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Development of an attitude scale towards science literacy for secondary school pupils

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ABSTRACT

This study aimed to develop a valid and reliable scale that reveals secondary school pupils' attitudes toward science literacy. The survey model, one of the quantitative research methods, was used in the study. The validity and reliability study of the scale was carried out on secondary school pupils attending public schools in Turkey in the 2022-2023 academic year. Data were collected from 546 secondary school pupils. The structure of the draft scale, established through Exploratory Factor Analysis (EFA), consisted of 16 items and 4 dimensions. The scale was administered to 392 secondary school pupils to verify the structure revealed by EFA. This validated a 16-item and 4-dimension structure. The total variance explained by the scale was 50.11%. The Cronbach alpha coefficient, which indicates the scale's internal consistency, was calculated to be 0.867. Fit indexes were calculated as X2/df =2.38, NFI= 0.92, NNFI= 0.94, RFI= 0.90, CFI= 0.95, GFI= 0.93, AGFI= 0.90, SRMR= 0.055, IFI= 0.95 and RMSEA= 0.060. In conclusion, it can be said that the "Attitude Towards Science Literacy Scale" is qualified to measure the attitude of secondary school pupils towards science literacy.

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Introduction

Individuals must keep up with the new circumstances in changing and evolving social conditions. This need leads them to education, one of the fundamental drivers of change today. Education is a lifelong process and the most critical tool to ensure the multifaceted development of an individual. The attitudes, behaviours, self-efficacy, and communication skills that individuals develop in changing and evolving social conditions are shaped by educational settings (Tombul, 2014). One of the objectives of modern education is to teach individuals how to access knowledge rather than knowledge transfer (Özyurt, 2020).

In today's world, where knowledge is developing at a breakneck pace, keeping up has become essential. Individuals are expected to improve their ability to access information. Therefore, what is expected from individuals is not to know all the knowledge specific to a field but to be able to make comments and judgments by reflecting on this knowledge and to use the gained knowledge to solve everyday problems (Kuyumcu-Vardar & Acar, 2018). These characteristics that are expected from individuals highlight the concept of literacy. Initially, literacy was only considered as "being able to read." However, from this point, it has evolved to mean educated, sophisticated, good reader, and enlightened (Rusli, 2012). Thus, the concept of literacy is a broad concept that encompasses much more than the ability to read.

The concept of literacy that has developed over time has many types in the literature, such as mathematical literacy (İlhan et al., 2019), environmental literacy (Kinslows et al., 2019), media literacy (Jang & Kim, 2018), computer literacy (Tsai et al., 2019), and health literacy (Yılmaz-Güven et al., 2018). New literacy concepts have emerged as living conditions changed and developed (Önal, 2010). One of the literacy types that has diversified with knowledge development is science literacy.

Science literacy means that scientific knowledge becomes a concept scientific arguments are constructed, scientific ideas are generated, and evidence is provided from the analysis of the resulting data (Ballenger, 1997; Bazerman, 1988; Germann & Aram, 1996). Science literacy refers to the individual's understanding of science and the ability to participate in and the meaning of science-related processes, values and ethics (Dawson & Venville, 2009). This understanding involves using science literacy to comprehend and use scientific knowledge, draw evidence-based conclusions, and make decisions about the natural world and human interactions with (Foster & Shiel-Rolle, 2011; Holbrook & Rannikmae, 2009).

Science literacy plays an important role in solving the problems of individuals in daily life, understanding the environment and nature, comprehending the relationship between science and life, raising individuals above the development level of the society they live in (Turgut, 2007), and developing the ability to be creative by reusing science in daily life (Irmital & Atun, 2018; Jufrida et al., 2019). In parallel, science-literate individuals can understand and explain scientific phenomena and are willing to design scientific studies in science and technology and interpret, evaluate and prove them (OECD, 2016). Science literacy improves the ability to conduct research again, duplicative and consequently improves the life quality (DeBoer, 2000; Dragoş & Mih, 2015; Norris & Phillips, 2003; Sülün, et al., 2009).

Science literacy has been explained and interpreted from different perspectives. Showalter (1974) classified science literacy into seven dimensions and explained the characteristics of a scientifically literate person as follows: understands the nature of scientific knowledge; uses scientific concepts, theories, principles and rules in the most appropriate way in interacting with the universe; uses scientific processes effectively; is aligned with the values that define science; understands that science, technology and society are in interaction; continues his/her science education through his/her life; and improves him/herself using science and technology. Shen (1975) categorised science literacy into practical, civic and cultural dimensions. Miller (1983), on the other hand, analysed the concept under three dimensions: the nature of science, knowledge of scientific content and concepts, and the relationship between science, technology and society.

Although the concept of science literacy dates back to many years ago, it started to be used in its current form in the 1950s (DeBoer, 2000). The importance of science literacy has continued to increase until today, and it has become one of the main objectives of education (Bybee, 1997; DeBoer, 1991; Laugksch, 2000).

Creating a science-literate society is one of the essential objectives of science education (Lee, 2004). Learners' attitudes and behaviours should be improved to create a science-literate society (Sinaga et al., 2017; Upahi et al., 2017). Science-literate school learners were observed to use the learned knowledge to solve everyday problems, leading to the conclusion by the authors that science literacy is one of the most critical skills students should strengthen (Jufrida et al., 2019).

The school system should monitor science literacy, especially from the primary school level, because science is essential in producing pupils with critical and creative thinking skills (Safrizal et al., 2022). Therefore, for children and young people to develop positive attitudes towards science and science literacy, they need to show curiosity and interest (Wolfinger, 2000). At this point, it is essential to measure their attitudes towards science literacy.

