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Research Article

Ecological Literacy Measurement Tool for Adults: Validity and Reliability Study

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Abstract – The aim of this study is to develop a valid and reliable measurement tool for obtaining information about the ecological literacy of adults. For this purpose, a 72-item and three-part measurement tool was created in accordance with information in the literature and presented to experts for their opinions. After finalizing the scale in accordance with the feedback received, the 25-item 5-point Likert-type Ecological Literacy Awareness Scale, the 17-item true/false-type Ecological Literacy Knowledge Test (1), and the 17-item multiple-choice Ecological Literacy Knowledge Test (2) were created. The exploratory factor analysis (EFA) group comprised 294 teacher candidates studying in the Ankara and Balıkesir provinces of Turkey. The confirmatory factor analysis (CFA) group comprised 376 teacher candidates. The 59-item draft measurement tool was administered to two study groups. These study groups were selected by convenience sampling method, a non-probability sampling method. The data of the first group were used for exploratory factor analysis and the data of the second group were used for confirmatory factor analysis. It was determined that the finalized 37-item and three-part Ecological Literacy Measurement Tool for Adults (ELMT) was valid and reliable in determining the awareness and knowledge of teacher candidates about ecological literacy.

Key words: ecological literacy, ecological awareness, measurement tool, teacher candidate, adult.

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Introduction

Ecological literacy entails understanding that the environment is the basis of prosperity (Boehnert, 2015). The literature on ecological literacy emphasizes the role of scientific knowledge and ecological thought in identifying cause-and-effect relationships related to the environment (Orr, 1992). The overall goal of ecological literacy is to create a frame of thought that recognizes relationships with the natural world, understands interactions, and supports the development of new possibilities for building interdependent sustainable ways of living. Ecological literacy thus prioritizes education to enable informed and engaged citizens to make decisions and take action on environmental issues (Lewinsohn et al., 2015).

While environmental literacy focuses on values and problem-solving, ecological literacy focuses on systems and transforming ecological knowledge into behaviors and attitudes (Coyle, 2005; Disinger & Roth, 1992; McBeth et al., 2008; Payne 2005, 2006; Roth, 1968; Roth, 1992). Eco-literacy involves general concepts such as sustainable living and Gaia (McBride et al., 2013). These concepts highlight the importance of environmental issues and the ability of individuals to use their knowledge to make choices in daily life.

The consensus among experts in this field is that "an ecologically literate person is one who understands the relevance and implications of ecological concepts and human impact on ecosystems" (Balgopal & Wallace, 2009). Vygotsky's sociocultural theory of human learning, which states that the definitions of ecosystem concepts and those concepts themselves are developed through communication and natural observations, is of use for identifying ecologically literate individuals. According to this theory, social interaction has an important role in the development of cognition (Vygotsky, 2012). Since advanced cognitive development tools depend on the adoption of formal and non-formal education, cognitive development cannot be separated from its social context (Yılmaz, 2017). Thus, the lexicons created through background knowledge and context, different sociocultural backgrounds, and the different reflected worldviews need to be considered. To date, many scales for measuring ecological literacy have been developed (Casper et al., 2021; Changchen et al., 2022; Larijani, 2010; Morrone et al., 2001; Stables, 1998; Wilke, 1995a, 1995b).

When we look at the studies on environmental education, we come across studies that aim to define human-environment interactions regarding environmental knowledge, environmental beliefs, behaviors and ecological literacy (Louv, 2006; McBride et al., 2013).

"Environmental education" terms was searched and 86 scales found from Turkish Measurement Tools Directory between 1995 and 2020 have been indexed in the Turkish Measurement Tools Directory (*Türkiye Ölçme Araçları Dizini*: TOAD). These scales measure environmental awareness and sensitivity, environmental attitudes, environmental awareness, environmental behavior, environmental literacy, behaviors towards environmental problems, and the knowledge levels of certain age groups (Akbaş & Kırımlı, 2019; Aslan et al., 2008; Çabuk & Karacaoğlu, 2003; Okyay et al., 2021; Öcal & Önsüz, 2020; Ören et al., 2010; Özcan, 2022; Özdemir, 2023; Özer & Yıldırım, 2021; Timur & Yılmaz, 2013; Uzun & Sağlam, 2006; Yavuz et al., 2014; Yeşilyurt et al., 2013). The samples used in establishing and testing these scales have consisted of various grade levels of students receiving formal education. While there are tools that specifically measure the knowledge of adults regarding ecological literacy (Çabuk & Haktanır, 2017; Okur-Berberoğlu, 2020). The scale developed in the present study is unique in that it was prepared for adults and provides a multidimensional perspective for measuring knowledge and awareness of ecological literacy.

The items and dimensions of the scale were designed for the concept of ecological literacy as defined by Orr (1992) and Capra (1996). By this definition, ecological literacy involves understanding the natural processes that make life on earth possible and exhibiting knowledge, skills, attitudes, values, and understanding towards nature (Capra, 1996; Capra & Stone, 2010).

