Assessing Scientific Literacy Levels of High School Students by Scientific Inquiry Literacy Test

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SUMMARY

The purpose of this research is to determine the scientific literacy levels of students in 9th, 10th, 11th and 12th grades of high school by using the scientific literacy research test. In the study, it was investigated whether there is a significant difference in scientific literacy among students studying at different levels in secondary education. Scientific literacy test developed by Carl J, Wenning was used to determine the scientific literacy levels of the students. The research was carried out with a total number of 187 students at different levels studying in secondary education. In the analysis of the data, arithmetic mean, standard deviation, t-test and analysis of variance were used to determine scientific literacy levels. According to the results of the research, there was a significant difference between the students' scientific literacy levels between the 9th and 11th grade students and the 12th grade students in favor of the 12th grade students, while there was no significant difference between the 10th and 12th grade students.

Keywords: Secondary education, Scientific literacy, Scientific literacy inquiry test

INTRODUCTION

The needs vary within each century. Likewise, the concept of literacy, which was used in the world only in the sense of being able to read and write, has started to share its place with concepts such as financial literacy, media literacy, digital literacy and scientific literacy, which we will focus on in this study. According to the study carried out by TURKSTAT in 2021, the rate of illiterate people in Turkey was 80.8% in 1935, while this rate decreased to 2.5% in 2021, showing a continuous downward trend over the years. The proportion of primary, secondary or equivalent school graduates increased from 3.6% in 1970 to 25% in 2021. The proportion of high school graduates or equivalent was 2.6% in 1970, while it was 22.4% in 2021. (TURKSTAT, 2022) Looking at these figures, we can say that an increasing graph is observed in literacy in our country. However, this situation has now turned out to be scientific literacy race with other developed countries. How can we explain the importance of the concept of Scientific Literacy, which entered the agenda of the 2019 European Parliament with expressions of an educational challenge, was held for weeks (Canada), was included in the 5-year plans of countries with percentage targets (China), and seminars were held for its citizens (Norway)?

It is seen that the importance given to scientific literacy increased especially after the Second World War, when it was stated that the security and success of nations depended on the speed of scientific knowledge, and after Sputnik was sent to space in 1957 (DeBoer, 2000). Scientific literacy, as a concept, first appeared in the literature with the article written by Paul Hurd in the middle of the 20th century, but different definitions have been made until today (Turgut, 2007). Hurd (1958) pointed out the importance of scientific literacy by expressing that science has become one of the most characteristic features of modern society with its applications in technology. However, Pella et all (1958), scientific literacy; Little is certain or agreed upon about what scientific literacy means, until it claims to include an understanding of the basic concepts of science, the nature of science, the ethical work of scientists, the interrelationships between science and the humanities, and the differences between science and technology. (Acted by Hodson 2008)

About a quarter of a century later the American Association for the Advancement of Science; The American Association for the Advancement of Science defines a scientifically literate person as "a person who understands the principles of science, is familiar with the natural world, and uses scientific knowledge and method for individual and social purposes" (AAAS, 1989). According to this definition, scientific literacy should not only include scientific knowledge and understanding of scientific ideas, but also the process of applying this knowledge. Individuals should be able to look at scientific texts with a critical eye and interpret the contents correctly (Utma 2017).

4 years later, Scientific Literacy Standards were published within the scope of Project 2061. In this study, scientific literacy standards were included at preschool-second grade, third-fourth grade, fifth-eighth grade, and ninth-twelfth grade levels (AAAS, 1993). Both Science for All Americans and Scientific Literacy Standards studies emphasize that science teaching should be based on inquiry (Bybee, 2000).

Koch and Eckstein (1995) defined scientific literacy as the ability to make sense of a scientific text with active and critical participation. A scientifically literate person should be able to look at the text with a critical approach and interpret it from a theoretical perspective.

With these studies, the concept of scientific literacy has gradually started to enter the education curricula in other countries. In the curriculum changes made in Turkey in 2004, the vision of the science curriculum was determined as "all citizens to be science literate" (Köseoğlu, Tümay, & Budak, 2008). In these curricula, scientific literacy is addressed with the dimensions of knowledge, skill, emotion and science-technology-society-environment (Şahin & Ateş, 2018).

