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Development of a Measurement Tool for Determining Secondary School Students' Energy Literacy Levels

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Abstract

The purpose of this study is to develop a measurement tool to determine the energy literacy levels of secondary school students in science classes. This study was conducted using a survey design, which was addressed within the scope of quantitative study methodology. The sample of the study consisted of 278 secondary school students enrolled in two secondary schools located in Ağrı province. In this study, a measurement tool consisting of three parts was developed based on expert opinions. The first part of the measurement tool was developed to determine students' cognitive energy literacy levels. The results indicated that, a multiple-choice test consisting of 38 questions with moderate difficulty, high discriminative power, and high reliability was obtained. The second part of the measurement tool was developed to determine students' affective energy literacy levels. As a result of the analysis conducted for the second part, a questionnaire consisting of 16 items, with a four-factor structure and high reliability, was obtained. The third part of the measurement tool was developed to assess students' behavioral energy literacy levels. Analysis of the third part revealed that, a questionnaire consisting of 17 items, with a four-factor structure, and high reliability was obtained.

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Introduction

In contemporary science education, a primary goal is to help students explore natural phenomena and understand the fundamental principles that govern interactions in nature (Alsop & Watts, 2003). Instructional processes are therefore designed to provide students with opportunities to apply the knowledge and skills they acquire to everyday situations. In line with this approach, science instruction includes learning-supportive activities such as observation, experimentation, and data analysis (Osborne, 2007). Despite these efforts, students often experience difficulties in learning science. This is largely because many scientific concepts are abstract, interconnected, and complex (Ayvacı et al., 2015).

Numerous studies on students' perceptions of the concept of energy indicate that energy is addressed across a wide range of disciplines, which makes the concept difficult for students to understand clearly (Güneş & Taştan-Akdağ, 2016; Ürey & Kavgacı, 2021). In addition, research has shown that students who do not develop a clear understanding of energy experience greater difficulty in learning other science topics. For instance, Ürey (2018) found that students' incorrect and/or incomplete conceptions of energy led them to express non-scientific views about photosynthesis.

Numerous studies in the literature have shown that students at different grade levels struggle to develop a clear understanding of the concept of energy and often hold non-scientific views about energy-related topics (Başkan-Takaoğlu, 2018; Boz, 2020; Güneş & Taştan-Akdağ, 2016; Kıryak et al., 2019; Oluk & Oluk, 2016). Therefore, it can be concluded that greater emphasis should be placed on energy education.

Within the scope of energy education, instruction addresses key topics such as the definition of energy, energy transfer and transformation, energy conservation and storage, energy production, energy sources, types of energy, and the efficient and safe use of energy (Ayvacı et al., 2021; Güneş & Taştan-Akdağ, 2016; Kurnaz & Sağlam-Arslan, 2011). In addition, energy education aims to promote students' positive attitudes and responsible behaviors toward environmental issues, including air pollution, climate change, and global warming (DeWaters & Powers, 2013; Ertaş et al., 2019; Lee et al., 2015; Lin & Lu, 2018). In this sense, science courses address not only core energy concepts but also related environmental concepts. Ultimately, the goal is to develop energy-literate individuals.

Energy-literate individuals are those who have a cognitive understanding of energy-related concepts, can take responsibility for addressing energy-related problems, and are able to develop appropriate behaviors in this regard. In addition, energy education aims to foster individuals who hold positive attitudes toward energy-related issues and use energy in a conscious and responsible manner (DeWaters & Powers, 2013). According to DeWaters and Powers (2013), the main characteristics of energy-literate individuals include the following:

- Have a basic understanding of how energy is used in everyday life.
- Understand the impacts of energy production and consumption on the environment and various aspects of society.

- Recognize the effects of individual, collective, and organizational energy-related decisions and actions on the global community.
- Acknowledge the need for energy conservation and the development of alternatives to fossil fuel–based energy sources.
- Make choices, decisions, and actions that reflect an informed and responsible approach to energy resource development and energy consumption.
- Possess the cognitive, affective, and behavioral skills necessary to achieve the goals of energy literacy.

Although the cognitive qualities expected of energy-literate individuals are explicitly stated as learning outcomes in the science curriculum, affective and behavioral qualities are generally conveyed implicitly (Ayvacı et al., 2015). Therefore, it is important to examine this implicit structure within the science curriculum and to identify elements related to energy literacy. Moreover, many studies in the literature indicate that energy literacy–related dimensions are not adequately represented in curricula (Boz & Görgülü-Arı, 2021; DeWaters & Powers, 2013).

A review of the literature on energy literacy shows that existing studies generally fall into three main groups. The first group includes studies that examine students' views on energy and basic energy-related concepts (Başkan-Takaoğlu, 2018; Güneş & Taştan-Akdağ, 2016; Kavgacı, 2020; Oluk & Oluk, 2016; Ünal-Çoban et al., 2007). The second group consists of studies that focus on the dimensions of energy literacy among different sample groups (Ayata, 2021; Boz & Görgülü-Arı, 2021; Lee et al., 2015; Oluk et al., 2019). In addition to these studies, the literature includes several scale development studies related to energy. However, these scales are generally subject-specific and focus on particular topics such as renewable energy, electrical energy, or nuclear energy (DeWaters et al., 2013; Dumanoğlu & Akçay, 2018; Güney, 2018; Okur & Yalçın-Özdilek, 2013). Overall, the literature lacks a comprehensive measurement tool that addresses energy as a complex and interdisciplinary concept in all of its dimensions.

This study aimed to develop a holistic measurement tool for secondary school students within the science curriculum that addresses energy literacy across cognitive, affective, and behavioral dimensions.

Method

This study was conducted using a survey design, which is considered within the scope of the quantitative research method.

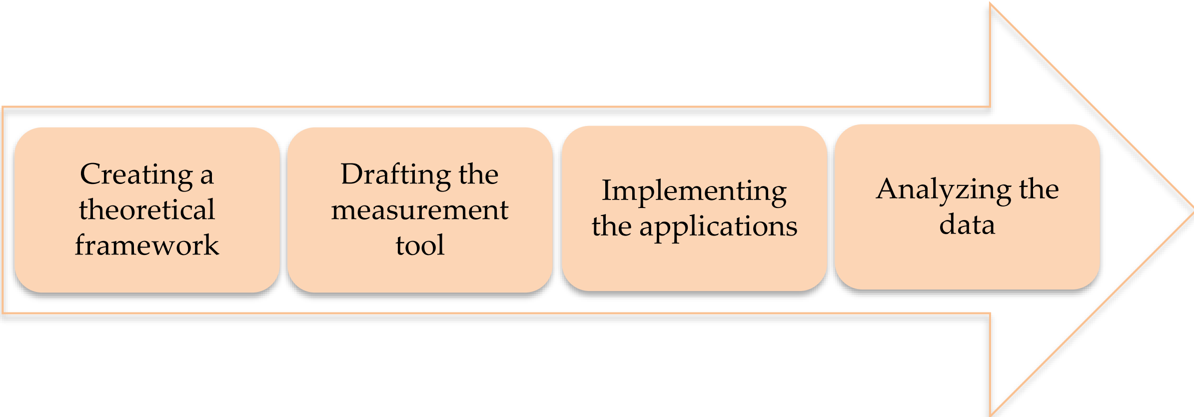

Figure 1. The stages of the measurement tool development process

Theoretical Framework on Energy Literacy

In this study, the aim was to design a theoretical framework for energy literacy in the context of the science curriculum. Based on this point, the learning outcomes related to energy literacy in the Science Curriculum were determined. Then, a form including the content summaries in the textbooks related to these learning outcomes was developed. This form was developed in collaboration with two faculty members (U1, U2) who are experts in the field of energy education and one science teacher (U3). As a result of the content analysis, a theoretical framework for energy literacy in the context of the science curriculum was created. Table 1 presents the theoretical framework of energy literacy in line with the opinions of three field experts.