Science literacy has been the goal of science education for all countries. International assessment practices have been developed to evaluate science literacy. The results of the evaluations shed light on future directions by influencing national education policies (Zhang et. al., 2023). In order to identify the weaknesses of their education programs and compare them with other countries, countries participate in exams such as the Programme for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS), which are prepared by the Organization for Economic Cooperation and Development (OECD) and conducted with the participation of more than 10 million 15-year-old students from 79 countries. Since PISA and TIMMS exams measure students' science literacy levels, their achievements in science and some of their skills, the attitudes that students will develop towards science literacy are also important. Developing positive attitudes towards science literacy in students was found to be a determinant in science achievement (Abell & Lederman, 2007). The increase in achievements in science has made it necessary to develop a data collection tool that can evaluate attitudes towards science literacy. (Istyadji & Sauqina, 2023).

In order to develop an attitude scale towards science literacy, data collection tools already developed were analysed. Çalık et al. (2024) devised a Turkish version of the pre-service science teachers' science literacy perception scale developed by Suwono, et al. (2022). The scale consists of 8 dimensions and 41 items and the reliability of the scale was calculated as 0.90. Susandi, et.al. (2020) developed a scale for science literacy on direct current for vocational high school students. The scale consists of 3 dimensions and 13 items and its reliability was calculated as 0.58. Mun, et al. (2015) developed a scale to measure the degree of science literacy of secondary school learners. The study group of the scale consisted of secondary school pupils in China, Australia and South Korea. The scale consists of 4 dimensions and 48 items.

Fives et al. (2014) developed a science literacy assessment test to make inferences about the science literacy levels of secondary school pupils. The reliability of the scale consisting of 2 dimensions and 25 items was calculated as 0.80. Laugksch & Spargo (1996) developed a basic science literacy test consisting of 110 questions answered as true and false to determine the degree of science literacy of university students. Duruk (2012) conducted a Turkish adaptation study of the basic science literacy test developed by Laugksch & Spargo (1996) for pre-service teachers. The test consisted of 3 dimensions and 49 items and the reliability coefficient was calculated as 0.82. The universal science literacy scale developed by Mun, et al. (2015) for pre-service science teachers was translated into Turkish by Çelik & Can (2017). The target group of the scale consisted of pre-service science teachers. The scale consisted of 4 dimensions and 48 items and the reliability coefficient of the scale was calculated as 0.91. Caymaz (2008) developed a self-efficacy scale for science literacy for prospective science and technology and classroom teachers. The scale consisted of one dimension and 33 items and the reliability coefficient of the scale was calculated as 0.91. Turan-Bektaş (2020) developed a science literacy scale to determine the science literacy of the society. The scale consists of 6 dimensions and 43 items and the reliability coefficient of the scale was calculated as 0.80. Bybee (2008) evaluated science literacy in PISA and stated that this is reflected in contemporary learning policies. Wenning (2006) developed the NOS literacy test which consists of 35 items. The target group of the test is high school learners. The test is not an achievement test and is generally used in pretest-posttest experimental designs. Gormally, et al. (2012) developed a scientific literacy test for biology students. The test consists of 28 questions and measures the skills of undergraduate biology students on the basic aspects of scientific literacy.

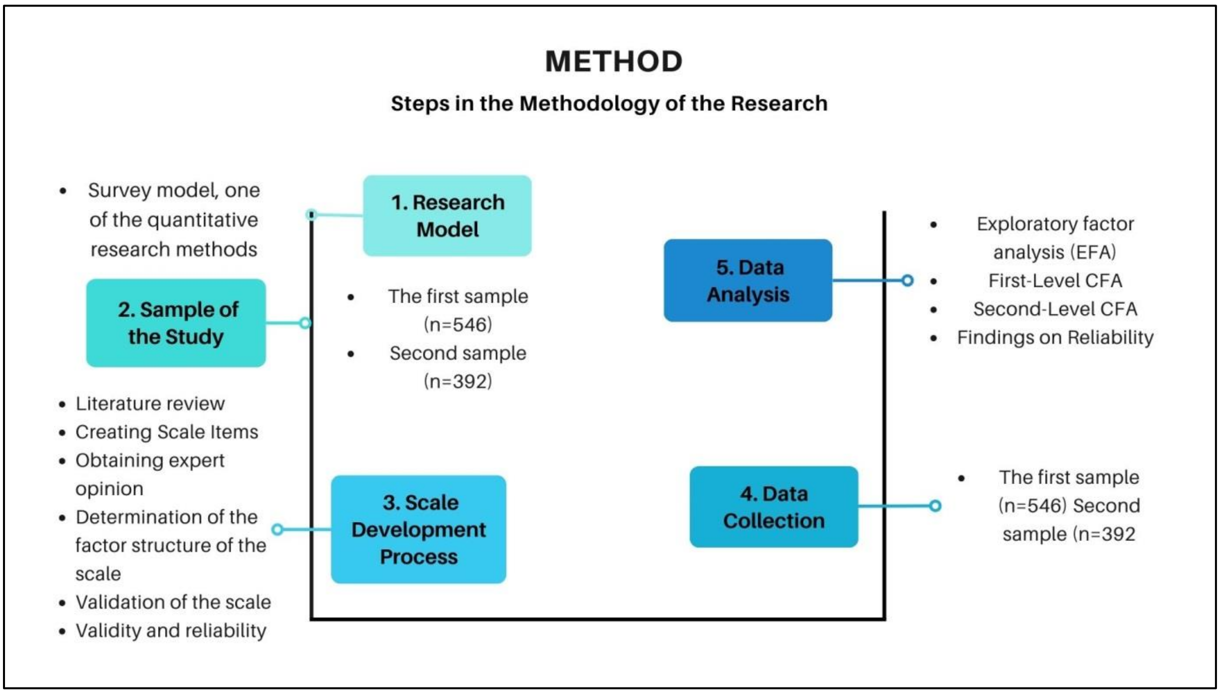
The tools measuring science literacy were mostly aimed at high school pupils, university level students and teacher candidates as the sample group. In addition, these data collection tools have limitations in that they are not sufficient to measure affective characteristics such as attitude and motivation science literacy. Science learning and teaching includes not only cognitive dimension but also affective characteristics of individuals (Çalık et al., 2024). Therefore, considering the developments in science education, it is stated that the affective dimension plays a key role in the teaching of science. This situation necessitates that the affective dimension is important in the learning and teaching process and that the affective dimension should be included in the process as well as the cognitive dimension (Çalık et al., 2024; Jackson, 2018). As a result of the literature search, it was determined that there is no scale that can satisfactorily measure the attitude towards science literacy at the secondary school level and it was felt that this deficiency in this field needed to be filled. Therefore, the aim of this study is to develop a valid and reliable attitude towards science literacy scale.

