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RECONCEPTUALIZING AND FIELD TESTING THE SCIENTIFIC LITERACY FRAMEWORK BY EXPLORING THE ASPECT OF SCIENTIFIC LITERACY IN TURKISH SCIENCE CURRICULUM

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Abstract. *The aim of this research was twofold. The first aim was to revise the existing scientific literacy framework developed by Boujaoude in accordance with the current literature about scientific literacy. The second aim was to explore how the aspects of scientific literacy were reflected in the Turkish science curriculum using the revised framework. The impact of science and technology on environment resulted in the need for both scientifically and environmentally literate individuals and therefore, any framework examining scientific literacy should include the interaction between science, technology, society, and environment as an aspect. Moreover, a new aspect was suggested for the framework, the affective side of science, considering the affective outcomes of science education. Finally, the science curriculum from grades 3 to 8 was analyzed using the revised framework. Results showed that the revisions on the framework resulted in a more rigorous framework which evaluates scientific literacy more precisely. Moreover, the results about the analysis of science curriculum indicated that the knowledge of science and the investigative nature of science were reflected in the objectives of the curriculum more than other aspects. The results and implications were discussed.*

Keywords: *affective domain, document analysis, science curriculum, science education, scientific literacy framework.*

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Introduction

The education systems all over the world are under the pressure of the industrial revolution. In considering what kind of education meets the needs of today, educators should focus on the curriculum to prepare young individuals for this purpose. Bayliss (1999, p. 9) argued that "many people in education are realizing that the time for tinkering with the traditional curriculum is over". There is a need for such a curriculum which fosters creativity and imagination as today's industrial world requires. The skills and knowledge required for the needs of today should be integrated into the curriculum of different disciplines. Science education and the skills required for today's world have a lot in common (e.g. creativity, productivity, and critical thinking) which makes science education more critical for educating students to handle the challenges of the day. It has been emphasized that scientific literacy is one of the characteristics of the citizens of the societies to meet the needs of today (Cansiz & Turker, 2011; Choi, Lee, Shin, Kim, & Krajcik, 2011). Although scientific literacy has been emphasized since the 1950s (Choi et al., 2011), it has multiple meanings (Pearson, Moje, & Greenleaf, 2010). Two visions of scientific literacy have shaped these definitions (Roberts, 2007). One vision has focused on understanding key scientific concepts, principles, and facts; the other has emphasized the use of knowledge in situations students face in daily life as citizens (Roberts, 2007).

The developments in science and technology produce controversial issues in which people need to make decisions. Most of the controversial issues include an environmental aspect because those developments influence the environment and its components too. For example, as the nuclear chemistry and physics develops and technology advances, nuclear power plants have emerged. Then, the impact of nuclear power plants on environment and organisms have begun to take place in the agenda of scholars all over the world. Such problems require thorough investigation and decision-making by a variety of stakeholders. The public is also among those stakeholders. This necessitates that public, as the stakeholders, should be equipped with the

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knowledge and skills to make informed decisions about social and environmental problems. That is, there exists a need for both scientifically and environmentally literate citizens in today's world (Bybee, 2008). Therefore, there is a need for such a science curriculum which targets to achieve this goal. In deciding whether the curriculum is competent in preparing scientifically literate individuals, a framework covering all aspects of scientific literacy is needed. Such a framework might have the capacity to assess the science curriculum in terms of scientific literacy. Chiappetta, Fillman, and Sethna (1991) proposed four aspects for the construct *scientific literacy*. BouJaoude (2002) used Chiappetta et al.'s (1991) study as the base for developing the scientific literacy framework to evaluate the curriculum. This framework has been widely used in many studies in recent years too (e.g. Cansiz & Turker, 2011; Erdoğan & Köseoğlu, 2012; Forjan & Sliško, 2017; Kılıç, Haymana, & Bozyılmaz, 2010; Wei & Chen, 2017). However, it requires modification since the characteristics of scientifically literate individuals as well as the definition of scientific literacy has been shaped by the fast-changing world. Therefore, as being one of the aims of this research, the framework was reconceptualized and a revised framework was suggested for the use by the researchers to analyze science curriculum and other science-related documents.