Table 1. The theoretical framework for energy literacy

Elements	**Categories**	**Subcategories**	**Field Experts**		
			U1	**U2**	**U3**
Basic Elements	Key concepts	Energy	✓	✓	✓
		Heat	✓	✓	✓
		Light	✓	✓	
		Voice	✓		✓
		Electricity	✓	✓	
	The nature of energy	Energy transfer/transmission	✓		✓
		Energy transformation		✓	✓
		Energy conservation	✓	✓	✓
		Energy storage	✓		
	Energy types	Kinetic energy	✓	✓	✓
		Potential energy	✓	✓	✓
	Energy sources	Non-renewable resources	✓	✓	✓

		Renewable resources	✓	✓	✓
Related Elements	Energy and the environment	Natural phenomena	✓		
		Energy production in living organisms		✓	✓
		Energy health and safety	✓		✓
	Energy and technology	Power plants	✓		✓
		Technological tools		✓	✓
	Energy and the economy	Efficient use of energy	✓	✓	✓
		Illegal use of energy	✓		

Drafting the Measurement Instrument

The measurement tool designed to determine secondary school students' energy literacy levels in the context of the science curriculum consists of three parts. The first part is an example of a test containing multiple-choice questions to assess students' energy literacy levels. In the process of designing the first part, firstly, teaching outcomes were determined based on the theoretical framework of energy literacy. Then, 44 questions with four options were designed according to the teaching outcomes. In the process of creating the draft, two faculty members working in the field of energy education and one science teacher were utilized. Necessary corrections were made in line with the opinions of the field experts. In general, feedback was received from the field experts in the form of "some multiple-choice questions covered more than one outcome, some questions did not match the outcomes, the questions should be organized visually, and there were spelling mistakes". The specification table created according to Bloom's Taxonomy for the final version of the first section is presented in Appendix 1.

The second part consists of a scale containing 5-point Likert-type items for assessing students' energy literacy levels. The first draft of the second part included 25 items. The opinions of field experts were consulted regarding the first draft. In general, the field experts gave feedback that "items with the same meaning were included, some negative items caused comprehension difficulties, the questionnaire should be organized visually, and there were spelling mistakes". In this context, it was decided to include 18 items in the final draft of the second part. Thirteen of these items, "I3, I6, I7, I8, I9, I10, I11, I12, I13, I14, I15, I16, I18," were organized based on the fifth, sixth, and seventh grade science curriculum. The remaining five items, "I1, I2, I4, I5, I17," were designed in parallel with the theoretical framework of energy literacy.

The third part consists of a scale containing 5-point Likert-type items for assessing students' energy literacy levels. The first draft of the third section included 25 items. The opinions of field experts were consulted regarding the first draft. In general, the field experts gave feedback that "items with similar meanings were included, some items were confusing, the scale should be visually organized, and there were spelling mistakes". In this context, it was decided to include 18 items in the final draft of the third section. Thirteen of these items, "I1, I2, I3, I4, I5, I9, I10, I11, I12, I13, I14, I15, I17," were organized based on the fifth, sixth, and seventh grade science curriculum. The remaining five items, "I6, I7, I8, I16, I18," were designed in parallel with the theoretical framework of energy literacy.

Implementation of the Practices

This study was conducted with 278 seventh-grade students enrolled in Secondary School A and Secondary School B located in the central district of Ağrı province during the 2021–2022 academic year. Data collection was carried out in both schools under the supervision of science teachers. Detailed information about the study sample is presented in Table 2.

Table 2. Sample of the study

School	Girl		Male		Total		Age Ranges
	N	%	N	%	N	%	
A Secondary School	76	44	98	56	174	100	13-14
B Secondary School	58	56	46	44	104	100	13-15

Data Analysis

The data obtained from the measurement tool designed to determine the energy literacy levels of secondary school students in the context of the science curriculum were analyzed in three stages.

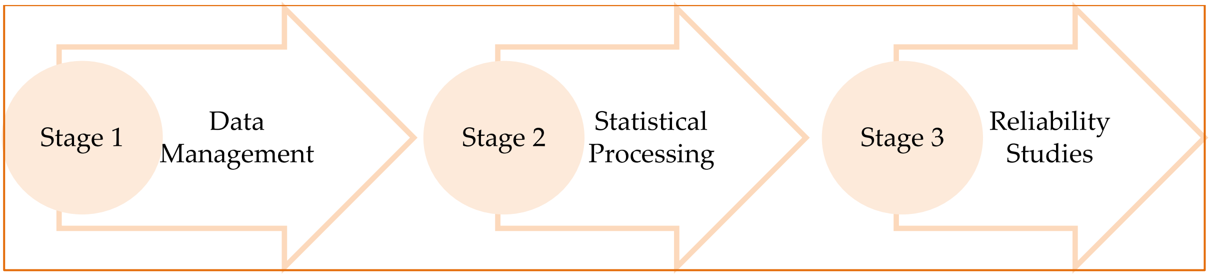

Figure 2. Data analysis process

The data obtained from the first part of the measurement tool were given scores as "correct answer (1 point), wrong answer (0 point), and blank (0 point)". Subsequently, item analyses were conducted. For this purpose, the number of correct answers given by 27% of the students in the upper group and 27% of the students in the lower group to the related questions was determined. Then, the number of students in the upper group (N), the number of students in the lower group (N'), the total number of correct answers (Dtop), the number of correct answers in the upper group (Düst), the number of correct answers in the lower group (Dalt), item difficulty index (pi) and item discrimination index (rjx) values were determined. Table 3 shows the formula of item difficulty index (pi) values and evaluation criteria for the questions in the first section (Büyüköztürk, 2018).

Table 3. Calculation of item difficulty index (PI) values

Formula	Evaluation Criteria
$pi = \frac{\text{Dalt} + \text{Düst}}{\text{N} + \text{N}'}$	According to Büyüköztürk (2018); • Questions with an item difficulty index less than 0.3 or greater then 0.8 should be removed from the measurement tool.

Table 4 shows the formula and evaluation criteria for the item discrimination index (pi) values for the questions in the first section (Büyüköztürk, 2018).