Miller (2006) also compared the scientific literacy levels of adults in European countries and the United States of America. 33 countries, including Türkiye, were included in this study. When we look at the results of the research, it is seen that while adults in Sweden, the USA and the Netherlands are in the first place, 2% of the adults in our country are scientifically literate at a sufficient level and are in the last place compared to other countries (Cited by Şahin and Ateş, 2018).

Laugksch (2000) also stated that supporting scientific literacy is a national wealth and that scientifically literate individuals will be successful in competing in international markets. In addition, Glynn and Duit (1995) stated that scientifically literate students can be expected to make informed decisions about their future in science, education and social issues.

In order to rank higher in this race with other countries, the forms of questions faced by students have also changed with the new education programs. Previously, the questions were more theoretical and knowledge-oriented, but in the new system, we are faced with new generation questions. The purpose of this system is to reduce rote-based learning in students and to enable them to understand, interpret, and conclude what they read, that is, to become scientifically literate individuals.

Arduç and Kahraman (2021), in their review of the literature on scientific literacy in Turkey between 2010 and 2019, drew attention to the existence of master's theses with a rate of 61%, as well as articles and a small number of doctoral dissertations.. In Turkey, with the introduction of scientific literacy concept into education programs, there has been a striking increase in the number of studies in this field.

There are studies that appears in different forms related to scientific literacy in the field of science; on the effects of teaching methods and techniques on scientific literacy (Güçlüer, 2012; Keskin & Çam, 2019; Gültekin, 2009; Gülhan, 2012; Boran, 2014 & Yıldız, 2010), on the scientific literacy levels of teachers and teacher candidates (Bartan,2020; Soğuksu , 2013; Tekin, 2013; Turgut, 2018; Memiş et al. 2016), on the adaptation of foreign scientific literacy tests to Turkish (Kalyon, 2020; Şahin & Ateş, 2018) and measuring the scientific literacy levels of students (Duruk, 2012; Kömek , 2012; Özbay, 2011; Keskin et al, 2016, Tezel & Tezgören, 2019; Sicimoğlu, 2020).

In this study, it was aimed to determine the scientific literacy levels of students in the 9th, 10th, 11th, 12th grades of secondary education by using the Scientific Literacy Inquiry Test.

METHOD

Scanning model was used as the method in this research. Because screening models are suitable for research that aims to describe a past or present situation as it exists (Karasar, 1999). The research is a relational research in the survey model. Relational screening model is a screening approach that aims to determine the existence of co-variation between two or more variables. In the relational screening model, whether the variables change together or not; if there is a change, it is tried to determine how it happened (Karasar, 2011).

Population and Sample

The universe of the research is a high school in Doğanhisar district of Konya province in 2022-2023 academic year. The sample consists of 187 students. 43 of them 9th grade students, 52 of them 10th grade students, 45 of the 11th grade students and 44 of them 12th grade students.

Data Collection Tool

The Scientific Literacy Research Test which was developed by Carl J, Wenning in 2007, was used as a data collection tool in the research. The test includes multiple-choice and interpretation-based questions.

The standard deviation of the sample is 4.62, and the standard error of the mean 2.49. The KR20 reliability coefficient is 0.71. For the test used in this study, the forward translation design was preferred in the translation from English to Turkish. In advanced translation, a single translator or preferably a group of translators adapts the test from the source language to the target language. The equivalence of the two versions of the test is then evaluated by another group of translators/experts. Revisions can be made to the target language version of the test to correct problems identified by translators/experts. Sometimes, as a final step, another person, though not necessarily a translator, may evaluate the target language version of the test and edit it to "fix" the test (Hambleton, 2005).

The data obtained from the research were analyzed with the SPSS program. In the analysis of the data descriptive statistics (frequency, percentage, mean), T test, ANOVA and correlation analyzes were used.

FINDINGS

In this section, the findings that emerged as a result of the analysis of the scientific literacy test data of 9th, 10th, 11th and 12th grade students are included.