Realizing the fact that science education in primary and middle school has a key role in building a society with scientifically literate citizens; the science curriculum at these levels of education should have the necessary elements of scientific literacy (Cansiz & Cansiz, 2019). In a curriculum, there are three main components: objectives, instruction, and assessment (Anderson, 2010). Objectives have been considered as the most specific aspect of the curriculum as they follow the philosophy, aims, and goals (Behar-Horenstein, 2010). In other words, they act as the starting point for teaching. Teachers look at the objectives and decide on methods for teaching, classroom activities, teaching materials and the way to assess the students' learning. Therefore, the knowledge, skills, and values emphasized in the objectives should be determined carefully. Since the objectives describe what the learners are able to do after the instruction, their role in fostering scientific literacy becomes more critical. Being one of the prime components of the curriculum, if the objectives include the knowledge and skills that are required for educating scientifically literate individuals, then the curriculum might achieve its purpose. That is, if the objectives are written in a way that emphasizes the aspects of scientific literacy, then the problems in educating scientifically literate students might be diminished. Therefore, objectives should be analyzed if they target the intended learning outcomes in terms of scientific literacy which was the other aim of this research.

Existing Scientific Literacy Framework developed by Boujaoude

Boujaoude (2002) developed the framework to analyze science curricula based on Chiappetta et al. (1991) and Chiappetta, Sethna, and Fillman's (1993) work. Chiappetta et al.'s (1991) scientific literacy themes are 1) the knowledge of science, 2) the investigative nature of science, 3) science as a way of thinking, and 4) interaction of science, technology, and society.

The first one, *the knowledge of science*, refers to the content aspect. When the focus is to teach scientific knowledge and make students remember and use that knowledge, it refers to the first theme (Chiappetta et al., 1993). Chiappetta et al. underlined that this theme covers the transfer of scientific knowledge from teacher to students.

The second theme, namely *the investigative nature of science* refers to what is known as science process skills. This theme aims to evaluate whether students are engaged with science process skills and use them actively (Chiappetta et al., 1993). This is important in that it emphasizes the activities which foster students to reason, to interpret, and to evaluate; and encourages them to involve activities by exploring scientific knowledge rather than rote memorization of scientific knowledge.

The third theme in Chiappetta et al.'s framework is *science as a way of thinking*. The governing idea in this theme is about the nature of science and scientific knowledge. This theme is particularly important to figure out how scientists carry out scientific inquiries and use reasoning skills. (Chiappetta et al., 1993). The knowledge emphasizing the historical development of scientific knowledge, scientists' approaches to their work, and the role of evidence has been sorted under this category (Chiappetta et al., 1993).

The last theme in the framework is the *interaction of science, technology, and society*. If the scientific endeavor intends to demonstrate the impacts of science on the public, it is related to this theme. The advantages and disadvantages of science and technology on society, cases illustrating the science or technology-related social issues have been categorized under this category (Chiappetta et al., 1993).

Boujaoude (2002) used Chiappetta et al.'s work as the foundation of his study and adapted the four aspects of scientific literacy to analyze science curricula. The author made three modifications to the framework. First, he

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added the issues: the use of science in making every day personal decisions, resolve science-related problems in daily life, and engage with moral and ethical topics in science to the aspect *interaction of science, technology, and society*. Second, the author suggested analyzing the different domains (e.g. general science and physics) of scientific literacy separately defending that one cannot be scientifically literate in all subject areas. Thirdly, he preferred using *science as a way of knowing* instead of science as a way of thinking since the former covers the epistemology of science (Boujaoude, 2002). The framework Boujaoude adapted is given in Table 1.

Table 1. Scientific Literacy Framework developed by Boujaoude (2002).

Aspects of Scientific Literacy
Aspect 1. The knowledge of science: - Facts, concepts, principles, laws, hypotheses, theories, and models of science
Aspect 2. The investigative nature of science: - Using methods and process of science such as observation, measuring, classifying, inferring, recording and analyzing data, Communicating using a variety of means such as writing, speaking, using graphs, tables, and charts, making calculations, and experimenting - Emphasis on hands-on minds-on science
Aspect 3. Science as a way of knowing: - Emphasizes thinking, reasoning, and reflection in the construction of scientific knowledge and the work of scientists - Empirical nature in science - Ensuring objectivity of science - Use of assumptions in science - Inductive and deductive reasoning - Cause and effect relationships - The relationship between evidence and proof - Role of self-examination in science - Describes how scientists experiment
Aspect 4. Interaction of science, technology, and society: - Impact of science on society - Inter-relationships between science, society, and technology - Careers - Science-related social issues - Personal use of science to make everyday decisions, solve everyday problems, and improve one's life - Science-related moral and ethical issues

In this research, the existing scientific literacy framework was revised, and the Turkish science curriculum was analyzed with it. Overall, the following research questions guided this research:

1. Is the existing scientific literacy framework consistent with the current literature about scientific literacy?
2. How does the Turkish science curriculum reflect the aspects of scientific literacy?