Table 4. Calculation of item discrimination index (rjx) values

Formula	Evaluation Criteria
$rjx = \frac{\text{Düst} - \text{Dalt}}{\text{N}}$	According to Büyüköztürk (2018); • 0,40≤ rjx; the item is a very good • 0,30≤ rjx<0,39; the item is a good • 0,20≤ rjx<0,29; the item should be corrected • rjx<0,20; the item should be removed

While calculating the reliability of the first part, the number of items in the test (K), the difficulty level of item i (pi), the difficulty level of item i (qi), and the variance value of the test scores (Sx2) were calculated. Based on these values, the Kuder Richardson-20 (KR-20) internal consistency coefficient was determined. Table 5 shows the formula and evaluation criteria for the Kuder Richardson-20 (KR-20) internal consistency coefficient value (Kuder & Richardson, 1937; Tavşancıl, 2014).

Table 5. Calculation of Kuder Richardson-20 (KR-20) internal consistency coefficient values

Formula	Evaluation Criteria
$\text{KR} - 20 = \frac{\text{K}}{\text{K} - 1}\left(1 - \frac{\sum pi.qi}{S_{x^2}}\right)$	According to Tavşancıl (2014); • 0,00≤KR-20<0,40; the test is not reliable • 0,40≤KR-20<0,60; the test is low reliability • 0.60≤KR-20<0.80; the test is quite reliable • 0.80≤KR-20<1.00; the test is highly reliable

In this study, the data obtained from the first part of the measurement tool were analyzed using Microsoft Excel 2016.

In the second and third sections of the measurement tool, 5-point Likert-type questionnaires were included. The data obtained from the second section were scored as "strongly disagree" (0 point), "disagree" (1 point), "undecided" (2 points), "agree" (3 points), and "strongly agree" (4 points). The data obtained in the third section were scored as "never" (0 point), "rarely" (1 point), "sometimes" (2 points), "usually" (3 points), "always" (4 points). Student responses to the negative items in the second and third sections were reversed. Then, the suitability of the data set for Exploratory Factor Analysis was evaluated. Table 6 shows the procedures and evaluation criteria for assessing the suitability of the data set for Exploratory Factor Analysis (Fabrigar & Wegener, 2012; Gürbüz & Şahin, 2014).

Table 6. Evaluation of the suitability of the data set for exploratory factor analysis

Transactions	Evaluation Criteria
1. KMO Sampling Adequacy Test value was calculated.	• According to Fabrigar & Wegener (2012), the suitability of the data set for factor analysis is considered excellent if the KMO value is 0.90 and above, valuable if it is 0.80, and moderate if it is 0.70.
2. Barlett Sphericity Test value was calculated.	• According to Gürbüz & Şahin (2014), $p < .005$ as a result of Barlett's Sphericity Test is required to show that there is a sufficient level of relationship between the variables for factor analysis.

Finally, Exploratory Factor Analysis was conducted using Principal Component Analysis-Multivariate (Varimax) orthogonal rotation method. Table 7 shows the procedures and evaluation criteria for Exploratory Factor Analysis (Büyüköztürk, 2018).

Table 7. Procedures performed regarding exploratory factor analysis

Transactions	Evaluation Criteria
1. The extraction value in the Common Variance Table of the items was analyzed.	• According to Gürbüz & Şahin (2014), items with an extraction value less than 0.2 should be removed from the measurement tool and the analysis should be repeated.
2. Scree plot of the slope was analyzed.	• According to Gürbüz & Şahin (2014), it is understood that the factors after the point where the graph starts to plateau or flatten do not make a significant contribution to the explained variance.
3. The eigenvalues in the Total Explained Variance Table were analyzed.	• According to Büyüköztürk (2018), factors with eigenvalues greater than 1 are considered significant. It is recommended that the total variance explained by all factors should be at least 50%.
4. The factor loadings in the Components Matrix Table were analyzed.	• According to Gürbüz & Şahin (2014), the lower limit of the factor loading value to be displayed is recommended to be 0.3.
5. The factor load distributions in the Rotated Components Matrix Table were examined.	• According to Büyüköztürk (2018), items that are under more than one factor and the difference between the loading values in these factors is less than "0.100" should be removed from the scale.
6. Factors are named.	• According to Gürbüz & Şahin (2014), items gathered under the same factor are named to indicate a common theme.

While calculating the reliability of the second and third sections, the number of items in the test (K), the variance value of each item (Vi), and the variance value of the test were first calculated. Based on these values, Cronbach's Alpha reliability coefficient (α) values were determined. Table 8 shows the formula and evaluation criteria for the Cronbach Alpha Reliability Coefficient (α) value (Cronbach, 1951; Tavşancıl, 2014).

Table 8. Calculation of cronbach alpha reliability coefficient (α) values

Formula	Evaluatinon Criteria
$\alpha = \left(\frac{K}{K-1}\right)\left(1 - \frac{\sum V_i}{V_T}\right)$	According to Tavşancıl (2014); • 0,00≤ α <0,40; the test is not reliable • 0,40≤ α <0,60; the test is low reliability • 0.60≤ α <0.80; the test is quite reliable 0.80≤ α <1.00; the test is highly reliable

In this study, the data obtained from the second and third parts of the measurement tool were analyzed using the IBM SPSS Statistics 2025 package program.

Findings

This section presents the results of the analyses conducted on the first (cognitive), second (affective), and third (behavioral) sections of the measurement tool.

First (Cognitive) Part of the Measurement Tool

The first part consists of a test containing multiple-choice questions to determine the energy literacy levels of seventh-grade students cognitively. Table 9 presents the item analysis results for the first part of the measurement tool.

Table 9. Item analysis results for the first part of the measurement tool

Question Number		D_{Total}	$D_{Üst}$	D_{Alt}	pi	rjx	Conclusion
Before	After						
1	1	131	48	19	0,45	0,39	Good
2	2	143	55	27	0,55	0,38	Good
5	3	135	53	18	0,48	0,47	Very Good
6	4	141	56	14	0,47	0,57	Very Good
7	5	155	53	22	0,51	0,42	Very Good
8	6	127	47	18	0,44	0,39	Good
9	7	164	58	30	0,59	0,38	Good
10	8	144	55	24	0,53	0,42	Very Good
11	9	169	57	26	0,56	0,42	Very Good
12	10	165	66	25	0,61	0,55	Very Good
13	11	145	55	22	0,52	0,45	Very Good
14	12	165	58	30	0,59	0,38	Good
15	13	141	61	20	0,55	0,55	Very Good
16	14	145	61	25	0,58	0,49	Very Good
19	15	134	47	21	0,46	0,35	Good
20	16	154	54	24	0,53	0,41	Very Good
21	17	146	62	18	0,54	0,59	Very Good