Methods

The steps in the research method are shown in Figure 1 as a flowchart and each step is explained in detail under the relevant headings.

Figure 1

Steps in the methodology of the study



Research Model

The survey model, one of the quantitative research methods, was used in this study to reveal secondary school pupils' attitudes toward science literacy. The survey model describes a situation in the present or past as it is (Karasar, 2009).

Sample of the Study

The sample consisted of secondary school pupils in Antalya city centre in the 2022-2023 academic year. Data were collected from two separate samples at two different times. The first sample (n=546) was used to identify the underlying factor structure, and the second sample (n=392) was used to validate the factor structure found in the first stage. Convenience sampling was used for both groups. Convenience sampling is a method of collecting respondents from accessible and easily applicable units to minimize time, money and labour constraints (Büyüköztürk et al., 2019). The demographic information of the samples is shown in Table 1.

Table 1

First and second samples

Variable	First Sample		Second Sample	
Grade	f	%	f	%
5th-Grade	136	24.91	102	26.02
6th-Grade	144	26.37	104	26.53
7th-Grade	137	25.09	94	23.98
8th-Grade	129	23.63	92	23.47
Overall	546	100	392	100

Table 1 shows the distribution of the first and second samples by grade. Since the scale will be developed for secondary school learners, it was ensured that the number at each grade level was about the same. The sample size should be sufficient for a healthy factor structure (Tabachnick & Fidell, 2007). Regarding sample size, 50 is accepted as very poor, 100 as poor, 200 as adequate, 300 as good, 500 as very good, and 1000 as excellent (Comrey & Lee, 1992). Accordingly, the sample size of this study is very good for factor analysis.

Scale Development Process

The first step in developing the Attitudes Toward Science Literacy Scale (ATSLS) was to review the national and international literature. An item pool to be used in the scale was created after a detailed literature review. Published scales and studies on science literacy were reviewed in generating the item pool (Bybee, 2008; Caymaz, 2008; Çalık, et al., 2024; Çelik & Can, 2017; Duruk, (2012); Fives, et al., 2014; Gormally, et al., 2012; Laugksch & Spargo, 1996; Liu, 2009; Miller, 1983; Mun, et al., 2015; OECD, 2007; Shen, 1975; Showalter, 1974; Susandi, et al., 2020; Suwono, et al., 2022; Wenning, 2006).

A 46-item draft scale was drawn up and sent to ten experts to evaluate the content validity. The experts in the study consisted of six science teachers who are experts in the field of science, two Turkish teachers who are experts in the field of Turkish, the language of application of the study, two academicians who are experts in the field of measurement and evaluation, and one academician who is an expert in the field of science education. The purpose of content validity is to show the extent to which the written scale items measure the desired behaviours (Büyüköztürk et al., 2019). A 46-item scale was obtained after the corrections and suggestions of the experts. The suggestions and corrections made by the experts regarding the draft scale were as follows: some of the scale items were too long or too short, no integrity between the items explain, items that are not comprehensible in terms of language and content appropriateness, and items not suitable for secondary school level. The draft scale was rearranged and sent to the experts for the second time and the scale was then finalised.

The scale was of the Likert type. Likert type scales are basically developed to measure attitudes. In this study, 5-point version was used: "strongly agree = 5 points", "agree = 4 points", "partially agree = 3 points", "disagree = 2 points", and "strongly disagree = 1 point". In the studies conducted in Turkey, the 5-point Likert type is mostly preferred (Gegez, 2010; İslamoğlu & Alnıaçık, 2016; Nakip, 2006). Exploratory factor analysis, reliability analysis and correlation analysis were performed on the 5-point Likert-type draft scale to reveal the factor structure of the scale. In the second stage, confirmatory factor analysis was performed to verify the factor structure in another sample. Then, in the second stage, confirmatory factor analysis was conducted to verify the emerging factor structure in another sample.

Data Collection

In the first stage, the ATSLS was administered to 650 secondary school pupils in public schools in Antalya, Turkey. 5th, 6th, 7th, and 8th-grade students were evenly distributed in the sample. Before the analysis, 104 survey forms were removed because of incorrect completion, and the analysis was conducted with 546 forms. The data showed a normal distribution, and the analysis continued on the same data set. In the second stage, the scale, whose factor structure was formed, was administered to 450 secondary school pupils 58 surveys were excluded leaving 392 forms.

Data Analysis

An exploratory factor analysis (EFA) was conducted. EFA classifies the items and reduces the number of items in the scale, grouping them into factors under which similar items are assigned and explaining their relationship. In EFA, an item's factor load should be at least 0.32 (Tabachnick & Fidell, 2013). The Kaiser-Meyer-Olkin (KMO) value, which indicates the suitability and sufficiency of the size of the data set for analysis, should be greater than 0.60 (Tabachnick & Fidell, 2001, Büyüköztürk, 2018). The factor structure should explain at least 50% of the total variance (Gürbüz & Şahin, 2015). According to Büyüköztürk (2018), while it is sufficient for the variance explained to be 30% or more in single-factor scales, it is desired for the variance explained to be more in multi-factor scales. In addition, the number of items per factor is also an important criterion to be met. There should be at least three items under each factor to ensure model-data fit (Ding et al., 1995).