When the "Sustainable Development Goals" (https://www.kureselamaclar.org) adopted by 193 member countries of the United Nations in 2015 to be achieved by the end of 2030 are examined, it is seen that adults of all ages and professions have the responsibility of being ecologically literate in order to achieve these goals. In a study that systematically reviewed the research on education for sustainable development in early childhood, it was determined that the environmental dimension of sustainability was addressed rather than its socio-cultural and economic dimensions, and this was explained by the fact that environmental issues are more concrete for children (Güler-Yıldız et al., 2021).) It is known that childhood is a critical period in terms of learning to value the living and non-living beings that exist on earth, and that teachers have a very important role in supporting children to become responsible citizens towards their environment (Pamuk-Kahriman & Olgan, 2020; Scott & Sulsberger, 2019). For this reason, it is important to take the necessary precautions for teachers to become ecologically literate starting from the pre-service period. Taking these requirements into consideration, this study aimed to develop a scale to determine the ecological literacy levels

of prospective teachers. It is thought that preparing training programs for teachers, taking into account the information to be obtained through this scale, will provide a scientific basis for the training to achieve its purpose.

This study was planned with the aim of developing a valid and reliable multidimensional measurement tool that will provide information about the ecological literacy of adults.

Method

In this section, the study groups, study design, demographic information, data collection tools, and data analysis are discussed.

Study Design

This study was planned with the aim of developing a valid and reliable multidimensional measurement tool that will provide information about the ecological literacy of adults. Accordingly, the study was conducted using a descriptive design. Descriptive research aims to develop tools for describing, comparing, classifying, analyzing, and interpreting the characteristics of individuals, groups, institutions, methods, or materials (Cohen et al., 2005).

Study Groups

This research included two study groups. The exploratory factor analysis (EFA) group comprised 294 teacher candidates studying in the Ankara and Balıkesir provinces of Turkey. The confirmatory factor analysis (CFA) group comprised 376 teacher candidates from Ankara and Balıkesir. The study groups were selected using the convenience sampling method as a non-probability sampling method (Büyüköztürk, 2008). Data on participants' demographic information, knowledge and opinions on environmental issues, and environmental awareness and knowledge of ecological literacy were obtained with forms developed by the researchers. All participants were enrolled in the study on a voluntary basis.

Table 1 Demographic information about EFA and CFA groups were given.

Table 1 Demographic Information of the Sample

	EFA Group*	**CFA Group***
Age	19-25 years 92.5% (n=272)	18.1% (n=68) (First grade)
Grade	26-30 years 2.7% (n=8) 31-35 years 2.0% (n=6) 36-45 years 2.0% (n=6) 46 years and above 0.7% (n=2)	36.4% (n=137) (Second grade) 13.8% (n=52) (Third grade) 23.1% (n=87) (Fourth grade) 8.5% (n=32) (Other)
Department	5.6% (n=14) 6.1% (n=18) Biology Ed. 29.9% (n=88) Science Ed. 15.6% (n=46) Psyc. guidance and counseling Dept. 48.3% (n=142) Preschool Ed.	11.4% (n=43) Biology Ed. 1.3% (n=5) Science Ed. 71.8% (n=270) Preschool Ed. 0.5% (n=2) Classroom teaching Ed. 14.9% (n=56) Other departments
City	48.3% (n=142) Ankara 51.7% (n=152) Balıkesir	44.4% (n:167) Ankara 55.6%(n=209) Balıkesir
Gender	82.3% (n=242) Female 17.7% (n=52) Male	81.1% (n=305) Female 18.9% (n=71) Male
Total	294	376

EFA Group: Exploratory factor analysis group; CFA Group: Confirmatory factor analysis group

As seen in the Table 1, in the EFA group, 82.3% (n=242) of the participants were female and 17.7% (n=52) were male, while 92.5% (n=272) were aged 19-25 years, 2.7% (n=8) were aged 26-30 years, 2.0% (n=6) were aged 31-35 years, 2.0% (n=6) were aged 36-45 years, and 0.7% (n=2) were aged 46 years and above. In this group, 5.6% (n=14) of the teacher candidates studying at a university second time and those who were both employed and studying were aged 30 years and above. While 6.1% (n=18) of the participants were enrolled in undergraduate programs for teaching biology, 29.9% (n=88) were science teaching undergraduates, 15.6% (n=46) were psychological guidance and counseling undergraduates, and 48.3% (n=142) were preschool education undergraduates. Finally, 48.3% (n=142) of the participants lived in Ankara and 51.7% (n=152) lived in Balıkesir.

In the CFA group, 81.1% (n=305) of the participants were female and 18.9% (n=71) were male. The graduated participants were distributed as follows: 11.4% (n=43) were graduates of programs for teaching biology, 1.3% (n=5) were science teaching graduates, 71.8% (n=270) were preschool education graduates, 0.5% (n=2) were classroom teaching graduates, and 14.9% (n=56) had graduated from other departments. Among those who were currently studying, 18.1% (n=68) were in the first year, 36.4% (n=137) were in the second year, 13.8% (n=52) were in the third year, 23.1% (n=87) were in the fourth year, and 8.5% (n=32) were in other years of their programs. % 44.4(n=167) of the participants lived in Ankara and 55.6% (n=209) lived in Balıkesir.