22	18	157	60	21	0,55	0,53	Very Good
24	19	147	54	17	0,48	0,50	Very Good
25	20	139	62	17	0,53	0,61	Very Good
26	21	148	50	24	0,51	0,35	Good
27	22	137	49	16	0,44	0,45	Very Good
28	23	145	53	28	0,55	0,34	Good
29	24	157	54	23	0,52	0,42	Very Good
30	25	153	54	27	0,55	0,36	Good
31	26	154	60	27	0,59	0,45	Very Good
32	27	163	66	23	0,60	0,58	Very Good
33	28	156	62	23	0,57	0,53	Very Good
35	29	166	58	32	0,61	0,35	Good
36	30	144	60	22	0,55	0,51	Very Good
37	31	155	61	24	0,57	0,50	Very Good
38	32	163	65	26	0,61	0,53	Very Good
39	33	149	64	22	0,58	0,57	Very Good
40	34	170	67	30	0,66	0,50	Very Good
41	35	143	56	22	0,53	0,46	Very Good
42	36	150	63	24	0,59	0,53	Very Good
43	37	154	63	19	0,55	0,59	Very Good
44	38	158	57	28	0,57	0,39	Good

As a result of the item analysis of the first part, it was decided to remove six questions (Q3, Q4, Q17, Q18, Q29, and Q34) from the measurement tool. It was determined that the item difficulty index (pi) values calculated for the questions coded "Q3, Q4, Q18, and Q34" in the first part of the first section were not in the appropriate range. In addition, it was determined that the item discrimination index (rjx) values calculated for the questions coded "Q17 and Q29" were not suitable for the evaluation criteria. The questions coded "Q1, Q3, Q4, Q6, Q15, Q19, and Q22" in the last part of the first section were coded "Q2, Q7, Q9, Q10, Q11, Q12, Q13, Q14, Q15" with item difficulty index (pi) values less than 0.50, The item difficulty index (pi) value of the questions coded "Q16, Q17, Q18, Q20, Q21, Q23, Q24, Q25, Q26, Q27, Q28, Q29, Q30, Q31, Q32, Q33, Q34, Q35, Q36, Q37, Q38" was found to be greater than 0.50. In addition, the item discrimination index (rjx) value of the questions coded "Q1, Q2, Q6, Q7, Q12, Q15, Q21, Q23, Q25, Q29 and Q38" was less than 0.40. The item discrimination index (rjx) value of the questions coded "Q3, Q4, Q5, Q8, Q9, Q10, Q11, Q13", the item discrimination index (rjx) value of the questions coded "Q14, Q16, Q17, Q18, Q19, Q20, Q22, Q24, Q26, Q27, Q28, Q30, Q31, Q32, Q33, Q34, Q35, Q36, Q37" was found to be greater than 0.40.

The KR-20 internal consistency coefficient value for the reliability of the final version of the first section was found to be 0.81.

Second (Affective) Part of the Measurement Tool

The second part was designed to determine the affective energy literacy levels of seventh-grade students. This section is an example of a questionnaire with 5-point Likert-type items.

In the process of developing the second section, initially a draft consisting of 18 items was prepared. Following the EFA, it was decided that two items would be removed from the questionnaire. Subsequently, the EFA was repeated and the final version of the questionnaire was evaluated. In the process of developing the second section, the Kaiser-Meyer-Olkin Test and Bartlett's Test of Sphericity were first examined to assess the suitability of the relevant data set for analysis. Table 10 presents the results of the Kaiser-Meyer-Olkin Test and Bartlett's Test of Sphericity.

Table 10. KMO and Bartlett Sphericity test results for the second section

Values		I. Analysis	II. Analysis
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,702	,706
Bartlett's Test of Sphericity	Approx. Chi-Square	820,875	797,505
	df	153	120
	Sig.	,000	,000

When Table 10 is examined, it is understood that the Kaiser-Meyer-Olkin values ("0.702"; "0.706") obtained because of both analyses are at the "excellent" level and Bartlett's test of sphericity chi-square values (x2 = "820.875" and "797.505"; sd="153" and "120"; $p < 0.05$) are significant. It is seen tahat, the data set was quite suitable for exploratory factor analysis. While deciding on the factor structure of the second part, factor analyses were conducted using Principal Component Analysis-Multivariate (Varimax) orthogonal rotation method. First, the "extraction values" corresponding to the standard variance value of the item in the Common Variance Table of the Items were examined.

In the analysis of the second part, it was observed that the extraction values corresponding to the standard variance value of the item were between "0.335 and 0.648" and "0.344 and 0.638", respectively. The extraction values for all items were found to be greater than 0.2. At this stage, it was not deemed appropriate to remove any item from the questionnaire. To determine the number of factors obtained because the analysis of the second section, the "scree plot" was first examined. Figure 3 shows the scree plot obtained during the factor analysis of the final version of the second section.

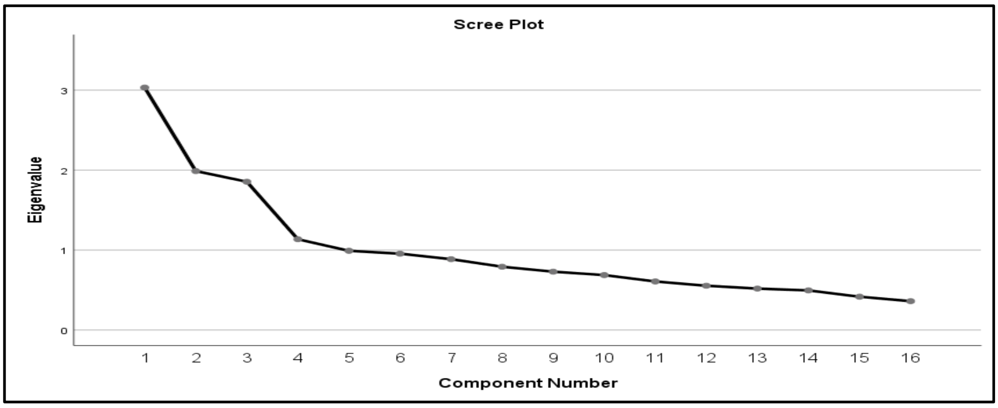

Figure 3. Slope scatter plot for the second section

The "Total Explained Variance Table" was examined to understand the number of factors in the second section more clearly and to determine the explained variance values for each factor. Table 11 presents the Total Explained Variance Table for the final version of the second section.