After determining the factor structure by EFA, the data obtained from the second sample were subjected to first- and second-order CFA to confirm the structure's validity and reliability. The goodness-of-fit value ranges in the literature were used to evaluate the CFA results (Schermelleh-Engel et al., 2003). Cronbach's alpha (α) coefficient was used to determine the reliability of the scale, and finally, simple correlation analysis was used to reveal the relationship between sub-dimensions and the overall scale. The data were analysed using SPSS 22 and LISREL 8.80 statistical package programmes.

Findings

Results of ATSLS' Item Analysis

Item analysis was conducted to examine the differentiation of the items in ATSLS and whether they were related to the behaviours being measured. Table 2 shows the item analysis results.

Table 2

Results of item analysis

Item No	Item Total Correlation Score	Mean	Skewness	Kurtosis	SD
1	0.523	3.97	-0.780	0.388	0.913
2	0.603	3.37	-0.238	-0.984	1.209
3	0.436	4.01	-1.159	0.652	1.117
4	0.561	3.84	-0.788	0.111	1.040
5	0.544	4.16	-1.314	0.954	1.092
6	0.526	3.70	-0.604	-0.299	1.093
7	0.574	4.08	-1.013	0.379	1.021
8	0.592	3.71	-0.776	-0.686	1.364
9	0.461	3.65	-0.661	-0.661	1.269

10	0.561	3.78	-0.705	-0.385	1.177
11	0.564	3.91	-0.888	-0.181	1.180
12	0.445	3.46	-0.471	-0.852	1.272
13	0.484	3.69	-0.683	-0.550	1.238
14	0.458	3.81	-0.858	0.002	1.173
15	0.540	3.58	-0.575	-0.806	1.296
16	0.538	3.70	-0.606	-0.523	1.166
17	0.543	3.76	-0.789	0.007	1.110
18	0.526	3.61	-0.536	-0.528	1.146
19	0.563	4.08	-1.178	0.675	1.089
20	0.553	3.87	-0.949	0.168	1.150
21	0.458	3.79	-0.690	-0.342	1.140
22	0.480	4.01	-1.051	0.626	1.059
23	0.438	3.47	-0.480	-1.017	1.381
24	0.564	3.98	-1.088	0.530	1.115
25	0.456	3.87	-0.974	-0.242	1.307
26	0.538	3.83	-0.770	0.059	1.074
27	0.424	3.98	-1.030	0.574	1.082
28	0.390	3.66	-0.547	-0.355	1.124
29	0.520	3.94	-1.065	0.515	1.121
30	0.570	4.17	-1.436	0.869	1.244
31	0.568	4.00	-1.198	0.127	1.346
32	0.513	3.98	-1.006	0.518	1.068
33	0.616	3.85	-0.859	0.162	1.115
34	0.545	3.52	-0.485	-0.778	1.275
35	0.490	4.00	-0.996	0.615	1.027
36	0.496	4.03	-1.103	0.525	1.104
37	0.613	4.00	-1.081	0.510	1.096
38	0.528	3.83	-0.760	-0.049	1.092
39	0.403	3.77	-0.712	-0.170	1.120
40	0.579	3.62	-0.547	-0.555	1.206
41	0.458	3.93	-0.998	0.034	1.202
42	0.454	2.59	0.288	-0.823	1.228
43	0.492	2.55	0.435	-0.389	1.149
44	0.616	4.18	-1.335	0.907	1.118
45	0.591	4.16	-1.289	0.341	1.254
46	0.629	4.21	-1.375	1.118	1.086

Item Total correlation analysis in Table 2 shows that the correlation coefficients of all items were higher than .30. A correlation value higher than .30 means that the items are differentiative (Büyüköztürk, 2018). The normality check of the scale items showed that each item's kurtosis and skewness values were between ±1.5 and distributed normally (Tabachnick & Fidell, 2013). In addition, the mean values of the scale items were between 2.55 and 4.21.

Results of EFA

In order to determine the suitability of the data for factor analysis, Kaiser-Meyer-Olkin (KMO) and Bartlett values were calculated, and the results are shown in Table 3.

Table 3

Results of Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of sphericity

Kaiser-Meyer-Olkin (KMO)		0.906
Chi-square Value	x^2	3076.894
Bartlett's Test of Sphericity	sd	190
	p	0.000

According to Table 3, the KMO value of the scale was 0.90, and Bartlett's sphericity test (χ^2=3076,894, p<0.001) was statistically significant. The KMO value, which indicates the suitability and adequacy of the size of the dataset for analysis, should be above 0.60 (Field, 2013; Worthington & Whittaker, 2006). The results show that the data are suitable for factor analysis.

The results of EFA conducted to determine the scale's factor structure are given in Table 4.