Research Methodology

General Background

This research utilized document analysis. It is a type of qualitative research method and includes a systemic practice for assessing printed and electronic materials (Bowen, 2009). This research was conducted during the 2018-2019 fall semester after the 2018 science curriculum had been released by the Turkish Ministry of National Education.

The Unit of Analysis: The Turkish Science Curriculum at a Glance

In this research, the recent science curriculum in Turkey was analyzed. It was released in 2018 for grades 3 to 8. Science is formally introduced to the students first in 3rd grade in primary school. There is a national curriculum for all science teachers to follow. Topics in the curriculum have been deepened in each grade with increasing complexity. At the end of 8th grade, students would take 792 hours of science with 326 objectives. Until the end of middle school, science is taught including chemistry, physics, and biology by the science teachers. In secondary school, these three disciplines are taught separately. The recent curriculum includes new trends in science educa-

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tion as a result of reforms such as socio-scientific issues, science-technology-engineering-mathematics practices, and values education.

Data Analysis

This research occurred in five steps. In the first step, the authors of this research had reviewed the literature about scientific literacy and then they evaluated the degree to which the existing scientific literacy framework was consistent with the current literature about scientific literacy. In the second step, the existing aspect of the framework was revised, and a new aspect was suggested based on the literature. Third, the two researchers reached consensus on each aspect of the framework and their descriptions. Moreover, they scrutinized each objective independently and assigned it to one of the five aspects. In the next step, they compared their analyses and found that there were 28 inconsistencies out of 326 decisions. Therefore, the interrater reliability was calculated as 91.4%. Then, Cohen's Kappa (Cohen, 1960) was administered to test the significance of this interrater reliability. The interrater reliability was statistically significant (Cohen's Kappa = .78, $p < .001$). Based on Landis and Koch's (1977) criteria, the level of agreement was substantial. In the final step, the researchers focused on inconsistent decisions and negotiated on them. The process of data analysis was iterated until a convincing agreement was reached on categorization. And finally, all inconsistencies were resolved, and a full agreement was obtained. The summary of the research procedure was given in Figure 1.

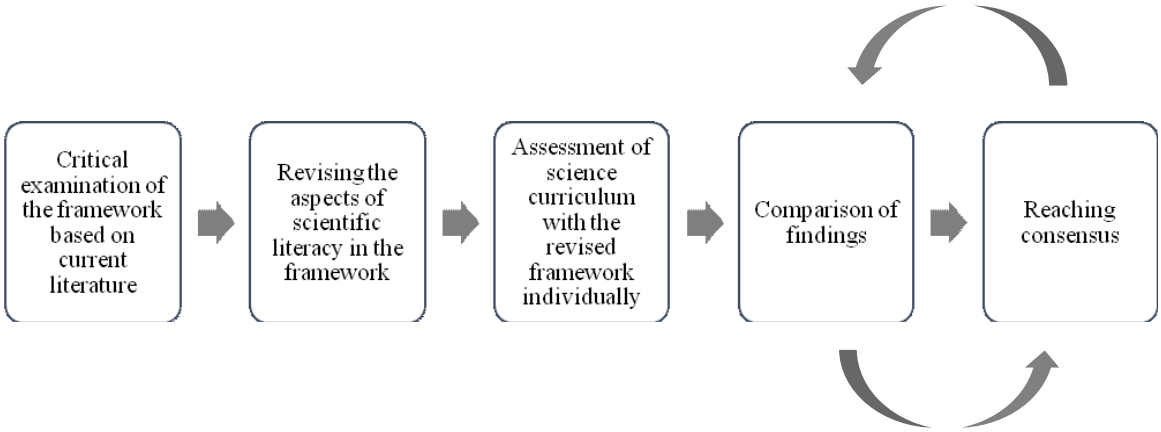

Figure 1. The summary of the research procedure.