Data Collection Tools

The data collection tools were developed in accordance with the scale development stages proposed by DeVellis (2017).

In the first stage, the theoretical models of and concepts related to ecological literacy, which the measurement tools developed in this study are intended to measure, were identified and explained.

In the second stage, a literature review was conducted. As a result, it was observed that various scientific studies on environmental literacy, environmental sensitivity, responsibility, environmentally friendly behaviors, and environmental awareness, knowledge, and attitudes have been conducted with children from different age groups and students studying in different undergraduate programs, mostly teaching programs. In addition, there are also studies reviewing educational programs and research conducted on the aforementioned topics. The item pool of this study was created primarily in accordance with the study by Morrone et al. (2001), as well as other studies conducted with students enrolled in different undergraduate teaching programs (Aksoy & Karatekin, 2011; Altınöz, 2010; Artun et al., 2013; Berberoğlu & Tosunoğlu, 1995; Çelebi Öncü & Ünlüer, 2015; Demircioğlu et al., 2015; Doğan, 2013; Erten, 2005; Genç & Genç, 2013; İbiş, 2009; Karakaya & Çobanoğlu, 2012; Karatekin & Aksoy, 2012; Kayalı, 2010; Kıyıcı et al., 2014; Özkubat & Demiriz, 2013; Özsevgeç et al., 2010; Teksöz et al., 2010; Timur, 2011; Tuncer et al., 2009; Tuncer et al., 2014). The dimensions of ecological literacy and the concepts involved in these dimensions were determined and an item pool including items for each dimension was created.

In the third stage, the format of the items was arranged to include 5-point Likert-type scale choices, true/false questions, and multiple-choice questions, with due diligence to ensure that the items appropriately measured the knowledge and behaviors of teacher candidates regarding ecology (Tezbaşaran, 2008).

In the fourth stage, an expert opinion form was prepared to obtain expert opinions on the dimensions of the tools and the concepts they addressed. A total of eight experts (one in measurement and evaluation, one in soil science, one in earth sciences, two in science education, and three in early childhood education) were asked to evaluate the 72 items in terms of their relationships with the four main topics of ecology: the basic principles of ecology, human-nature interactions, environmental values/environmental ethics, and sustainable living.

In the fifth stage, revisions were made in line with the opinions of the experts and three scale drafts with a total of 59 items were created. These were titled "Ecological Literacy Awareness Scale," "Ecological Literacy Knowledge Test (1)," and "Ecological Literacy Knowledge Test (2)." While Knowledge Test (1) consisted of true/false questions, Knowledge Test (2) consisted of multiple-choice questions. Thus, the validity and reliability of these tests were evaluated with different statistical methods. These knowledge tests were numbered sequentially for the same reason. The first part of the instrument included seven questions addressing the demographic information of the participants and their opinions on environmental issues.

In the sixth stage, the scale items were read to five adults. It was determined that three items were not comprehensible and they were revised. The draft scale with the revised items was then administered to 40 adults in writing. The evaluation revealed that the items in the scale were comprehensible. Finally, the scale was completed by volunteering teacher candidates.

Ecological Literacy Awareness Scale

In line with the experts' opinions, the final 25 items in the scale were formatted as a 5-point Likert-type scale and a draft scale form with instructions was created. Using the Likert-type system, respondents scored the extent to which they agreed with a given statement instead of choosing statements they agreed with. In other words, the respondent would respond to all items and indicate the degree of the response. The total score of the scale was calculated as the sum of these individuals scores. Thus, the awareness scale developed here was based on self-reporting (Tavşancıl, 2006: 198) and scale items were scored by respondents from 1 ("strongly disagree") to 5 ("strongly agree").

Sixteen of the scale items were positive statements and nine were negative statements. The items were listed randomly irrespective of the dimensions to which they belonged and whether they were positive or negative. Before implementation, five adults were asked to answer the draft scale verbally and the items in the scale were found to be comprehensible.

Ecological Literacy Knowledge Test (1)

The 17 items of this test were formatted as questions with true/false/don't know answers and a draft scale form with instructions was created. Scale items were scored as true (1) or false (0). Sixteen of the items consisted of true statements and one consisted of a false statement.

Ecological Literacy Knowledge Test (2)

The 17 items of this test were formatted as multiple-choice questions with four possible answers. A draft scale form with instructions was created.

Before implementation, five adults were asked to answer the draft scale verbally and the items in the scale were found to be comprehensible.

Statistical Analysis

EFA was used in the development process of the Ecological Literacy Awareness Scale and item and test statistics were calculated as part of the development process of the Ecological Literacy Knowledge Tests (1) and (2). The main purpose of EFA is to reduce or summarize a large number of variables that are thought to be related to each other into a smaller number of basic dimensions in order to facilitate understanding and interpreting the relationships between them. In other words, it is a method for dimension reduction and the elimination of dependency structures, similar to principal component analysis (Tatlıdil, 1996). Missing data, outliers, and normality assumptions were examined before the analysis was begun (Tabachnick & Fidell, 2001).