Table 11. Total explained variance table for the final version of the second section

Items	Initial Eigenvalues			Subtraction Sums of Squared Loads			Sum of Squared Loadings after Rotation		
	Total	Variance Explained (%)	Cumulative (%)	Total	Variance Explained (%)	Cumulative (%)	Total	Variance Explained (%)	Cumulative (%)
1	3,032	18,951	18,951	3,032	18,951	18,951	2,911	18,196	18,196
2	1,988	12,424	31,376	1,988	12,424	31,376	1,982	12,387	30,584
3	1,855	11,592	42,968	1,855	11,592	42,968	1,936	12,102	42,686
4	1,135	7,094	50,062	1,135	7,094	50,062	1,180	7,376	50,062
5	,991	6,193	56,255						
6	,955	5,968	62,222						
7	,886	5,536	67,758						
8	,791	4,945	72,703						
9	,729	4,559	77,262						
10	,687	4,293	81,556						
11	,607	3,794	85,350						
12	,553	3,459	88,809						
13	,518	3,239	92,047						
14	,495	3,096	95,143						
15	,417	2,603	97,746						
16	,361	2,254	100,000						

When Table 11 is examined, the result indicate that, there are four factors with "Eigenvalue statistics" greater than 1 in the second section. It is understood that these factors explain 50.062% of the total variance. As a result of the first analysis, five factors with eigenvalue statistics (Eigenvalues) greater than one were observed. The "Rotated Components Matrix Table" was examined to determine the factors and the loading values of the factors on which the items in the second section were loaded. In the Rotated Components Matrix Table obtained because of the first analysis of the second section, it was determined that the items coded "I3" and "I10" were included under more than one factor, and there was a difference of less than "0.100" between the loading values in these factors. Therefore, it was deemed appropriate to remove the items coded "I3" and "I10" from the questionnaire.

Table 12. Rotated components matrix table for the second Section

Factor	Item Number		Items	Factors			
	Before	After		1	2	3	4
Being Interested	I-4	I-3	I would like to read books with information about energy.	,759			
	I-16	I-14	I read the user manuals of electric vehicles carefully.	,756			
	I-5	I-4	I enjoy watching documentaries about energy.	,696			
	I-15	I-13	I wonder how electric vehicles work.	,621			
	I-2	I-2	I don't want schools to include courses on energy.	,594			
	I-14	I-12	I don't wonder how electricity is produced.	,509			
	I-1	I-1	I am interested in energy-related issues.	,505			
Being Aware	I-7	I-6	I am aware of the importance of the sun for life.		,813		
	I-6	I-5	I am aware that living things need energy to carry out their vital activities.		,796		
	I-18	I-16	I am aware of the economic importance of thermal insulation.		,745		
Being a Fun	I-8	I-7	I am against the use of low-quality fuels for heating.			,707	
	I-9	I-8	I am not against excessive lighting in tourist facilities and shopping centers.			,700	
	I-12	I-10	I support legal regulations against sound pollution.			,684	
	I-11	I-9	Buildings should be constructed in such a way that daylight is sufficiently utilized.			,602	
Being Responsive	I-13	I-11	I am ready to take responsibility for addressing energy-related environmental problems.				,772
	I-17	I-15	I am ready to take responsibility for saving electricity.				,637

When Table 12 is examined, it is seen that the items coded "I1, I2, I3, I4, I12, I13 and I14" are in the first factor (Being Interested), the items coded "I5, I6 and I16" are in the second factor (Being Aware), the items coded "I7, I8, I9 and I10" are in the third factor (Being a Fan) and the items coded "I11 and I15" are in the fourth factor (Being Responsive). In addition, it is understood that the items in the first factor have loadings between 0.759 and 0.505, the items in the second factor between 0.813 and 0.745, the items in the third factor between 0.707 and 0.602, and the items in the fourth factor between 0.772 and 0.637. To determine the reliability of the second section, the Cronbach's Alpha reliability coefficient (α) Value was calculated. Table 13 presents the Cronbach's Alpha reliability coefficient results for the final version of the second section.

Table 13. Reliability calculations for the second section factors

Factors	Part-II	
	Number of Items	"α" Value
Factor 1 (Interest)	7	,757
Factor 2 (Awareness)	3	,712
Factor 3 (Becoming a Fun)	4	,621
Factor 4 (Being Responsible)	2	,523
Total	16	,612

When Table 13 is examined, it is understood that the "α" Value for the "being interested" factor, which constitutes the second part of the measurement tool, is (0.757), the "α" Value for the "being aware" factor is (0.712), the "α" Value for the "being a fan" factor is (0.621) and the "α" Value for the "being sensitive" factor is (0.523). It is seen that the "α" Value for the entire second part is (0.612).

The Third (Behavioral) Part of the Measurement Tool

The third section was designed to determine the energy literacy levels of secondary school students in terms of behavioral learning. This section is an example of a questionnaire with 5-point Likert-type items.

In the process of developing the third section, initially a draft consisting of 18 items was prepared. Following the EFA, it was decided that one item would be removed from the questionnaire. Subsequently, the EFA was repeated and the final version of the questionnaire was evaluated.

In the process of developing the third section, the Kaiser-Meyer-Olkin Test and Bartlett's Test of Sphericity were first examined to assess the suitability of the relevant data set for analysis. Table 14 presents the results of the Kaiser-Meyer-Olkin Test and Bartlett's Test of Sphericity.

Table 14. KMO and Bartlett Sphericity test results for the third section

Values		I. Analysis	II. Analysis
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,800	,803
	Approx. Chi-Square	1072,519	1050,688
Bartlett's Test of Sphericity	df	153	136
	Sig.	,000	,000

When Table 14 is examined, it is seen that the Kaiser-Meyer-Olkin values (",800"; ",803") obtained as a result of both analyses are at "excellent" level and the Bartlett's test of sphericity chi-square values (x2 = "1072,519" and "1050,688"; sd="153" and "136"; $p < .005$) are significant. It is understood that, the data set is quite suitable for exploratory factor analysis.

While deciding on the factor structure of the third section, factor analyses were conducted using Principal Component Analysis-Multivariate (Varimax) orthogonal rotation method. First, the "extraction values" corresponding to the standard variance value of the item in the Common Variance Table of the Items were examined. In the analysis of the third section, it was observed that the extraction values corresponding to the standard variance value of the item were between "0.300 and 0.831" and "0.283 and 0.640", respectively. The extraction values for all items were found to be greater than 0.2. The results indicate that, no item was initially removed from the measurement tool. To determine the number of factors obtained because of the analysis of the third section, the "scree plot" was first examined. Figure 4 shows the scree plot obtained during the factor analysis of the final version of the third section.

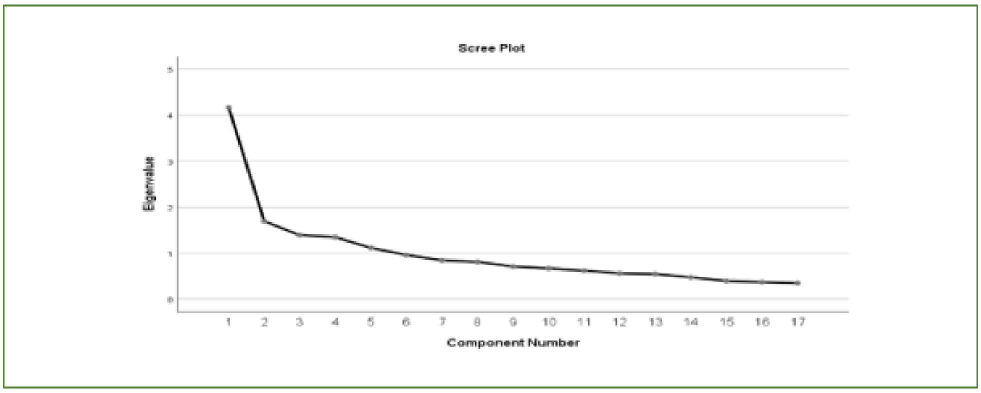

Figure 4. Slope scatter plot for the third section

When Figure 4 is examined, it is seen that the third part of the measurement tool consists of a four-factor structure. The "Total Explained Variance Table" was examined to understand the number of factors in the third section more clearly and to determine the

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explained variance values for each factor. Table 15 presents the Total Explained Variance Table for the final version of the third section.

