-decoding skills were examined in the study using 4 subscales. The preservice teachers were found to have a high degree of overall ICT-decoding skills. However, ICT-decoding skill levels were found to be low as the technical knowledge need grew despite the fact that ICT-decoding skill levels were found to be high overall. In future studies with different study groups, it should be investigated whether this circumstance is similar. It was discovered that the preservice instructors had weak coding skills in particular. At this point, it is advised that courses supporting advanced technical skills, coding skills, and basic digital skills be made available to preservice teachers.

The preservice teachers were also examined in the dimensions of sensemaking, debugging, and problem-solving skills within the scope of the scale. In particular, the preservice teachers were found to have the highest score at the level of sensemaking in ICT-decoding skills. They scored the lowest in the debugging dimension. However, the score results in all three dimensions were close to each other and determined as high level. At this point, it is noteworthy that the preservice teachers did not differentiate in the subdimensions of ICT-decoding skills. However, in debugging and problem solving, they moved from the borderline to one level above the middle level, which should not be overlooked. To develop coding skills, it may be advised in future research to organize trainings and activities that promote debugging and problem-solving skills. The teaching of Information Technologies in universities may potentially be affected by such a situation. These course contents can be organized to assist with the development of debugging and problem-solving skills in decoding skills.

Researchers view future studies on ICT-decoding skills in two aspects, one of which is to examine the relationship between decoding skills and different higher-order cognitive skills. In another perspective, decoding skills are a new skill that has been recently introduced to the literature. As in ICT-decoding skills, it can be suggested to define the skill and develop measurement tools in new disciplines. For example, future studies can be conducted in the following subjects.

- Examining the relationship between learners' reading the code written by another person and their decoding skills in subjects such as programming, robotic coding, text-based coding,
- Examining the relationship between note reading in music education and learning to play a new instrument on decoding skills,
- Examination of the relationship between code solving skills and situations where the result should be reached by going from the part to the whole (puzzle solving, crime scene investigation, diagnosing a disease, and alike),
- Examining the relationship between decoding skills and the reverse engineering,

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