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test were also conducted before EFA. The KMO measure reflects the strength of the relationship between a dependent variable and a single independent variable when the effects of all other independent variables are constant. If this value is lower than 0.50, the data are not appropriate for factor analysis (Tavşancıl, 2006). Bartlett's test is used to test the null hypothesis, which posits that correlations in a correlation matrix are equal to zero, or that no relationship exists between variables. The results of Bartlett's test were found to be significant. Thus, it was concluded that there was a relationship between the variables and that this relationship was statistically significant (Kalaycı, 2009).

Eigenvalue calculations and scree plot curves were then used to determine how many dimensions the scale items would be grouped within (Çokluk et al., 2014). Items with factor loadings of less than 0.30 or more than 0.10 were removed from the scale (Büyüköztürk, 2008). Whether the variance explained by the remaining items in the scale was greater than 40% was examined in line with the calculated factor loadings (Çokluk et al., 2014). Finally, Cronbach's alpha reliability coefficient calculations were used to determine the reliability of the answers given to the scale items. The reliability threshold of the dimensions and the whole scale was found to be 0.60 (Kalaycı, 2009).

While developing the Ecological Literacy Knowledge Tests, discrimination and difficulty indices, which are among the approaches for item statistics, were calculated, and then the test statistics of the selected items were calculated. The item discrimination index measures the power of an item to distinguish respondents who have the characteristics intended to be measured from those who do not. The item difficulty index measures the percentage of respondents who answered an item correctly. As a result of these calculations, items with item discrimination values below 0.30 were removed (Özçelik, 2009). The content validity of the remaining items was examined and test statistics (descriptive statistics and KR-20 reliability) were calculated.

While developing the Ecological Literacy Awareness Scale, CFA of the data was performed for the second study group to examine whether the item factor distribution obtained in EFA was confirmed or not. Before CFA, the data were analyzed for accuracy, missing data, and outliers. As a result, some participants were identified as outliers according to their standardized z scores based on a range of +3 to -3, and they were excluded from the data pool (Çokluk et al., 2014). In addition, in order to examine the reliability of the data obtained from the second study group, Cronbach's alpha internal consistency coefficient and CR values were calculated for both the whole scale and its dimensions.

Results

In this section, findings related to the development of each measurement tool are reported.

Findings Related to the Development Process of the Ecological Literacy Awareness Scale

To examine the validity and reliability of the Ecological Literacy Awareness Scale, the answers of 294 adults who completed the scale were subjected to EFA. The KMO value was 0.790 and the result of Barlett's test was found to be significant ($p<0.05$). The data were thus determined to be appropriate for factor analysis (Tavşancıl, 2006). After the analysis, it was seen that there were four dimensions with eigenvalues greater than 1, but the difference between the eigenvalues of the last two dimensions was very small. Figure 1 shows that the items of the scale were grouped within two dimensions.

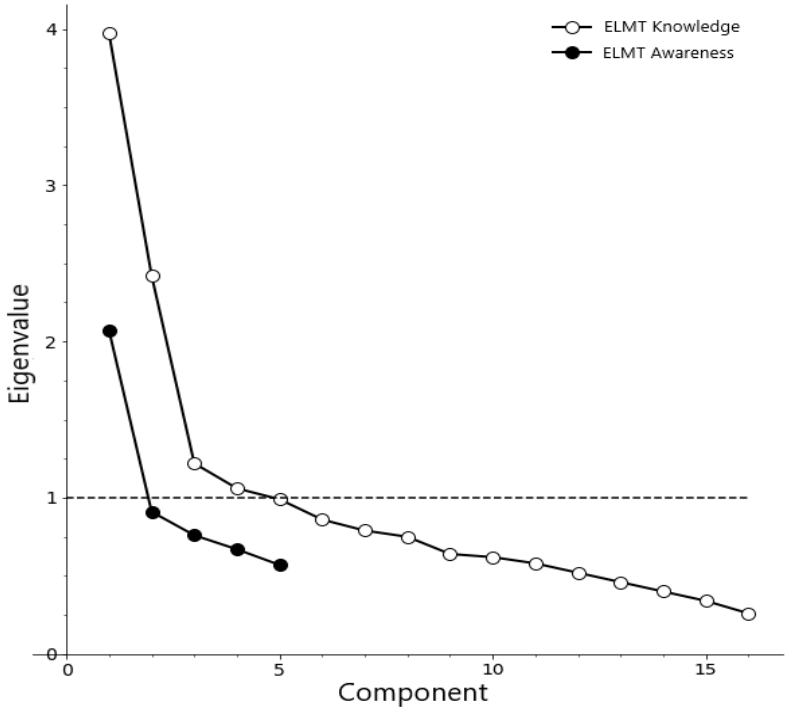

Figure 1 Factor Analysis Results Regarding Components and Eigenvalues of the Ecological Literacy Awareness Scale

In line with the information obtained, the analysis was repeated for two factors. Items with factor loadings below 0.30 and overlapping items (i.e., factor loadings between two factors being below 0.10) were removed from the scale. The analysis was repeated and orthogonal rotation was used to ensure more precise separation of item clusters. The factor loadings of the 16 items remaining in the scale after the analyses are shown in Table 2.