Table 15. Total explained variance table for the final version of the third section

Items	Initial Eigenvalues			Subtraction Sums of Squared Loads			Sum of Squared Loadings after Rotation		
	Total	Variance Explained (%)	**Cumulative (%)**	Total	Variance Explained (%)	Cumulative (%)	Total	Variance Explained (%)	Cumulative (%)
1	4,161	24,476	24,476	4,161	24,476	24,476	4,082	24,009	24,009
2	1,692	9,952	34,428	1,692	9,952	34,428	1,702	10,013	34,022
3	1,390	8,175	42,603	1,390	8,175	42,603	1,424	8,376	42,398
4	1,348	7,929	50,533	1,348	7,929	50,533	1,383	8,134	50,533
5	1,114	6,552	57,085						
6	,959	5,640	62,725						
7	,843	4,958	67,683						
8	,810	4,765	72,448						
9	,709	4,169	76,617						
10	,667	3,921	80,537						
11	,618	3,637	84,175						
12	,561	3,298	87,473						
13	,545	3,207	90,679						
14	,474	2,787	93,467						
15	,393	2,311	95,777						
16	,370	2,177	97,954						
17	,348	2,046	100,000						

When Table 15 is examined, the finding suggest that there are four factors with "Eigenvalue statistics" greater than 1 in the third section. It is understood that these factors explain 50.533% of the total variance. As a result of the first analysis, five factors with eigenvalue statistics (Eigenvalues) greater than one were observed.

The "Rotated Components Matrix Table" was examined to determine the factors and the loading values of the factors on which the items in the third section were loaded. In the Rotated Components Matrix Table obtained because of the first analysis of the third section, it was determined that the item coded "I15" was included under more than one factor, and there was a difference of less than "0.100" between the loading values in these factors. Therefore, it was deemed appropriate to remove the item coded "I15" from the questionnaire. Table 16 presents the Rotated Components Matrix Table for the third section.

Table 16. Rotated component matrix table for the third section

Factor	Item Number Before	Item Number After	Items	Factors 1	2	3	4
Health Measures	I-2	I-2	I watch/listen loudly to media such as TV and radio.	,775			
	I-5	I-5	I don't stay in the sun for long on hot days.	,746			
	I-9	I-9	I take care to eat a regular and balanced diet.	,740			
	I-11	I-11	I take care to consume foods of animal origin (meat, milk, eggs, etc.).	,699			
	I-14	I-14	I don't exercise and walk in my free time.	,676			
	I-3	I-3	I do not look at objects that emit strong light for a long time.	,665			
	I-13	I-13	I do not pay attention to food hygiene (cleanliness).	,652			
	I-10	I-10	I make sure I eat enough fruit and vegetables.	,553			
	I-12	I-12	I am careful not to eat too much fatty food.	,491			
Security Measures	I-4	I-4	I take care not to touch extremely hot and cold objects.		,715		
	I-8	I-8	I pay attention to safety precautions when using electrical equipment.		,652		
	I-7	I-7	I don't try to fix electrical appliances on my own.		,617		
	I-6	I-6	I use electrical appliances with the help of adults.		,513		
Social Rules	I-16	I-15	I pay attention to the economical use of energy.			,776	
	I-18	I-17	On cold days, I take care to close the doors and windows in my environment.			,769	
Savings Measures	I-1	I-1	I take care not to be in noisy environments for a long time.				,795
	I-17	I-16	For short distances, I prefer to walk rather than ride motorized vehicles.				,773

When Table 16 is examined, it can be concluded that the items coded "I2, I3, I5, I9, I10, I11, I12, I13 and I14" are in the first factor (Health Measures), the items coded "I4, I6, I7 and I8" are in the second factor (Security Measures), the items coded "I15 and I17" are in the third factor (Social Rules) and the items coded "I1 and I16" are in the fourth factor (Savings Measures). In addition, it is understood that the items in the first factor have loadings between 0.775 and 0.491, the items in the second factor between 0.715 and 0.513, the items in the third factor between 0.776 and 0.769, and the items in the fourth factor between 0.795 and 0.773. To determine the reliability of the third section, the Cronbach's Alpha reliability coefficient (α) value was calculated.

Table 17 presents the Cronbach's Alpha reliability coefficient results for the final version of the third section.

Table 17. Reliability calculations for the third section

Factors	Part-III	
	Number of Items	"α" Value
Factor 1 (Health Measures)	9	,849
Factor 2 (Security Measures)	4	,517
Factor 3 (Social Rules)	2	,510
Factor 4 (Savings Measures)	2	,471
Total	17	,730

When Table 17 is examined, it is seen that the "α" Value for the "health measures" factor, which constitutes the third part of the measurement tool, is (0.849), the "α" Value for the "security measures" factor is (0.517), the "α" Value for the "saving measures" factor is (0.510) and the "α" Value for the "social rules" factor is (0.471). The "α" Value for the entire third section is (0.730).

Discussion and Conclusion

This chapter presents the discussion and results of the first (cognitive), second (affective), and third (behavioral) sections of the measurement tool developed to determine the energy literacy levels of secondary school students.

Discussion and Conclusions Regarding the First Section (Cognitive)

In the first part, a test containing multiple-choice questions to assess the energy literacy levels of secondary school students was included. In the process of designing the first part, teaching outcomes were developed based on the theoretical framework of energy literacy. Then, a draft containing 44 questions with four options was created. The opinions of field experts were consulted regarding the first draft. In line with the opinions of the field experts, the learning outcomes were rearranged, a specification table was created, questions that were difficult to understand were simplified, questions were rearranged visually, and spelling mistakes were eliminated. In many studies in the literature (Bolat & Karamustafaoğlu, 2019; Dumanoğlu & Akçay, 2018; Öner Armağan & Demir, 2019; Üçüncü & Sakiz, 2020), expert opinions were consulted at this stage. The results indicate that, in some studies (Aydın & Selvi, 2020; Kızkapan & Bektaş, 2018; Sontay & Karamustafaoğlu, 2020; İlhan & Hoşgören, 2017), the specification table was organized. Preparatory activities carried out during the development process of measurement tools contribute to the content validity of the measurement tool. Karasar (2009) defines content validity as "how well the questions

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in the measurement tool measure the skills to be measured". In this context, it is concluded that the final draft of the first section covers the knowledge and skills necessary for secondary school students' energy literacy in the cognitive sense.