Table 4

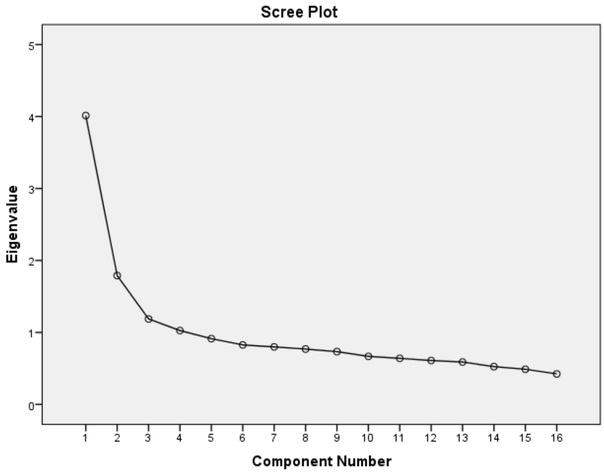
Results of EFA Analysis

Factor	Dimension	Item No	Eigen Value	Variance (%)	Total Variance (%)
1	Nature of Science Knowledge	46, 44, 38, 37, 32, 39,	2.475	15.468	15.468
2	Science-Technology Knowledge	31, 30, 25, 23	2.035	12.721	28.189
3	Science Content Knowledge	9, 12, 17	1.827	11.420	39.609
4	Technology Usage Knowledge	29, 24, 19	1.680	10.499	50.108

Table 4 shows that EFA resulted in a 16-item scale with 4 factors. The remaining items were excluded from the analysis because they were classified under more than one factor or did not have the desired factor load. The eigenvalue, explained variance, and scree plot were checked to determine the number of factors of the scale (Çokluk et al., 2010). According to the eigenvalue criterion, factors with an eigenvalue ≥ 1 are included in the scale's factor structure (Guttman, 1954; Kaiser, 1960; Field, 2013). According to the explained variance criterion, the total explained variance of a scale should be at least 50% (Gürbüz & Şahin, 2015). Regarding EFA results, the eigenvalue of each factor was greater than 1. The variances explained by these factors were: Factor 1 =15.468%, Factor 2 = 12.721%, Factor 3 = 11.420%, and Factor 4 = 6.530%, which explain 50.108% of the total variance. The last criterion, the scree plot, is shown in Figure 2.

Figure 2

Scree plot of ATSLS



Each point represents a factor in the scree plot of the scale shown in Figure 2. The point on the graph where the slope fell dramatically determines the number of factors (Cattell, 1966). The graph's eigenvalues are ranked in decreasing order; thus, the most important factors are in the first place. Accordingly, the optimum number of factors is where the line begins to stabilize (Gorsuch, 2003). The slope decrease was stabilized at point four. Accordingly, all 3 criteria used to determine the factor structure were met, and they are consistent with each other. Thus, the draft scale was set with 4 factors and 16 items. The factor loads and item-total correlations of the scale are shown in Table 5.

Table 5

Factor loads and item total correlations of ATSLS

Item No	ATSLS	1st Factor	2nd Factor	3rd Factor	4th Factor	Common Variance
46	Learning science subjects by experimenting creates new ideas in me	0.751				0.589
44	I feel happy when we do experiments in science class.	0.692				0.529
38	I am interested in gaining scientific knowledge through experimentation and observation.	0.594				0.454
37	I come up with new ideas while learning scientific knowledge	0.569				0.361
32	Studying scientific models gives me a sense of inquiry	0.522				0.429
39	Following developments in science makes me happy	0.515				0.460
31	Technology is important in meeting the needs of society.		0.753			0.615
30	Tools and equipment developed through technology are useful to society.		0.706			0.584
25	I want to use the knowledge I learn in science class in daily life.		0.677			0.516
23	I like to listen to news about technology.		0.588			0.353
9	I am fascinated by how ships can stay afloat.			0.785		0.622
12	I am curious why aeroplanes and cars have pointed front ends.			0.699		0.523
17	I want to know the difference between heat and temperature.			0.630		0.504
29	I am interested in using the latest technologies in my everyday life.				0.746	0.583

24	Using my knowledge of technology in daily life makes me happy.	0.683	0.526
19	The impact of technology on human life attracts my attention.	0.527	0.370

The first factor consisted of 6 items; factor loads were between 0.751 and 0.515, and was named "Nature of Science Knowledge". The second factor consisted of 4 items; factor loads were between 0.753 and 0.588 and was named "Science-Technology Knowledge". The third factor consisted of 3 items; factor loads were between 0.785 and 0.630 and was named "Science- Content Knowledge". The fourth factor consisted of 3 items; factor loads were between 0.746 and 0.527 and was named "Technology Usage Knowledge".

Results of the First-Level CFA

First-level CFA was performed on the data obtained from the second sample (N=392) to validate the 16-item and 4-factor structure of the scale that was formed after EFA. CFA-1 examined the model's standardised path diagram and *t italicise*-values. The model's goodness of fit values were calculated and shown in Table 6.

Table 6

CFA goodness of fit values of ATSLS

Fit Indices	Fit Values	Acceptable Fit	Perfect Fit
X^2/sd	2.38	$2 \leq \chi 2$ / sd ≤ 3	$0 \leq \chi 2$ / sd ≤ 2
RMSEA	0.060	0.05 ≤ RMSEA ≤ 0.08	0.00 ≤ RMSEA ≤ 0.05
AGFI	0.90	0. 85 ≤ AGFI <0.90	0.90 ≤ AGFI ≤ 1. 00
NFI	0.92	0.90 ≤ NFI ≤ 0.95	0.95 ≤ NFI ≤ 1.00
CFI	0.95	0.90 ≤ CFI ≤ 0.95	0.95 ≤ CFI ≤ 1.00
IFI	0.95	0.90 ≤ IFI ≤ 0.95	0.95 ≤ IFI ≤ 1.00
GFI	0.93	0.90 ≤ GFI < 0.95	0.95 ≤ GFI ≤ 1. 00

Table 6 shows that $\chi 2$ /sd (2.38), RMSEA (0.06), NFI (0.92), and GFI (0.93) of the model obtained from CFA-1 indicate an acceptable fit, while AGFI (0.90), CFI (0.95) and IFI (0.95) values indicate a perfect fit (Schermelleh-Engel et al. 2003). The model's standardised path diagram applied to the 4-factor scale and t-values' path diagrams are shown in Figure 3 and Figure 4.