Research Results

The first purpose of this research was to reconceptualize the scientific literacy framework. Therefore, the result based on the first research question was presented initially. This is followed by presenting result based on the second research question which was about to examine the objectives of science curricula using the revised framework.

The Revised Scientific Literacy Framework

Based on the recent literature on science education and scientific literacy, it was concluded that some adaptations and additions were required to the original framework to better assess scientific literacy. First, *environment* was added to the aspect of the *interaction of science, technology, and society*. The impact of science and technology on the environment was emphasized by Science-Technology-Society-Environment approach (Aikenhead, 2003; Fensham, 1988a, 1988b; Pedretti, 2003; Pedretti & Nazir, 2011). Science and technology do not only influence society but also have an impact on the environment. One of the major goals of science education is to understand the interaction between science, technology, society, and the environment. Especially as a result of the advancement of new technologies, the concerns about environmental issues increased. This led educators to develop such a science curriculum which fosters individuals to cultivate an understanding of these issues and skills to deal with

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environmental challenges. Environmental issues are complex in nature and this requires higher-order thinking skills such as interpreting, reasoning, evaluating, analyzing, and problems solving. As this issue is getting more important, the last aspect of the scientific literacy framework is changed as the *interaction of science, technology, society, and environment*. Secondly, there existed a need for another aspect which we call *affective side of science*. This aspect emphasizes empathy, commitment, interests, attitudes, appreciations, values, and feelings about science. Education is not only for cognitive outcomes but also for affective outcomes (Stone & Glascott, 1997). Social and emotional skills such as having empathy, being commitments, having interests and positive attitudes, emphasizing values and feelings should be included in science curriculum. Science curriculum is key to cultivate those skills. Therefore, the *affective side of science* was added to the framework. The final form of the framework is provided in Table 2.

Table 2. Revised Scientific Literacy Framework.

Aspects of Scientific Literacy	Descriptors
Aspect 1: The knowledge of science	- Facts, concepts, principles, laws, hypotheses, theories, and models of science
Aspect 2: The investigative nature of science	- Using methods and process of science such as observation, measuring, classifying, inferring, recording and analyzing data, - Communicating using a variety of means such as writing, speaking, using graphs, tables, and charts, making calculations, and experimenting - Emphasis on hands-on minds-on science
Aspect 3: Science as a way of knowing	- Emphasizes thinking, reasoning, and reflection in the construction of scientific knowledge and the work of scientists - Empirical nature in science - Ensuring objectivity of science - Use of assumptions in science - I nductive and deductive reasoning - Cause and effect relationships - The relationship between evidence and proof - Role of self-examination in science - Describes how scientists experiment
Aspect 4: Interaction of science, technology, society, and environment	- Impact of science and technology on society and environment - Inter-relationships between science, society, technology, and environment - Careers - Science-related social issues and environmental issues - Personal use of science to make everyday decisions, solve everyday problems, and improve one's life - Science-related moral and ethical issues - Use of science to discuss environmental issues and being involved in the decision-making process on these issues
Aspect 5: Affective side of science	- Having environmental awareness - Taking responsible action for the environment and its components - Being responsible for personal, local, and global issues - Proposing action plans for social improvement and following with commitment. - Valuing ethical standards - Cooperating in group activities (displays teamwork)

Results of the Analysis of Science Curricula with the Revised Scientific Literacy Framework

With the aim of exploring how sufficient the Turkish science curriculum to prepare scientifically literate individuals, the objectives were examined and categorized based on the revised framework (see Table 2). The results were organized based on each aspect.

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Aspect 1: The knowledge of science

This aspect of scientific literacy was matched with scientific facts, ideas, doctrines, regulations, propositions, models, and prototypes. When the objectives included descriptions, explanations, or model preparations, they were classified under this aspect. These objectives were observed in the middle school curriculum more. In grade 3, 33.3% (12 out of 36) of the objectives were categorized under this aspect. A typical example of an objective is *explains the basic functions of the five sense organs in human beings*. With this objective, students are expected to explain the facts related to the sense organs' functions. That is, it emphasizes the knowledge underlying the sense organs. In grade 4, 26.1% (12 out of 46) of all objectives were assigned to this aspect. This percentage increased in grade 5 to 37.5% (15 out of 40 objectives), and in grade 6 to 42.6% (26 out of 61 objectives). In grade 7 and 8, though, it decreased to 41.9% and 32.4%, respectively. The frequencies, percentages, and the total number of objectives in each grade were presented in Table 3.