The final draft of the first part was administered to 278 seventh-grade students. Then, item analyses were performed on the data obtained from the applications. At this stage, item difficulty index and item discrimination index values were calculated for each question. Six questions (questions coded S3, S4, S17, S18, S29, S34) whose item difficulty index (pi) and item discrimination index (rjx) values were not in the appropriate range were not included in the final version of the test (Büyüköztürk, 2018). It was determined that the item difficulty index (pi) values of 31 questions in the final version of the first part were greater than 0.5. It was determined that the item difficulty index (pi) values of the questions coded "S1, S3, S4, S6, S15, S19, and S22" were less than 0.50. Büyüköztürk (2018) states that questions with an item difficulty index statistic less than 0.50 are complex, and questions with a higher value are easy. In this context, it was concluded that the final version of the first part of the measurement tool was of medium difficulty. It was determined that the item discrimination index (rjx) values of 27 questions in the final version of the first part were greater than 0.4. The item discrimination index (rjx) values of the questions coded "S1, S2, S6, S7, S12, S15, S21, S23, S25, S29, and S38" were found to be less than 0.40. Büyüköztürk (2018) states that if the item discrimination index (rjx) values of the questions in a test are 0.40 and above, the discrimination power of the test is high. In this context, it was concluded that the final version of the first part of the measurement tool was highly discriminative. The KR-20 value was calculated to determine the reliability of the final version of the first section. As a result of the reliability analysis, it was concluded that the KR-20 value was "0.81". Tavşancıl (2014) states that tests with a KR-20 value greater than 0.8 are highly reliable. It is understood that the items in the final version of the first section are free from random errors, the measured variable is unidimensional, the test items are homogeneous, the test items are compatible with each other, the sample is heterogeneous, the internal consistency and construct validity of the test are high (Tavşancıl, 2014).

Discussion and Conclusions Regarding the Second Section (Affective)

In the second part, a questionnaire containing 5-point Likert-type items was included to determine the affective energy literacy levels of secondary school students. In the design process of the second part, a draft consisting of 25 items was created based on the theoretical framework of energy literacy. The opinions of field experts were consulted regarding the first draft. In line with the opinions of the field experts, it was decided to remove seven repetitive items from the questionnaire that caused difficulty in comprehension, spelling mistakes were corrected, and the questionnaire was visually reorganized.

The final draft of the second part was applied to 278 seventh-grade students. The suitability of the data set obtained from the applications for Exploratory Factor Analysis was questioned. The Kaiser-Meyer-Olkin value was found to be at an "excellent" level (Büyüköztürk, 2018; Fabrigar & Wegener, 2012). Bartlett's test of sphericity chi-square value was found to be "significant" (Gürbüz & Şahin, 2014). In this context, it was concluded that the data set was suitable for conducting Exploratory Factor Analysis. While deciding on the factor structure of the second part, factor analyses were performed using Principal Component Analysis-Multivariate (Varimax) orthogonal quadrature method. As a result of the analysis, a four-factor structure consisting of 16 items was obtained. These factors were named as "being interested", "being aware", "being a supporter", and "being sensitive". There were seven items in the factor of being interested, three items in the factor of being aware, four items in the factor of being a fan, and two items in the factor of being sensitive.

To determine the reliability of the final version of the second section, the "Cronbach Alpha coefficient (α) value" for each factor was calculated. The "α" Value for the "being interested" factor of the second section was (0.757), the "α" Value for the "being aware" factor was (0.712), the "α" Value for the "being a fan" factor was (0.621) and the "α" Value for the "being sensitive" factor was (0.523). The "α" Value for the entire second section was found to be (0.612). According to Tavşancıl (2014), as the "α" Value approaches 1.00, the reliability of the measurement tool increases. In this context, it is understood that the second section is generally quite reliable.

Discussions and Conclusions Regarding the Third Section (Behavioral)

In the third section, a questionnaire containing 5-point Likert-type items was included to determine the energy literacy levels of secondary school students. In the design process of the third section, a draft consisting of 25 items was created based on the theoretical framework of energy literacy. The opinions of field experts were consulted regarding the first draft. In line with the opinions of the field experts, it was decided to remove seven items that had similar meanings and caused difficulties in comprehension from the questionnaire, spelling errors were corrected, and the questionnaire was visually reorganized. The final draft of the third section was applied to 278 seventh-grade students. The suitability of the data set obtained from the applications for Exploratory Factor Analysis was questioned. The Kaiser-Meyer-Olkin value was found to be at an "excellent" level (Büyüköztürk, 2018; Fabrigar & Wegener, 2012). Bartlett's test of sphericity chi-square value was found to be "significant" (Gürbüz & Şahin, 2014). In this context, it was concluded that the data set was suitable for conducting Exploratory Factor Analysis.

While deciding on the factor structure of the second part, factor analyses were performed using Principal Component Analysis-Multivariate (Varimax) orthogonal quadrature method. As a result of the analysis, a four-factor structure consisting of 17 items was obtained. These factors were named as "Health Measures", "Security Measures", "Social Rules", and "Savings Measures". There were nine items in the Health Measures factor, four items in the Security Measures factor, two items in the Social Rules factor, and two items in the Savings Measures factor. To determine the reliability of the final version of the third section, the "Cronbach Alpha coefficient (α) value" for each factor was calculated. The "α" Value for the "health measures" factor in the third section was (0.849), the "α" Value for the "security measures" factor was (0.517), the "α" Value for the "social rules" factor was (0.471) and the "α" Value for the "saving measures" factor was (0.510). The "α" Value for the entire third section was found to be 0.787. According to Tavşancıl (2014), as the "α" Value approaches 1.00, the reliability of the measurement tool increases. In this context, it is understood that the third section is generally quite reliable.

Recommendations

Based on the findings of this study, several recommendations can be proposed for researchers, educators, and policymakers.

First, the developed measurement tool can be applied to different grade levels to examine the developmental progression of students' energy literacy. In particular, longitudinal studies may provide deeper insights into how cognitive, affective, and behavioral dimensions evolve over time.

Second, future research may investigate the relationship between energy literacy and various demographic variables such as gender, socioeconomic status, and regional differences. Such studies would contribute to a more comprehensive understanding of the factors influencing energy literacy.

Third, the instrument developed in this study can be adapted and validated for use in different educational contexts and cultural settings. Cross-cultural comparisons may reveal important differences in students' energy literacy levels and contribute to the global literature.

Fourth, researchers are encouraged to integrate this measurement tool into intervention-based studies to evaluate the effectiveness of instructional strategies aimed at improving energy literacy. In this context, experimental or quasi-experimental designs may provide stronger evidence regarding causal relationships.

Fifth, similar measurement tools can be developed for other disciplines such as physics, chemistry, and biology to assess energy literacy in a more discipline-specific manner. This would allow for a more detailed analysis of students' conceptual understanding across different subject areas.

Finally, educators and curriculum developers should consider incorporating more explicit learning outcomes related to the affective and behavioral dimensions of energy literacy into science curricula. Enhancing these dimensions may contribute to the development of more responsible and environmentally conscious individuals.