Table 2 Item Factor Loadings of the Ecological Literacy Awareness Scale

Item	Factor	
	1	**2**
MB9	0.801	0.065
MB10	0.752	0.197
MB8	0.641	0.070
MB12	0.614	0.038
MB6	0.588	-0.061
MB3	0.551	0.074
MB5	0.551	-0.100
MB20	0.543	0.326
MB21	0.488	0.302
MB15	0.430	0.184
MB2	0.412	-0.089
MB14	0.356	-0.186
MB23	-0.095	0.857
MB25	-0.107	0.805
MB24	0.254	0.652
MB22	0.051	0.548

Table 2 shows that the factor loadings of the 12 items in the first dimension of the scale varied between 0.356 and 0.801. The factor loadings of the 4 items in the second dimension of the scale varied between 0.548 and 0.857. It was determined that the items in the first dimension, named "Environmental Values and Environmental Ethics," explained 25.315% of the variance, while the items in the second dimension, named "Sustainable Living," explained 15.322% of the variance. The 16 items of the scale explained 40.637% of the total variance, which is a rate that can be considered valid for further analysis (Çokluk et al., 2014).

Cronbach's alpha coefficient was used to determine the reliability of the answers given to the items of the Ecological Literacy Awareness Scale. The Cronbach alpha coefficient of the 12 items in the first dimension was 0.803 and that of the 4 items in the second dimension was 0.725. The reliability coefficient of the total 16 items of the scale was calculated as 0.773. This value suggested that the answers given by the teacher candidates to the scale items were reliable.

Some items from Ecological Literacy Awareness Scale:

8. I believe that the integrity of the ecosystem and the health of the natural environment determine the long-term health and well-being of people.

13. I believe that it is beneficial for the environment if the bag used for transportation is charged when purchasing any product.

15. I am ready to change my lifestyle to help protect the environment.

Findings Related to the Development Process of the Ecological Literacy Knowledge Test (1)

This 17-item test consists of true/false questions and it was prepared to measure the knowledge of adults about ecological literacy. Item discrimination and difficulty indices were calculated based on the answers of 294 adult respondents. The results are shown in Table 3.

Table 3 Discrimination and Difficulty Indices of the Items of The Ecological Literacy Knowledge Test (1)

Item	Item difficulty		Item discrimination	
	First analysis	Second analysis	First analysis	Second analysis
MC26	0.49	0.49	0.45	0.42
MC27*	0.91	---	0.10	---
MC28	0.73	0.73	0.49	0.56
MC29*	0.97	---	0.06	---
MC30	0.49	0.49	0.41	0.40
MC31*	0.98	---	0.04	---
MC32*	0.93	---	0.15	---
MC33	0.68	0.68	0.37	0.45
MC34	0.50	0.50	0.57	0.62
MC35*	0.94	---	0.07	---
MC36	0.41	0.41	0.49	0.55
MC37	0.51	0.51	0.47	0.51
MC38	0.52	0.52	0.42	0.42
MC39*	0.90	---	0.19	---
MC40*	0.91	---	0.14	---
MC41*	0.97	---	0.05	---
MC42	0.44	0.44	0.33	0.37

*Items removed from the test.

When Table 3 is examined, it is seen that the discriminatory powers of items 27, 29, 31, 32, 35, 39, 40, and 41 of the Ecological Literacy Knowledge Test (1) were below 0.30. These items were all answered correctly by 90% of respondents or more, which suggests low difficulty. Although these items were within the scope of the subject, it was determined that their discrimination was low as a result of their low difficulty for adults and these items were accordingly removed from the test.

Analyses were repeated for the remaining nine items in the Ecological Literacy Knowledge Test (1). Results showed that the difficulty indices of these items varied between 0.41 and 0.73. In other words, the test mostly comprised items with low to medium difficulty. The discrimination indices of the items ranged between 0.37 and 0.62. This indicates that the items in the Ecological Literacy Knowledge Test (1) had moderate to very good discrimination.

The test statistics of the items remaining in the test were calculated and the results are shown in Table 4.

Table 4 Test Statistics of the Ecological Literacy Knowledge Test (1)

Test statistics	**Values**
Number of participants	294
Minimum number of correctly answered questions	0
Maximum number of correctly answered questions	9
Mean difficulty of the items	0.530
Mean discrimination of the items	0.476
Reliability of the items (KR-20)	0.689

Table 4 shows that, of the 294 adult respondents, some could not answer any items of the Ecological Literacy Knowledge Test (1) correctly, while some answered all items correctly. The mean difficulty of the items in the test was calculated as 0.530. In other words, the test was found to have medium difficulty. Kline (2011) stated that achievement tests should be of medium difficulty. The mean discrimination of the items in the test was calculated as 0.476. Thus, it can be said that the test is a good discriminator. The reliability of the answers given to the items in the test was measured using the KR-20 coefficient. The KR-20 coefficient was calculated as 0.689, which showed that the internal consistency of the results was high.