Table 3. The frequencies and percentages in each grade for the knowledge of science.

	Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
The knowledge of science	12	33.3	12	26.1	15	37.5	26	42.6	31	41.9	22	32.4
Total number of objectives	*36*		*46*		*40*		*61*		*74*		*68*	

Aspect 2: The investigative nature of science

Generally speaking, the use of science process skills comes to prominence in this aspect. Besides, ways of communications such as writing, speaking, graphical representations, tables, and illustrations are emphasized. The objectives in this category were found in all grades with an increasing number from grade 3 to 7, except for grade 8. In the third grade, 38.9% of all objectives (14 objectives out of 36) emphasized the investigative nature of science. In these objectives, students were expected to participate actively in the classroom by either doing experiments or hands-on activities. A typical example objective is *does experiments to find out how a force acting on an object causes it to stop or start moving*. It is evident that students were expected to carry out simple experiments in the classroom using science process skills. This certainly goes beyond knowing the subject matter. Students were expected to transfer their science content knowledge to a particular situation in a different context. The percentage, frequencies and the total number of objectives for all grades are given in Table 4.

Table 4. The frequencies and percentages in each grade for the investigative nature of science.

	Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
The investigative nature of science	14	38.9	15	32.6	17	42.5	21	34.4	26	35.1	24	35.3
Total number of objectives	*36*		*46*		*40*		*61*		*74*		*68*	

Aspect 3: Science as a way of knowing

This aspect is mostly associated with the reasoning in producing scientific knowledge, the nature of science, and the work of scientists. Moreover, the role of evidence in the development of knowledge is considered within this aspect. It was not emphasized as much as the aspect 1 and 2 in the science curricula. With 23.9%, it had the highest percentage in grade 4 and with only 6.8% it had the lowest percentage in grade 7 among others. A typical objective regarding science as a way of knowing aspect is *discusses the opinions about the structure of the cell from*

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the past to the present in light of the technological developments. Here, students needed to know the history of the structure of the cell. They also needed to comprehend how scientists' work, experiments, and discussions have shaped the cell theory. They also required to understand how technological developments led to the modifications of the cell theory by making inferences based on evidence. That is, they were expected to consider science as a way of knowing rather than just a body of knowledge. The percentages, frequencies and the total number of objectives can be found in Table 5 for each grade.

Table 5. The frequencies and percentages in each grade for science as a way of knowing.

	Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
Science as a way of knowing	3	8.3	11	23.9	5	12.5	6	9.8	5	6.8	10	14.7
Total number of objectives	*36*		*46*		*40*		*61*		*74*		*68*	

Aspect 4: Interaction of science, technology, society, and environment

The interaction between science, technology, society, and environment is also among the aspects which are not emphasized in the objectives adequately. It includes the dynamic relationship between science, technology, society, and environment. The impact of science and technology on society and the environment or how the needs of society shape technology are included in this aspect. It is observed that the science curriculum of grade 8 included more objectives emphasizing this aspect (27.9%). On the other hand, in grade 7, this aspect was reflected the least (14.9%) among other grades. Two examples of objective regarding this aspect are *discusses the reasons and results of global climate change* and *gives examples of the innovative applications of solar energy in daily life and technology*. The percentages, frequencies and the total number of objectives are presented in Table 6 for all grades.

Table 6. The frequencies and percentages in each grade for the interaction of science, technology, society, and the environment.

	Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
The interaction of science, technology, society, and environment	9	25.0	10	21.7	7	17.5	12	19.7	11	14.9	19	27.9
Total number of objectives	*36*		*46*		*40*		*61*		*74*		*68*	

Aspect 5: The affective side of science

In the final version, we have added a new aspect to the framework. This aspect is associated with having environmental awareness, taking responsible action for the environment and its components, being responsible for personal, local, and global issues, proposing action plans for social improvement and following with commitment, valuing ethical standards, and cooperating in group activities. This aspect was seen in the objectives of science curricula too. That is, 8.3% of objectives (3 out of 36) in grade three, 4.3% in grade four (2 out of 46), 4.1% of objectives (3 out of 74) in grade seven and 2.9% of the objectives (2 out of 68) in grade eight were categorized under this aspect. Typical objectives are *pays attention to the waste control in a near environment and take care of a plant or an animal and report its growth*. The percentages, frequencies and the total number of objectives can be found in Table 7.