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Mehmet YILDIZ: *Conceptualization, literature review, data curation, methodology, implementation, data analysis, language editing, organization, and writing.*

Mustafa ÜREY: *Supervision, control, review and regulation.*

References

Alsop, S., & Watts, M. (2003). Science education and affect. *International Journal of Science Education, 25*(9), 1043-1047.

Ayata, S. (2021). *Investigation of the relationship between secondary school students' energy literacy and scientific epistemological beliefs and demographic variables* (Published master's thesis). Muğla Sıtkı Koçman University, Institute of Science and Technology, Muğla.

Aydın, E., & Selvi, M. (2020). Development of ecosystem, biodiversity and environmental problems achievement test for secondary school students. *Journal of Education and Society Research, 7*(2), 661-682.

Ayvacı, H. Ş., Küçük, M. & Bebek, G. (2021). Determination of mental models of gifted students about renewable energy resources. *Pamukkale University Journal of Education, 53*, 378- 402.

Başkan-Takaoğlu, Z. (2018). Energy concept understanding of high school students: A cross-grade study. *Universal Journal of Educational Research, 6*(4), 653-660.

Bolat, A., & Karamustafaoğlu, S. (2019). "Systems in Our Body" unit achievement test development: validity and reliability. *Gazi Journal of Educational Sciences, 5*(2), 131-159.

Boz, V. (2020). *Student views on energy resources and energy literacy: Case study* (Unpublished master's thesis). Yıldız Technical University, Istanbul.

Boz, V., & Görgülü-Arı, A. (2021). Teachers views about energy education and energy literacy. *IBAD Journal of Social Sciences, 11*, 93-110.

Büyüköztürk, Ş. (2018). *Data analysis handbook for social sciences*. Pegem Akademi.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika,16*, 297-334.

DeWaters, J. E. & Powers, S. E., (2013). Establishing measurement criteria for an energy literacy questionnaire. *Environmental Education, 44*(1), 38-55.

DeWaters, J., Qaqish, B., Graham, M., & Powers, S. (2013). Designing an energy literacy questionnaire for secondary and high school youth. *The Journal of Environmental Education, 44*(1), 56-78.

Dumanoğlu, F., & Akçay, B. (2018). Development of electric energy achievement test. *E-Kafkas Journal of Educational Research, 5*(2), 20-39.

Ertaş, H., Şen, A. İ., & Parmaksızoğlu, A. (2011). The effect of out-of-school scientific activities on 9th grade students' level of associating the subject of energy with daily life. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 5*(2), 178-198.

Fabrigar, L. R. & Wegener, D.T. (2012). *Exploratory factor analysis*. Oxford University Press.

Güneş, T., & Taştan Akdağ, F. (2016). Determination of perceptions of science high school students on energy and their levels of interdisciplinary association. *International Journal of Social Sciences and Education Research, 2*(2), 625-635.

Güney, A. (2018). *Developing an attitude scale towards nuclear energy and its environmental effects: Validity and reliability study* (Unpublished Doctoral Dissertation), Necmettin Erbakan University, Institute of Postgraduate Education, Konya.

Gürbüz, S., & Şahin, F. (2014). *Research methods in social sciences*. Seçkin Publishing.

İlhan, N., & Hoşgören, G. (2017). Development of life-based achievement test for science course: Acid base topic. *Journal of Science Teaching, 5*(2), 87-110.

Karasar, N. (2009). *Scientific research method* (19th edition). Nobel Publication.

Kavgacı, G. (2020). *Determination and comparison of the perceptions of prospective teachers in different education programs towards the concept of energy* (Unpublished master's thesis). Trabzon University, Institute of Postgraduate Education, Trabzon.

Kıryak, Z., Candaş, B., Karanisoğlu, B., & Özmen, H. (2019). Determining seventh grade students' knowledge levels about energy transformations through drawings. *Journal of Science Mathematics Entrepreneurship and Technology Education, 2*(2), 79-92.

Kızkapan, O., & Bektaş, O. (2018). Developing achievement test in science education: cell division and heredity example. *Maarif Mektepleri-International Journal of Educational Sciences, 2*(1), 1-18.

Kuder, G. F., & Richardson, M. W. (1937). The theory of the estimation of test reliability. *Psychometrika, 2*(3), 151-160.

Kurnaz, M. A., & Sağlam-Arslan, A. (2011). The effect of learning environment based on model-based learning approach on students' understanding of energy concept. *E-International Journal of Educational Research, 2*(2), 1-16.

Lee, L. S., Lee, Y. F., Altschuld, J. W., & Pan, Y. J. (2015). Energy literacy: Evaluating knowledge, affect, and behavior of students in Taiwan. *Energy Policy, 76*, 98-106.

Lin, K. Y., & Lu, S. C. (2018). Effects of project-based activities in developing high school students' energy literacy. *Journal of Baltic Science Education, 17*(5), 867.

Okur, E., & Yalçın-Özdilek, Ş. (2013). Effective use of energy and technological pollution awareness scale. *Kastamonu Journal of Education, 21*(1), 271-286.

Oluk, S., & Oluk, E. (2016). Some misconceptions of 7th grade secondary school students about the concept of energy in living things. *The Journal of Academic Social Science Studies, 51*, 97-111.

Oluk, S., Kaya-Şengören, S., & Babadağ, G. (2019). Evaluation of pre-service teachers' attitudes and behaviors towards energy saving in terms of some variables. *Dokuz Eylül University Buca Faculty of Education Journal, 47*, 1-13.

Osborne, J. (2007). Science education for the twenty first century. *Eurasia Journal of Mathematics, Science and Technology Education, 3*(3), 173-184.

Öner Armağan, F., & Demir, N. (2019). Astronomy achievement test development: Validity and reliability study. *International Journal of Educational Sciences, 3*(1), 52-70

Sontay, G., & Karamustafaoğlu, O. (2020). Development of achievement test for science course "Sun, Earth and Moon" Unit. *Gazi University Gazi Faculty of Education Journal, 40*(2), 511-551.

Tavşancıl, E. (2014). *Measurement of attitudes and data analysis with SPSS*. Nobel Publishing.

Üçüncü, G., & Sakiz, G. (2020). Achievement test development process: The case of primary school fourth grade matter recognition unit. *Kastamonu Journal of Education, 28(1), 82-94*.

Ünal-Çoban, G., Aktamış, H., & Ergin, Ö. (2007). Primary school 8th grade students' views on energy. *Kastamonu Journal of Education, 15*(1), 175-184.

Ürey, M. (2018). Defining the relationship between the perceptions and the misconceptions about photosynthesis topic of the preservice science teachers. *European Journal of Educational Research. 7*(4), 813-826.

Ürey, M., & Kavgacı, G. (2021). Determination and comparison of the perceptions of pre-service teachers with science and social sciences origins towards the concept of energy. *Van Yüzüncü Yıl University Journal of Faculty of Education, 18*(2), 463-493.