

## Exploring Turkish Upper Primary Level Science Textbooks' Coverage of Scientific Literacy Themes

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### Abstract

*Problem Statement:* Since the 1970s, scientific literacy has been a major goal of national educational systems throughout the world, and thus reform movements in science education call for all students to be scientifically literate. Despite some good curricular changes and developments across the globe, much remains to be achieved. Given that textbooks play a critical role in the teaching/learning process at all educational levels, their analysis is crucially important to support the recent science education reforms.

*Purpose of Study:* In this study, the four upper primary level science textbooks were analyzed to determine the inclusion of four themes of scientific literacy: (a) science as a body of knowledge, (b) science as a way of investigating, (c) science as a way of thinking, and (d) the interaction among science, technology, and society (STS).

*Methods:* The method used in this study was content analysis. Textbook analyses were conducted based on the procedures described by Chiapetta, Fillman and Sethna (1991a, revised 2004). The four science textbooks that were selected for content analysis were those approved by the Turkish Ministry of National Education (MEB) to be used in grades 4 and 5 for the 2011-2012 academic year. The content to be analyzed from the textbooks was selected in two different ways; the units 'the electricity,' 'human body,' and 'matter' from each textbook and systematic sampling of almost 20 percent of each textbook. Two raters independently coded each unit of analysis. There was good intercoder agreement with Cohen's kappa values, ranging from 0.61 to 0.79.

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*Findings and Results:* The findings revealed that the Turkish science textbooks do not provide a balanced coverage of scientific literacy themes. Almost half of the textual material in the four science textbooks appears to emphasize science as a body of knowledge. The textbooks appear to devote approximately one-third of their presentation to teaching science through investigation, and about one-fifth of their coverage is devoted to the interaction among science, technology, and society. However, science as a way of thinking was an almost non-existent paradigm in the four textbooks analyzed. Although there are no big differences between the four textbooks, the MEB upper primary level science textbooks have a slightly better balance of the four themes of scientific literacy, compared to the Lider and Semih Ofset publications, especially with regard to STS.

*Conclusions and Recommendations:* These results do not adhere to the discourse in the 2004 National Science Education Reform documents, which often accentuates the importance of scientific literacy. It is hoped that, in the light of the findings of this study, the imbalanced coverage of scientific literacy themes – especially inadequate treatment of scientific thinking in Turkish upper primary level science textbooks – will be improved in subsequent editions so that students are helped in their efforts to become scientifically literate.

*Keywords:* Scientific literacy, science textbooks, textbook analysis, upper primary level.

Over the past four decades, scientific literacy has emerged as a central goal for national educational systems throughout the world (Mc Eneaney, 2003), and reform movements in science education have called for all students to be scientifically literate (McCann, 1997; MEB, 2005). As a result of being a worldwide educational goal, there have been several efforts to define what exactly is meant by scientific literacy, especially since the 1980s (Choi et al., 2011). Science for All Americans (AAAS, 1989) defines a scientifically literate person as “one who is aware that science and technology are interdependent human enterprises with strengths and limitations; understands key concepts of science, ... and uses scientific ways of thinking for individual and social purposes” (p.4). National Science Education Standards (NRC, 1996) defines scientific literacy as “the knowledge and understanding of scientific concepts and processes required for personal decision making, participating in civic and cultural affairs and economic productivities” (p.22). Similar to this definition, Turkish primary science curriculum states scientific literacy under seven dimensions: the nature of science and technology, key science concepts, processes of science, interactions among STSE, scientific and technical skills, values underlying science and science related interests, and values (MEB, 2005). Likewise, Miller (1998) describes the term scientific literacy as including three areas: a vocabulary of basic scientific concepts, an understanding of the nature of scientific inquiry, and an understanding of the impact of science and technology on individuals and society. In the same vein, Hodson (1998; 2003) summarizes scientific

literacy dimensions used in the literature into four broad curricular domains comprising 'learning science,' 'learning to do science,' 'learning about science,' and 'learning to take sociopolitical action.' Although there is no a complete consensus about what counts as scientific literacy (Laugksch, 2000), the statements put forward by science educators share some common themes: the knowledge of science; the investigative nature of science; science as a way of thinking; and the interaction of science, technology, and society (Boujaoude, 2002; Chiappetta, Sethna, & Fillman, 1993).

In parallel to the developments in the world, science education has been the focus of national concern in Turkey during the last ten years. The Turkish government and the Ministry of National Education have launched curricular reforms at all levels. The 2004 primary curriculum was prepared based on the constructivist approach that emphasized student-centred active learning strategies, e.g. inquiry based learning. Furthermore, it underlined the importance of preparing the students for the challenges of the new century and emphasized the promotion of scientific literacy for all as the main goal of science education (Irez & Çakır, 2010). Science educators widely assert that inquiry-based teaching activities are the best route to achieving scientific literacy as they give students the opportunity to discuss and talk about scientific ideas (Brickman, Gormally, Armstrong, & Hallar, 2009). If teaching science as inquiry is to be implemented, then it is necessary to align students with a textbook that will be a fundamental component of the curriculum (Chiappetta & Fillman, 2007). In this vein, almost two decades ago, the AAAS (1993) encouraged the analysis and revision of science textbooks to conform with the Benchmarks for Science Literacy. In the Turkish context, the Ministry of National Education supported the development and revision of all curricular materials since the 2000s. Even though some progress was obtained with regard to having a scientifically literate population across globe, much remains to be achieved. A considerable factor contributing to the current situation may be related to the coverage of scientific literacy themes represented in science textbooks. For the reasons stated above, a careful analysis of the widely used Turkish science textbooks may play a critical role in reforming science education.