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Table 7. The frequencies and percentages in each grade for the affective side of science.

	Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	f	%	*f*	%	*f*	%	*f*	%	*f*	%	*f*	%
The affective side of science	3	8.3	2	4.3	0	0.0	0	0.0	3	4.1	2	2.9
Total number of objectives	*36*		*46*		*40*		*61*		*74*		*68*	

Table 8 provides the overall results. The emphasis on each aspect in each grade can be compared easily by investigating frequencies, percentages, and the total number of objectives.

Table 8. Summary of the results for five aspects of scientific literacy.

	Grade 3		Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	f	%	**f**	%	**f**	%	**f**	%	**f**	%	**f**	%
The knowledge of science	12	33.3	12	26.1	15	37.5	26	42.6	31	41.9	22	32.4
The investigative nature of science	14	38.9	15	32.6	17	42.5	21	34.4	26	35.1	24	35.3
Science as a way of knowing	3	8.3	11	23.9	5	12.5	6	9.8	5	6.8	10	14.7
Interaction of science, technology, society, and environment	9	25.0	10	21.7	7	17.5	12	19.7	11	14.9	19	27.9
Affective side of science	3	8.3	2	4.3	0	0.0	0	0.0	3	4.1	2	2.9
Total number of objectives	*36*		*46*		*40*		*61*		*74*		*68*	

Note: In the curriculum, some objectives focus on more than one aspect of scientific literacy. Therefore, the sum of the number of objectives in each column should not necessarily be equal to the total number of objectives!

To sum up, it is obvious that Turkish science curriculum released in 2018 includes objectives emphasizing *the knowledge and the investigative nature of science* aspects with a higher frequency than the other three aspects of the scientific literacy.

Discussion

The purpose of this research was to revise the scientific literacy framework developed by Boujaoude (2002) in terms of (1) understanding the interaction of science, technology, society, and environment (2) affective side of science including empathy, commitment, interests, attitudes, appreciations, values, and feelings. A second purpose was to analyze the science curricula in Turkey for primary and middle schools.

In this regard, we modified existing aspects of the framework and we also suggested an additional aspect in order to enhance its capacity to evaluate scientific literacy. The revised aspect underlined the interaction between science, technology, society, and environment. Khishfe (2014) emphasized raising students both scientifically and environmentally literate to take an active role in problems that affect the society as a result of the developments in science and technology. Especially, the rise in environmental problems we face in daily life leads to the need for education to increase awareness and concern for the environment within society. Such education is required since people are expected to participate in the decision-making process on issues including the environment. This is one of the essentials of scientific literacy. However, without having an understanding of environmental problems, their causes and effects, it is not possible to discuss and propose solutions. Therefore, environmental literacy has been considered within the construct of scientific literacy (Heiskanen, 2006). Qualified and responsible citizens should also be aware of the environment and its components to be scientifically literate. The additional aspect was the affective side of science. This aspect is associated with having environmental awareness, taking responsible action for the environment and its components, being responsible for personal, local, and global issues, proposing action plans for social improvement and following with commitment, having values and empathy. The recent definition of scientific literacy includes the affective dimension. For example, when OECD (2016) describes scientific literacy, the attitudinal aspect is considered an aspect of scientific literacy. The attitudinal aspect includes using scientific way

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of thinking in daily life situations, attentiveness to environmental problems, and attitudes towards science (OECD, 2016). That is, scientific literacy does not only requires having scientific knowledge and skills but also depend on affective domain outcomes such as attitude, values, awareness, empathy, responsibility, or commitment. Especially, positive attitudes and behaviors toward the environment have become critical issues in educating students as scientifically literate since people deal with environmental problems more than ever.