Figure 3

CFA-1 Results: Standardised Path Diagram

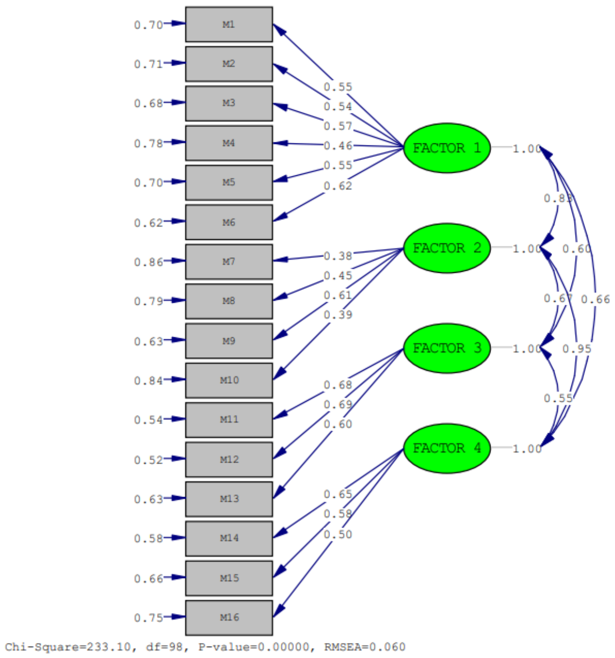


Figure 3 displays the standardised path diagram of the model from CFA-1, showing the loads of each item on the scale. Accordingly, Factor 1's loads are between 0.55 and 0.62, Factor 2's between 0.38 and 0.61, Factor 3's between 0.60 and 0.69, and the last factor's, Factor 4, between 0.50 and 0.65. The loads should be above 0.30 (Seçer, 2017) and the factor loads resulting from CFA-1 are above 0.30.

Figure 4

CFA-1 results: T- scroes

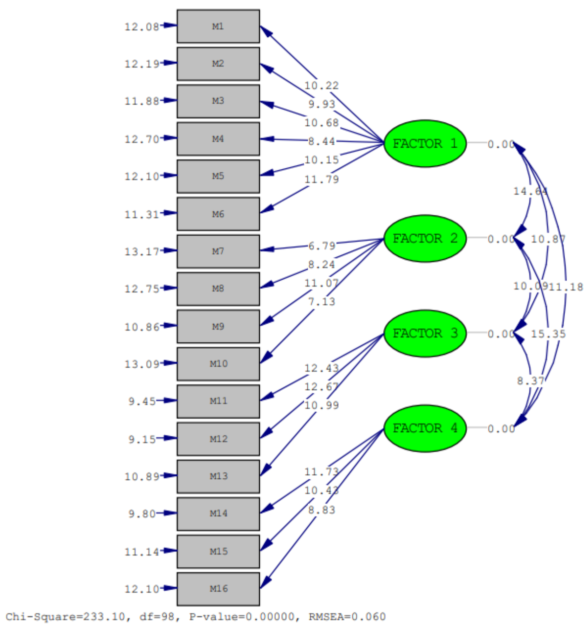


Figure 4 shows the t-values of the model obtained from CFA-1. There should be no red arrow in t values (Jöreskog & Sörbom, 1996), and there is no red arrow between the factors and items.

Result of Second-Level CFA

A second-level CFA is required for a scale with multiple factors (Meydan & Şeşen, 2011). The fit values of the model obtained from CFA-2 are shown in Table 7.

Table 7

CFA goodness of fit values of ATSLS

Fit Indices	Fit Values	Acceptable Fit	Perfect Fit
X^2/sd	2.38	$2 \leq \chi 2$ / sd ≤ 3	$0 \leq \chi 2$ / sd ≤ 2
RMSEA	0.060	0.05 ≤ RMSEA ≤0 .08	0.00 ≤ RMSEA ≤ 0.05
AGFI	0.90	0. 85 ≤ AGFI <0.90	0.90 ≤ AGFI ≤ 1. 00
NFI	0.92	0.90 ≤ NFI ≤ 0.95	0.95 ≤ NFI ≤ 1.00
CFI	0.95	0.90 ≤ CFI ≤ 0.95	0.95 ≤ CFI ≤ 1.00
IFI	0.95	0.90 ≤ IFI ≤ 0.95	0.95 ≤ IFI ≤ 1.00
GFI	0.93	0.90 ≤ GFI < 0.95	0.95 ≤ GFI ≤ 1. 00

Table 7 shows that the model resulting from the CFA-2 of the scale has an acceptable fit regarding $\chi 2$ /sd (2.38), RMSEA (0.60), NFI (0.92) and GFI (0.93) values. At the same time, it indicated a perfect fit for AGFI (0.85), CFI (0.95) and IFI (0.95) values (Schermelleh-Engel et al. 2003). The standardised path diagram and t-values of the model that emerged from CFA-2 are shown in Figure 5 and Figure 6.