Some items from Ecological Literacy Knowledge Test (1):

2. The increase in water temperature on the ocean surface affects the whole world.

5. Farmers grow corn one year, soy the next, and wheat the next year. This is called crop rotation. In this case, the need for pesticides is reduced.

7. The number of people the world can feed is limited.

Findings Related to the Development Process of the Ecological Literacy Knowledge Test (2)

The final aim of this study was to measure the knowledge of adults in terms of ecological literacy. Accordingly, item discrimination and difficulty indices were calculated for the 17 multiple-choice items based on the answers given by the participants. The results are shown in Table 5.

Table 5 Discrimination and Difficulty Indices of the Items of the Ecological Literacy Knowledge Test (2)

Item	Item difficulty		Item discrimination	
	First analysis	Second analysis	First analysis	Second analysis
ME50*	0.12	---	0.14	---
ME51*	0.89	---	0.09	---
ME52	0.75	0.75	0.32	0.33
ME53	0.26	0.26	0.30	0.34
ME54	0.60	0.60	0.32	0.31
ME55	0.63	0.63	0.30	0.34
ME56*	0.39	---	0.21	---
ME57	0.51	0.51	0.34	0.30
ME58	0.38	0.38	0.40	0.45
ME59*	0.87	---	0.19	---
ME60*	0.69	---	0.21	---
ME61	0.45	0.45	0.38	0.47
ME62	0.48	0.48	0.32	0.40
ME63	0.69	0.69	0.30	0.31
ME64	0.55	0.55	0.43	0.46
ME65	0.36	0.36	0.32	0.33
ME66	0.64	0.64	0.46	0.50

*Items removed from the test.

Table 5 shows that items 50, 51, 56, 59, and 60 of the Ecological Literacy Knowledge Test (2) had low discrimination (below 0.30). Accordingly, these items were removed from the test and the analyses were conducted again.

The item difficulty indices of the remaining 12 items of the Ecological Literacy Knowledge Test (2) were between 0.26 and 0.75. This suggests that the test mostly comprised items of low to medium difficulty. The discrimination indices of the items ranged between 0.31 and 0.50. This indicates that the items of the Ecological Literacy Knowledge Test (2) had moderate to very good discrimination.

The test statistics of the items remaining in the test were calculated and the results are shown in Table 6.

Table 6 Test Statistics of the Ecological Literacy Knowledge Test (2)

Test statistics	Values
Number of participants	294
Minimum number of correctly answered questions	0
Maximum number of correctly answered questions	12
Mean difficulty of the items	0.525
Mean discrimination of the items	0.373
Reliability of the items (KR-20)	0.695

Table 6 shows that, of the 294 adult respondents, some could not answer any items in the Ecological Literacy Knowledge Test (2) correctly, while some answered all items correctly. The mean difficulty of the items in the test was calculated as 0.525. This means that the test has medium difficulty. Kline (2011) stated that achievement tests should be of medium difficulty. The mean discrimination of the items in the test was calculated as 0.373. Therefore, the test was found to be a good discriminator. The KR-20 coefficient of this test was 0.695, which indicates that the internal consistency of the results was high.

Some items from Ecological Literacy Knowledge Test (2):

2. Which of the following is better than others in cleaning water in natural areas?

a. wetlands

b. lakes

c. rivers

d. I don't know

5. Which of the following is true about the total amount of water on Earth?

a. Increases

b. decreases

c. Constant

d. I don't know

Table 7 Parts and Numbers of Items in the Ecological Literacy Measurement Tool for Adults

Part	Format	Initial item count	Final item count
Awareness Scale	5-point Likert-type	25	16
Knowledge Test (1)	True/false	17	9
Knowledge Test (2)	Multiple-choice	17	12
Total		59	37

Table 7 shows the question formats used in the parts of the measurement tool and the distributions of initial items prepared according to expert opinions and final items remaining in the scale after revisions made based on validity and reliability analyses. As a result, the Awareness Scale had 16 final items, the Knowledge Test (1) had 9, and the Knowledge Test (2) had 12. Thus, the finalized Ecological Literacy Measurement Tool for Adults (ELMT) has a total of 37 items.

CFA Results

CFA was conducted to measure the construct validity of the Ecological Literacy Awareness Scale. The AMOS diagram of factor loadings and error variances obtained from CFA is given in Figure 2.