There is little question that in many classrooms, textbooks serve as the primary source of knowledge for the students (Brackenridge, 1989; Dikmenli, 2010; Kirkgöz, 2011; Stern & Roseman, 2004), provide the majority of instructional support beyond the teacher, and in many cases actually become the curriculum (Stake & Easley, 1978). The significant role of textbooks in the teaching and learning process has been analyzed by several researchers. The studies conducted by the National Science Foundation in the US revealed that more than 90 percent of 12,000 science teachers surveyed said that texts were the heart of their teaching, and they used texts 90 to 95 percent of the time (Hurd, 1981). In a similar study, Chambliss and Calfee (1998) stated that 75-90 percent of teaching activities in K-12 US classrooms relies on textbooks. In another extensive research, the Third International Mathematics and Science Study (TIMSS) researchers reported that teachers throughout the world use textbooks to guide their instruction, and science teachers in Japan, Germany, and the

United States base about 50 percent of their weekly teaching time on textbooks (Checkley, 1997). Sanchez and Valcarcel (1999), in their survey of experienced and novice teachers in Spain, found almost all of the teachers (92%) used textbooks as a “basic reference for their teaching units” (p.498). In a more recent study, Chiappetta, Ganesh, Lee and Phillips (2006) found out that over 90 percent of secondary school science teachers rely on textbooks for teaching purposes.

In summary, research in many countries and at different educational levels revealed that textbooks have a major influence in the teaching and learning process (Davila & Talanguer, 2009). In this context, an investigation of science textbooks can be an indirect help in understanding the contents, procedures, and activities used in classrooms (de Posada, 1998). Given the great influence of textbooks in curricular activities, it is of central importance that the balanced coverage of scientific literacy themes be included in the science textbooks used in schools.

One of the pioneering studies on science textbook analysis was carried out by Chiappetta, Sethna, and Fillman (1991b). They analyzed seven chemistry textbooks to determine whether the books provide a balance of the four themes of scientific literacy: knowledge, investigating, thinking, and STS. They noted that the majority of the textbooks were knowledge-oriented and devoted some space on engaging students in investigation. Later, Chiapetta, Sethna and Fillman (1993) examined five middle school life science textbooks to determine the emphasis given to the four themes of scientific literacy and reported that the textbooks stress two aspects of scientific literacy: science as a body of knowledge and science as a way of investigating. They devote very little text to the STS and no space to science as a way of thinking.

Using the procedures described by Chiappetta, Fillman and Sethna (1991a), Lumpe and Beck (1996) analyzed seven biology textbooks and reported that the most commonly covered themes in the textbooks were knowledge of science and investigative nature of science. In a similar study, Phillips and Chiappetta (2007) examined 12 middle school science textbooks with regard to the four themes of science literacy. They reported that the texts analyzed continued to stress science as a body of knowledge, despite devoting a higher proportion of textual content to science as a way of investigating and science as a way of thinking than in the past. In addition, many textbooks still devote little text to the STS.

Irez (2008) investigated the five secondary school biology textbooks in Turkey to examine the nature and the quality of treatment related to the nature of science. The textbooks reviewed revealed that science was generally presented as a collection of facts, not as an active process of creating and testing alternative explanations about nature. All the textbooks were found to present various poor, misleading, and inadequate descriptions regarding scientific enterprise. Kılıç, Haymana, and Bozyılmaz (2008) examined the elementary science and technology curriculum with respect to the themes of scientific literacy and science process skills. By analyzing learning outcomes and proposed activities in the curriculum, they reported that the curriculum emphasized the investigative nature and knowledge of science more than the STS. Science as a way of thinking is least emphasized in the curriculum. There

was no balance between the four themes of scientific literacy. Another study by Kahveci (2009) explored the effectiveness of 10 Turkish high school chemistry and 10 middle school science textbooks in terms of their reflection of reform. She reported that the textbooks all included unfair gender representations, a substantially higher number of input and processing questions than output level questions, and a high load of science terminology. In a very recent study, Chanjavanakul (2012) examined Chinese and Thai high school biology textbooks for the four themes of scientific literacy. Results showed that Chinese and Thai textbooks emphasize the themes of scientific literacy similarly. Both textbooks place the most emphasis on knowledge with at least 40 percent coverage. The investigative nature of science occupied approximately one-third of the textbooks, while science as a way of thinking occupied almost one-fifth of textbook space. The STS was represented by merely just over 1 percent of the textbook.