Figure 5

CFA results: standardized path diagram

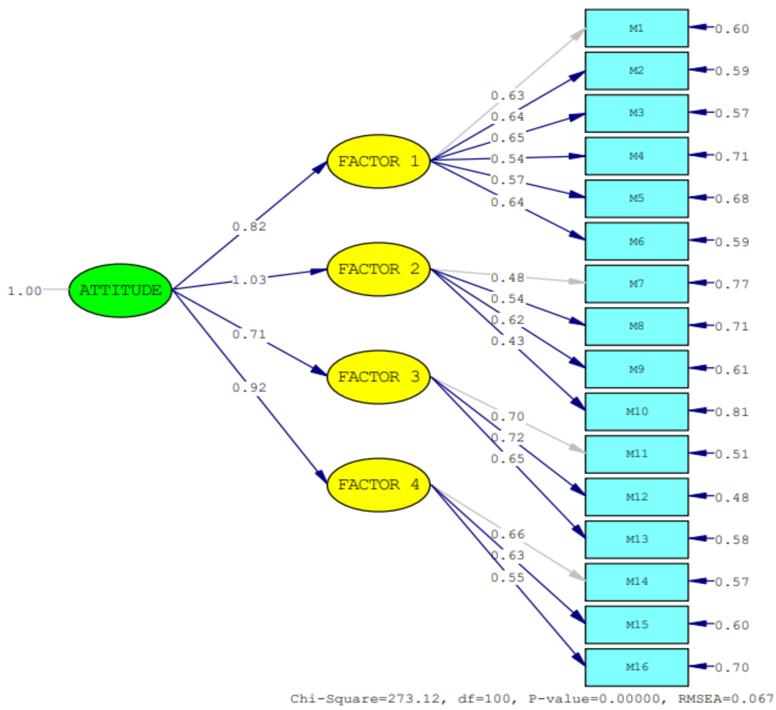


Figure 6

CFA results: T values

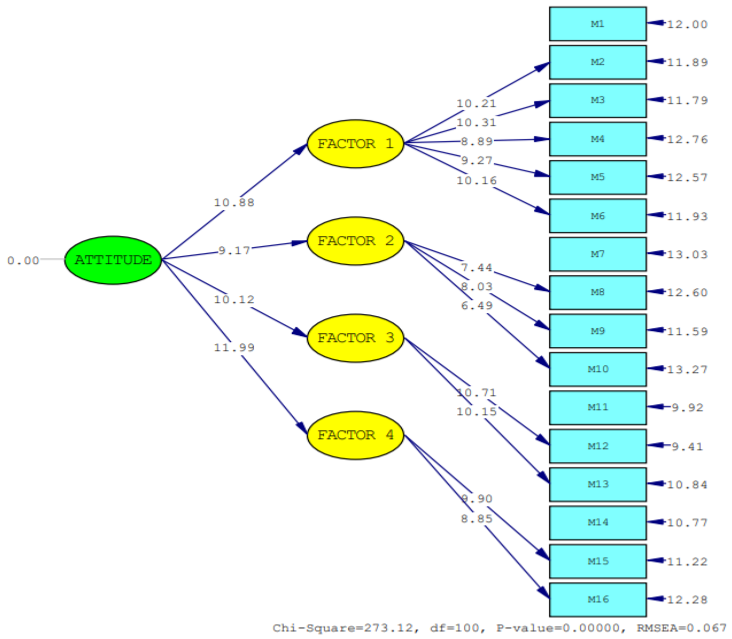


Figure 6 shows the t-values of the model resulting from CFA-2. Accordingly, the factors' t values are significant ($p<0.01$). The t value of the first factor was calculated to be 10.88, the second factor 9.17, the third factor 10.12, and the last factor 11.99. The factors' significant t values prove the model's acceptability (Schumacker & Lomax, 2004).

Findings on Reliability

ATSLS consisted of 4 factors and 16 items. Cronbach's Alpha internal consistency coefficients of the whole scale and its subdimensions were calculated separately to check reliability and are shown in Table 8.

Table 8

Cronbach alpha coefficients of ATSLS

Dimensions	Number of Items	Cronbach Alpha Coefficient
Nature of Science Knowledge	6	0.780
Science-Technology Knowledge	4	0.596
Science Content Knowledge	3	0.727
Technology Usage Knowledge	3	0.633
Overall Scale	16	0.867

Kayış (2010) and Şencan (2005) suggest that a Cronbach's Alpha coefficient between 0.40-0.60 is considered low but acceptable, while a coefficient between 0.60-0.80 is highly reliable. According to Table 8, it can be said that the first, third and fourth factors of the developed scale are highly reliable; the second factor's reliability is close to "highly reliable". The reliability coefficient of the overall scale is 0.867, which is quite high. The correlation between the overall scale and its dimensions is shown in Table 9.

Table 9

Pearson product moment correlation coefficients for ATSLS

Dimensions		1	2	3	4	5
1.	Nature of Science Knowledge	1	0.552	0.497	0.527	0.852
2.	Science-Technology Knowledge		1	0.464	0.604	0.804
3.	Science Content Knowledge			1	0.445	0.750
4.	Technology Usage Knowledge				1	0.772
5.	Overall Scale					1

Note. **p<0.01

Table 9 shows the relationship between the subfactors and the overall scale. According to the results, the relationship between the subfactors is between 0.445 and 0.604 (p<.01). According to Brown (2006), the relationship between the scale factors should be below 0.80. There is a positive and moderate relationship between the scale and its dimensions. In addition, the scale and all dimensions have positive and strong relationships. As a result, it can be said that the developed scale is a highly reliable measurement tool with a high internal consistency.

Discussion

This study was conducted to develop a scale to measure the attitudes of secondary school pupils towards science literacy. In the development process of the scale, EFA, CFA-1, CFA-2 and Cronbach's alpha coefficient were used for validity and reliability analyses. Firstly, data were collected from 546 secondary school students for EFA. The discriminability of the collected data was analysed for each item. The item-total correlation analysis showed that the correlation coefficients of all items were higher than 0.30. According to Büyüköztürk (2018), an item total correlation value higher than 0.30 means that item discrimination is achieved. Therefore, it can be said that the items in the draft scale have high discrimination. The normality check of the scale items showed that each item's kurtosis and skewness values were between ±1.5 and distributed normally (Tabachnick & Fidell, 2013).