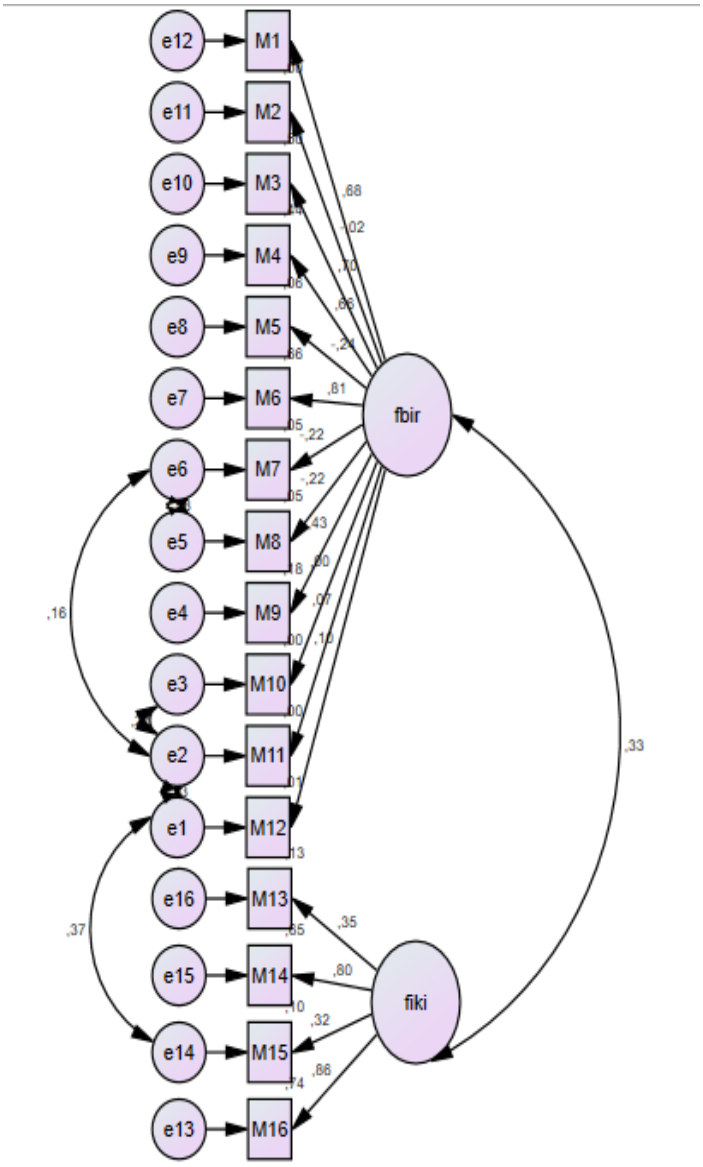

Figure 2 Ecological Literacy Awareness Scale AMOS Path Diagram

Various fit indices are used to examine the fit between covariance matrices. The fit index values and fit of the scale are accordingly presented in Table 8.

Table 8 Ecological Literacy Awareness Scale Confirmatory Factor Analysis Fit Indices

Fit Index	**χ^2/sd**	**GFI**	**IFI**	**RMSEA**	**RMR**	**TLI**	**CFI**
Value	(283,984/93) 3,054	0.907	0.878	0.074	0.081	0.839	0.875
Fit	Good Fit	Good Fit	Good fit	Good fit	Good fit	Good fit	Good fit

Table 8 shows that the χ2/sd (3.054) (Schermelleh-Engelet al., 2003), RMSEA (0.074) (Steiger, 2007), and RMR (0.081) (Brown, 2006 as cited in Çokluk et al., 2014) values of the scale reflect goodness of fit, satisfying the relevant thresholds of <5.00, <0.08, and ≤0.08, respectively. A GFI value of ≥0.90 (Tabachnick & Fidell, 2001) and TLI, CFI, and IFI values of ≥0.80 also indicate good fit (Browne & Cudeck, 1992; Chinda et al., 2012; Garson, 2008).

Table 9 Cronbach's Alpha, AVE, and CR Results

Items	**Factor loadings**	**Cronbach's alpha**	**CR**
Ecological Literacy Awareness Scale		0.727	0.935
Environmental Values and Environmental Ethics		0.625	0.896
M1	0.412		
M2	0.551		
M3	0.551		
M4	0.588		
M5	0.641		
M6	0.801		
M7	0.752		
M8	0.614		
M9	0.356		
M10	0.430		
M11	0.543		
M12	0.488		
Sustainable Living		0.695	0.878
M13	0.857		
M14	0.805		
M15	0.652		
M16	0.548		

Table 9 shows that the CR values of the Ecological Literacy Awareness Scale are above 0.8, which indicates that the scale has appropriate divergent validity (Fornell & Larcker, 1981). The Cronbach alpha coefficients of the scale suggest that the scale is reliable (Özdamar, 2004).

Conclusion, Discussion, and Suggestions

In this study, the Ecological Literacy Measurement Tool for Adults (ELMT) was developed to measure the ecological literacy of adults. The study was conducted with two

study groups. EFA was conducted with data obtained from the first group of 294 teacher candidates and CFA was conducted with data obtained from the second group of 376 teacher candidates. As a result of the analysis of the findings, the finalized ELMT was designed to consist of three parts, including the Awareness Scale, Knowledge Test (1), and Knowledge Test (2).

EFA was conducted to confirm the validity of the ELMT. The results of that analysis indicated that the tool had appropriate fit between its whole and its parts. In addition, CFA was performed to determine whether the items were valid. The results showed that the construct and content validity of the ELMT were both adequate. The expert team assembled to determine the content validity of the ELMT stated that the items in each part of the tool would be able to measure the ecological literacy levels of adults. Hence, it was concluded that the ELMT could measure the selected characteristic.