The analysis of the Turkish science curriculum with the revised scientific literacy framework yielded important results in terms of the potential of the curriculum to educate students as scientifically literate. The aim of the science curriculum is no longer associated with the achievement rather a broader term scientific literacy is incorporated into the curriculum. Scientific literacy also covers students' success in science, but it includes more than knowing science content knowledge. In order to maximize the potential of the science curriculum in terms of scientific literacy, it is vital to balance the emphasis on its aspects in the curriculum. Since scientific literacy is a multidimensional construct, ignoring some aspects or overemphasizing one aspect would definitely be reflected in the educational outcomes. It will also hinder the accomplishment of the goals of the curricula. This research found that the Turkish science curriculum lacks the balance in terms of the aspects of scientific literacy. The emphasis is more on the aspects *the knowledge of science* and *the investigative nature of science*. The aspect *science as a way of knowing* was also not emphasized as it should be. The last aspect, the affective side of science, was almost neglected in the curriculum from grades 3 to 8. This creates an important problem since scientific literacy is a whole with its all aspects. Leaving one aspect behind results in the failure of scientific literacy. As the future citizens of the society, students should be equipped with the five aspects at least basically because they will engage in science-related issues in their lives although they will not have science-related careers (Krajcik & Sutherland, 2010). The curriculum that is dominated by the knowledge of science and the investigative nature of science may not help students to grasp the dynamic interaction between science, technology, society, and the environment. This is because science is presented as a body of knowledge and rarely applied to the real world (Pedretti, 2003). The real-world context and issues help students comprehend the interaction between science, technology, society, and environment (Ramsey, 1993). The inclusion of issues such as global warming, genetically modified foods, nuclear power plants, and cloning in science curricula might help students realize how science and technology impact their lives and environment. Instead of isolating science from the real world, an authentic and contextualized science teaching and learning should be embraced by the educators, teachers and curriculum developers. It is necessary if the aim is to prepare students to take an active role in tomorrow's decision-making process. Moreover, the affective side of science is not usually given prominence in the curriculum. The outcomes of science education also include educating students as being emphatic, committed, responsible for the environment, and having values, attitudes, and awareness. The societies need citizens who have these social and emotional skills in addition to cognitive skills. Therefore, science curricula should also give emphasis to the affective outcomes.

Conclusions and Implications

This research was designed to revise the existing scientific literacy framework based on current scientific literacy literature. Within the scope of its aim, this research also analyzed the extent to which Turkish science curriculum reflects the aspects of scientific literacy in a balanced way using the revised framework.

The comparison of the existing framework with current scientific literacy literature showed that the existing framework was inadequate to reflect the "environment" aspect within its fourth aspect of "Interaction of science, technology, and society". Therefore, the name of this aspect was changed as "Interaction of science, technology, society, and environment" in the revised framework and corresponding descriptors were added. This research also suggested a completely new aspect to the existing framework as "the affective side of science" with corresponding descriptors considering the affective outcomes of science education. Moreover, the results emerging from the analyses of the Turkish science curriculum showed that the knowledge of science and the investigative nature of science were reflected in the objectives of the curriculum more frequently compared to other aspects. That is, the Turkish science curriculum did not reflect the aspects of scientific literacy in a balanced manner.

The findings from this research make several noteworthy contributions to the current science education literature. First, improving the original aspects and offering a new one to the existing framework may lead to have a more rigorous framework which might help researchers to assess scientific literacy more precisely in future research. This is essential to obtain a more comprehensive understanding of scientific literacy. Scientific literacy does not only refer to knowledge and skills in science but also includes values and attitudes. Therefore, this research addressed

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the need for this issue and revised the scientific literacy framework. Second, it provided empirical evidence for the validity of the revised framework by field-testing it. Although the validity was established by analyzing the Turkish science curriculum, the framework is not specific to the Turkish context. Therefore, international researchers can make use of the revised framework to analyze the science curriculum in their countries and inform authorities about the effectiveness of their curriculum. Third, the results of field-testing provided empirical evidence on the inadequacy of Turkish science curriculum regarding preparing scientifically literate students. It is a well-known fact that Turkey scores well below the OECD average in all PISA (The Programme for International Student Assessment) applications which evaluate 15-year-old students' scientific literacy together with mathematics and reading literacy. Preparing students as scientifically literate is accepted as the ultimate goal of science education worldwide. Citizens of any societies should be scientifically literate at a basic level in order to survive in a rapidly changing and highly competitive world of today. Students should possess the necessary knowledge and skills associated with scientific literacy. One way to achieve this is to improve science education at K-12 levels. In the process of teaching and learning science, the aspects of scientific literacy need to be approached holistically. That is, both knowledge and skill aspects should be included in the curriculum. There is certainly a need for further research on this issue to explore what other factors, in addition to the curriculum, may influence scientific literacy. As a result, curriculum developers, policymakers, and educators can make necessary revisions accordingly and might improve science education which prepares the students for the future.

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