Descriptive statistics were used to determine the scientific literacy levels of the students, by finding the frequency and percentage distributions. In order to determine whether there is a significant difference between the scientific literacy levels of the groups, t-test and analysis of variance were performed. Scientific Literacy Test was evaluated out of 100 points.

Table 1. Descriptive Statistics on the Scientific Literacy Inquiry Test Scores of the Classes

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
9	43	30,81	12,627	1,926	26,93	34,70	0	65
10	52	35,77	9,465	1,313	33,13	38,40	15	55
11	45	34,67	16,355	2,438	29,75	39,58	0	60
12	44	42,95	15,526	2,341	38,23	47,67	15	75
Total	184	36,06	14,175	1,045	34,00	38,12	0	75

It is observed that the class average score is the lowest in the 9th grades and the highest in the 12th grades according to Table 1. Also, the class in which the most questions were answered correctly was the 12th grades.

Table 2. Frequency Values of Scientific Literacy Inquiry Test

		GRADE 9	GRADE 10	GRADE 11	GRADE 12
N	Valid	43	52	45	44
	Missing	9	0	7	8
Mean		30,81	35,77	34,67	42,95
Std. Error of Mean		1,926	1,313	2,438	2,341
Median		30,00	35,00	35,00	45,00
Std. Deviation		12,627	9,465	16,355	15,526
Variance		159,441	89,593	267,500	241,068
Range		65	40	60	60
Minimum		0	15	0	15
Maximum		65	55	60	75
Sum		1325	1860	1560	1890

According to Table 2, it is seen that the highest intensity in the 9th grades is in the 30-point band, in the 10th grades the highest intensity is in the 35-point band, in the 11th grades the highest intensity is in the 35-point band, and in the 12th grades, the highest intensity is in the 45-point band.

Table 3. Scientific Literacy Inquiry Test 9th Grade Frequency Table

	Frequency	Percent	Valid Percent	Cumulative Percent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,9	2,3	2,3
	10	1	1,9	2,3	4,7
	15	2	3,8	4,7	9,3
	20	8	15,4	18,6	27,9
	25	6	11,5	14,0	41,9
	30	7	13,5	16,3	58,1
	35	6	11,5	14,0	72,1
	40	6	11,5	14,0	86,0
	45	1	1,9	2,3	88,4
	50	3	5,8	7,0	95,3
	55	1	1,9	2,3	97,7
	65	1	1,9	2,3	100,0
	Total	43	82,7	100,0	
Missing System		9	17,3		
Total		52	100,0		

In Table 3, it was observed that approximately 77% of 43 students had scores between 20-40. The number of correct answers is between 4-8 out of 20 questions.

Table 4. Scientific Literacy Inquiry Test 10th Grade Frequency Table

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15	1	1,9	1,9	1,9
	20	2	3,8	3,8	5,8
	25	7	13,5	3,5	19,2
	30	11	21,2	21,2	40,4
	35	11	21,2	21,2	61,5
	40	6	11,5	11,5	73,1
	45	7	13,5	13,5	86,5
	50	5	9,6	9,6	96,2
	55	2	3,8	3,8	100,0
	Total	52	100,0	100,0	

When Table 4 is examined, it is observed that approximately 20% of 52 students' scores are between 15-25, 43% of them are between 30-35, and about 36% of them are between 40-55. Compared to the 9th grade, the percentage of students above the median value is higher.

Table 5. Frequency Table of the 11th Grades of the Scientific Literacy Inquiry Test

	Frequency	Percent	Valid Percent	Cumulative Percent

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	1	1,9	2,2	2,2
	10	2	3,8	4,4	6,7
	15	4	7,7	8,9	15,6
	20	6	11,5	13,3	28,9
	25	4	7,7	8,9	37,8
	30	3	5,8	6,7	44,4
	35	6	11,5	13,3	57,8
	40	5	9,6	11,1	68,9
	45	3	5,8	6,7	75,6
	50	3	5,8	6,7	82,2
	55	1	1,9	2,2	84,4
	60	7	13,5	15,6	100,0
	Total	45	86,5	100,0	
Missing System		7	13,5		
Total		52	100,0		

When Table 5 is examined, it is observed that 44% of 45 students' scores are between 0-30, 24% of them are between 35-40, and about 31% of them are between 40-55. Compared to the 9th grade, the rate of students above the median is higher, and slightly less than the 10th grade.