For reliability analysis, the Cronbach alpha reliability coefficient and internal consistency (KR-20) coefficient were used. It was determined that the values obtained as a result of the reliability analysis of the ELMT were sufficient in relation to the whole scale. In other words, the tool was internally consistent.

The item pool of the scale initially included 72 items related to the four main topics of ecology: basic principles of ecology, human–nature interactions, environmental values/environmental ethics, and sustainable living. The 37 items remaining after validity and reliability analysis also addressed these four main topics of ecology, with 14 items for the basic principles of ecology, 7 items for human–nature interactions, 8 items for environmental values/environmental ethics, and 8 items for sustainable living. The basic principles of ecology (Duailibi, 2006), human-nature interactions (Muntean & Gînju, 2017), environmental values/environmental ethics (Martin, 2008), and sustainable living (Jiménez, 2019) were similarly associated with ecological literacy in various previous studies. Moreover, the ELMT includes topics addressed in the scale developed by Pitman and Daniels (2016) and the scale developed by Okur-Berberoğlu (2020) on ecological knowledge, while also including a new part on ecological awareness. Thus, it can be said that the ELMT measures a wider range of issues than its counterparts. Nevertheless, the ELMT is limited to the four basic principles of ecology and the concepts they involve. Future studies could expand the dimensions of the scale and develop different instruments by adding items related to other topics of ecology to this measurement tool.

In conclusion, it can be said that the 37-item ELMT is a valid and reliable measurement tool for measuring the ecological literacy of adults. This tool provides insight about the ecological literacy of respondents when all three parts and all items of the tool are applied together. Thus, the three parts of the scale should be used together. The tool has a score range of 16 to 101, with higher scores indicating higher levels of ecological literacy.

The results of this study show that a scale applicable for all professional groups involved in production and consumption, and especially researchers interested in environmental education, local governments wishing to determine the ecological literacy level of society, and non-governmental organizations, teachers, lecturers, and agricultural workers, has been produced.

The lacking knowledge of individuals whose ecological knowledge and awareness levels are measured with this tool should be advanced through preservice or in-service training programs, which can support individuals in developing the right attitudes and behaviors. It is also thought that the ELMT can be used in future studies to measure the effect and permanence of training programs prepared for adults after determining their ecological literacy levels. This tool does not measure the dimensions of attitudes and behaviors. Further development of valid and reliable measurement tools that can measure attitudes and behaviors in addition to the dimensions measured by the ELMT would provide a more comprehensive perspective on ecological literacy.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

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Research involving Human Participants and/or Animals

03/02/2021 date and 52899066/302.08.01/7769 number of the ethical statement. It was given by Balıkesir University Social Sciences and Humanities Ethics Commission.

Yetişkinler İçin Ekolojik Okuryazarlık Ölçme Aracı: Güvenirlik ve Geçerlik Çalışması

Özet:

Bu çalışma yetişkinlerin ekolojik okuryazarlık durumları hakkında bilgi edinilebilecek, geçerli ve güvenilir bir ölçme aracı geliştirmeyi amaçlamaktadır. Bu amaçla alan yazın taranarak oluşturulan 72 madde ve üç bölümlük ölçme aracı uzman görüşlerine sunulmuş alınan dönütler doğrultusunda yapılan düzenlemelerle 25 maddelik 5'li likert tipi Ekolojik Okuryazarlık Farkındalık Ölçeği; 17 maddelik doğru/yanlış tipi Ekolojik Okuryazarlık Bilgi Testi (1) ve 17 maddelik çoktan seçmeli Ekolojik Okuryazarlık Bilgi Testi (2) oluşmuştur. Bu araştırmaya iki çalışma grubu dahil edilmiştir. Açımlayıcı faktör analizi (EFA) grubu Ankara ve Balıkesir illerinde öğrenim gören 294 öğretmen adayından oluşmuştur. Doğrulayıcı faktör analizi (DFA) grubu 376 öğretmen adayından oluşmuştur. Toplam 59 maddelik taslak ölçme aracı iki çalışma grubuna uygulanmıştır. Çalışma grupları olasılığa dayalı olmayan örnekleme yöntemlerinden kolay örnekleme yöntemi ile belirlenmiştir. Çalışma gruplarından ilkinin verileri açımlayıcı faktör analizi hesaplarında, ikinci grubun verileri ise doğrulayıcı faktör analizi hesaplarında kullanılmıştır. Yapılan analizler sonucunda 37 madde ve 3 bölümden oluşan "Yetişkinler İçin Ekolojik Okuryazarlık Ölçme Aracı" nın öğretmen adaylarının ekolojik okuryazarlık konusundaki farkındalık ve bilgi durumlarını belirlemede geçerli ve güvenilir olduğu belirlenmiştir.

Anahtar kelimeler: ekolojik okuryazarlık, ekolojik farkındalık, öğretmen adayı, yetişkin.

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