KMO and Bartlett Sphericity test were examined to reveal the suitability and adequacy of the size of the data set for the analysis. Kaiser-Meyer-Olkin (KMO) value was 0.90 and Bartlett's test of sphericity ($\chi 2$=.3076,894, p<.001) was found to be significant. In the literature, it is stated that the Kaiser-Meyer-Olkin (KMO) value should be above 0.60. (Tabachnick & Fidell, 2001; Büyüköztürk, 2018).

As a result of the EFA analysis conducted after the desired conditions were met, a draft scale with 16 items and 4 factors emerged. The eigenvalue, explained variance, and scree plot were checked to determine the number of factors of the scale (Çokluk, et. al., 2010). According to the eigenvalue criterion, factors with an eigenvalue ≥ 1 are included in the scale's factor structure (Guttman, 1954; Kaiser, 1960; Field, 2013). According to the explained variance criterion, the total explained variance of a scale should be at least 50% (Gürbüz & Şahin, 2015). Regarding EFA results, the eigenvalue of each factor was greater than 1. The variances explained by these factors were: Factor 1 =15.468%, Factor 2 = 12.721%, Factor 3 = 11.420%, and Factor 4 = 6.530%, which explain 50.108% of the total variance.

The last criterion, the scree plot graph, was obtained. The point on the graph where the slope fell dramatically determines the number of factors (Cattell, 1966). The graph's eigenvalues are ranked in decreasing order; thus, the most important factors are in the first place. Accordingly, the optimum number of factors is where the line begins to stabilize (Gorsuch, 2003). The slope decrease was stabilized at point four. Accordingly, all 3 criteria used to determine the factor structure were met, and they are consistent with each other. Thus, the draft scale was set with 4 factors and 16 items.

First-level CFA was performed on the data obtained from the second sample (N=392) to validate the 16-item and 4-factor structure of the scale that was formed after EFA. The $\chi 2$ /sd (2.38), RMSEA (0.06), NFI (0.92) and GFI (0.93) values of the model obtained from CFA-1 indicate an acceptable fit; AGFI (0.90), CFI (0.95) and IFI (0.95) values indicate an excellent fit (Schermelleh-Engel et al. 2003). The draft scale consists of more than one factor. A second-level CFA is required for a scale with multiple factors (Meydan & Şeşen, 2011). Yapılan DFA-2 sonucunda ortaya çıkan modelin uyum iyiliği değerlerinden $\chi 2$ /sd (2.38), RMSEA (0.60), NFI (0.92) ve GFI (0.93) değerleri ile kabul edilebilir uyum gösterirken AGFI (0.85), CFI (0.95) ve IFI (0.95) değerleri ile mükemmel uyum gösterdiği ortaya çıkmıştır (Schermelleh & Moosbrugger, 2003).

ATSLS consisted of 4 factors and 16 items. Cronbach's Alpha internal consistency coefficients of the whole scale and its subdimensions were calculated separately to check reliability. It was calculated separately for the whole scale and its dimensions. Kayış (2010) and Şencan (2005) suggest that a Cronbach's Alpha coefficient between 0.40-0.60 is considered low but acceptable, while a coefficient between 0.60-0.80 is highly reliable. According to Table 8, it can be said that the first, third and fourth factors of the developed scale are highly reliable; the second factor's reliability is close to "highly reliable". The reliability coefficient of the overall scale is 0.867, which is quite high. The correlation between the overall scale and its dimensions is also important for reliability. According to Brown (2006), the relationship between the scale factors should be below 0.80. There is a positive and moderate relationship between the scale and its dimensions. In addition, the scale and all dimensions have positive and strong relationships. As a result, it can be said that the developed scale is a highly reliable measurement tool with a high internal consistency.

The literature review shows that the dimensions of science literacy are in line with "Scientific Content Knowledge," "Interactions among Science, Technology, Society, and Environment," and "Nature of Science Knowledge" (Miller, 1983). They are also similar to another dimensioning that includes "the Nature of Science and Technology, Key Scientific Concepts, Scientific Process Skills, Science-Technology-Society-Environment Relationships, Scientific and Technical Psycho-Motor Skills, Values that Constitute the Essence of Science, Attitudes and Values towards Science" (MEB, 2005). As a result, it can be said that the dimensions of the developed scale are in line with the theoretical structure of science literacy.

Conclusion and Implications

In this study, a data collection tool was developed and validated to measure secondary school students' attitudes towards science literacy. The developed scale of attitudes towards science literacy enables to evaluate the attitudes of secondary school students towards science literacy. The results of the assessment can be used to optimise policies in science education, improve teaching resources, identify areas for improvement in science literacy learning, and provide professional development for teachers in science education. more detailed results can be obtained by conducting semi-structured interviews with students.

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Appendix A

Attitude Towards Science Literacy Scale

Dimensions	Item No	Attitude Scale Towards Science Literacy	Strongly agree	Agree	Partially agree	Disagree	Strongly disagree
Nature of Science Knowledge	1	Learning science subjects by experimenting creates new ideas in me.					
	2	I feel happy when we do experiments in science class.					
	3	I am interested in gaining scientific knowledge through experimentation and observation.					
	4	I come up with new ideas while learning scientific knowledge.					
	5	Studying scientific models gives me a sense of inquiry.					
	6	Following developments in science makes me happy.					
Science-Technology Knowledge	7	Technology is important in meeting the needs of society.					
	8	Tools and equipment developed through technology are useful to society.					
	9	I want to use the knowledge I learn in science class in daily life.					
	10	I like to listen to news about technology.					
Science Content Knowledge	11	I am fascinated by how ships can stay afloat.					
	12	I am curious why aeroplanes and cars have pointed front ends.					
	13	I want to know the difference between heat and temperature.					
Technology Usage Knowledge	14	I am interested in using the latest technologies in my everyday life.					
	15	Using my knowledge of technology in daily life makes me happy.					
	16	The impact of technology on human life attracts my attention.					