Table 6. Scientific Literacy Inquiry Test 12th Grade Frequency Table

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	15	1	1,9	2,3	2,3
	20	2	3,8	4,5	6,8
	25	4	7,7	9,1	15,9
	30	7	13,5	15,9	31,8
	35	5	9,6	11,4	43,2
	40	2	3,8	4,5	47,7
	45	7	13,5	15,9	63,6
	50	4	7,7	9,1	72,7
	55	4	7,7	9,1	81,8
	60	3	5,8	6,8	88,6
	65	2	3,8	4,5	93,2
	75	3	5,8	6,8	100,0
	Total	44	84,6	100,0	
Missing System		8	15,4		
Total		52	100,0		

In Table 6, it is observed that approximately 48% of 44 students had scores between 15-40, 44% had scores between 45-55, and 18% had scores between 60-75%. Answering the most questions correctly (15 questions) is in the 12th grade.

Table 7. Scientific Literacy Inquiry Test ANOVA Results

(I)	(J)	Mean Difference (I-J)	Std. Error	Sig	95% Confidence	
					Lower Bound	Upper Bound
9	10	-4,955	2,808	,377	-12,88	2,97
	11	-3,853	2,905	,625	-12,05	4,35

	12	12,141*	2,921	,001	-20,38	-3,90
10	9	4,955	2,808	,377	-2,97	12,88
	11	1,103	2,773	,984	-6,72	8,93
	12	-7,185	2,790	,088	-15,06	,69
11	9	3,853	2,905	,625	-4,35	12,05
	10	-1,103	2,773	,984	-8,93	6,72
	12	-8,288*	2,888	,044	-16,44	-,14
12	9	12,141*	15,526	,001	3,90	20,38
	10	7,185	2,921	,088	-,69	15,06
	11	8,288*	2,790	,044	,14	16,44

*. The mean difference is significant at the 0.05 level.

First, the sig (p) value found as a result of the Levene test was checked to see if the data had a homogeneous distribution. Since this value is greater than 0.05, we can say that there is a homogeneous distribution. Then Scheffe test analysis was performed to determine between which groups the differences were. The Scheffe method was developed to compare all possible linear combinations between groups; this method is generally considered as a post hoc type that is the most flexible and can keep the margin of error under control (conservative) in case the number of groups to be compared is large (Scheffe, 1953).

When Table 7 is examined, according to the results of Scheffe test analysis, a significant difference was found between 9th grade students and 12th grade students and between 11th grade students and 12th grade students in favor of 12th grade students. There was no significant difference between 10th grade students and 12th grade students.

CONCLUSION AND DISCUSSION

As a result of the Scientific Literacy Test that we applied to 9th, 10th, 11th and 12th grade students, a significant difference was observed between 9-12, 11-12 grades, but no significant difference was found between other grades. However, as a result of the research in the 12th grades, we can say that more correct answers are given by the students and that the averages are higher, and that scientific literacy can be positively affected as the grade level increases.

However, regarding to the levels in each grade in general, it can be said that it is not at the expected level. While the average exam score was 67.6% in the classes where the original study was applied, it increased to 36.06% in our study. The difference is striking.

In our country, the inclusion of non-exam-oriented elective courses in the curriculum, which can help students read, analyze, establish relationships, and transfer this relationship to other events, especially at high school level, can help increase students' scientific literacy levels.

In order for the results of our study to be more generalizable, this test can be applied again as the same student group advances, and the change in the students' individual status can be observed.

In addition, the results of the test and other scientific literacy tests can be applied to the same student groups to examine the relationship between the results, the sample of the study can be expanded and the research can be diversified with questions that can provide different thinking.

In these times when it is of great importance for students to develop scientific thinking skills as well as academic success, an infrastructure can be created for students by adding elective courses such as scientific literacy, scientific thinking, science and ethics to the school curriculum during the high school period.

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