A brief literature review on textbook analysis revealed that some studies examined middle or secondary school science textbooks regarding scientific literacy, but none have specifically focused on exploring the representation of scientific literacy themes in the upper primary level textbooks. As Kahveci (2009) states, textbook analysis is atypical in the field of educational research in Turkey, and therefore, accessible information is meager in the science education literature. She also emphasizes that future research in the Turkish context may concern the examination of science textbooks being rewritten for the reform-based curricula that allow to make cross-comparisons and evaluate progressions. To my knowledge, it is difficult to find any research that focuses on the aspects of scientific literacy in science textbooks at the upper primary level (grades 4 and 5) at national and international levels. In this context, to help fill the gap, the present study aims to analyze Turkish upper primary level science textbooks for the emphasis given to the four themes of scientific literacy: (a) science as a body of knowledge, (b) science as a way of investigating, (c) science as a way of thinking, and (d) science and its interactions with technology and society. The present study explored the following questions:

1. Do Turkish upper primary level science textbooks provide a balance of scientific literacy themes?
2. What are the differences between grade 4 and 5 science textbooks in terms of the balance of scientific literacy themes?
3. How well do the textbook authors contribute to the requirements of the recent science education reform act?

## Method

### *Content Analysis Research Techniques and Reliability*

The method used in this study was content analysis. Kerlinger (1986) defined content analysis as a “method of studying communication in a systematic, objective, and quantitative manner for the purpose of measuring variables” (p.477). Through the classification or coding of textual information, the researcher develops inferences about the information (Krippendorff, 2004).

Reliability is a critical issue in content analysis research, as better reliability will enhance trustworthiness concerning coding units. In this study, intercoder reliability was determined by the use of Cohen’s *kappa* statistic, which is an appropriate measure for determining interrater reliability. Against the coders scoring in a random manner, Cohen’s *kappa* formula also takes chance agreement into consideration (Gwet, 2008). It should be noted that when analyzing the textbooks, the researchers’ expertise both in terms of science textbook analysis and nature of science should be seen as another factor ensuring reliability. The coders have previously analyzed biology textbooks for the nature of science (Irez, 2008).

The most crucial part of any analysis endeavor is the conceptual framework guiding the scientific questioning. The analysis procedure used in this study was developed and tested by Chiappetta, Fillman, and Sethna (1991a; revised 2004), and then used by several researchers in a variety of curriculum materials (Chiappetta et al., 1991b, 1993; Lumpe & Beck, 1996; Phillips & Chiappetta, 2007). It was determined to be both valid and reliable in coding for science literacy. This analysis guide consists of a 26 page booklet entitled *Procedures for Conducting Content Analysis of Science Textbooks*. The first part gives information about the conceptual framework used to define the science literacy themes and descriptors used for the analysis. The second part describes the units of analysis. The third part provides practice units to categorize in order for one to become more proficient in coding units. The fourth part requires the researcher to summarize his/her knowledge of the four categories of scientific literacy. The final part clarifies how to determine the percent of agreement and the Cohen’s *kappa* index for calculating inter-coder agreement (Chiappetta & Fillman, 2007).

### *Textbook Selection and Analysis*

The four science textbooks that were selected for content analysis were those approved by the Turkish Ministry of National Education (MEB) to be used in grades 4 and 5 for the 2011-2012 academic year. For this academic year, as seen in Table 1 below, the MEB approved only two different publications for the Science and Technology course for grade 4 and grade 5: The Ministry of National Education Publication (MEB-4) and Lider Publishing for grade 4 and the Ministry of National Education Publication (MEB-5) and Semih Ofset Publishing for grade 5.

Table 1.

The Fourth and Fifth Grade Science Textbooks Reviewed in This Study.

<i>Publisher</i>	<i>Grade</i>	<i>Title of Textbook</i>	<i>Edition</i>	<i>Date of Publication</i>	<i>Authors</i>
Lider Publishing (Lider-4)	4	Primary Science and Technology 4	1 <sup>st</sup>	2011	E. Nalbantlar, Kazım Palabıyık, Nuray Fıçıcılar
Ministry of National Education Publication (MEB-4)	4	Primary Science and Technology 4	1 <sup>st</sup>	2010	G. Bağcı Kılıç, M. Agaltay, H. K. Akçam, İ. İpek, F. Kablan
Semih Ofset Publishing (Semih Ofset-5)	5	Primary Science and Technology 5	1 <sup>st</sup>	2010	M. Oğuz, S. Şahin, Ş. Önder, A. Akar, İ. Karataş, N. Yurt
Ministry of National Education Publication (MEB-5)	5	Primary Science and Technology 5	2 <sup>nd</sup>	2011	G. Bağcı Kılıç, N. Bağcı, Ö. Bahadır, C. Emik, M. Evecen, R. S. Güneş Koç

In this study, the textual material to be analyzed in science textbooks was selected in the two ways. Initially, the same three units were analyzed in each textbook, which were electricity (subject matter related to physics), human body (subject matter related to biology), and matter (subject matter related to chemistry). In this analysis process, the coders realized that there were large differences among the units in terms of coverage of scientific literacy themes. Thus, approximately 20 percent of textual material in each textbook was systematically selected and analyzed (only pages ending with number 5 and 0 – except when a title page, the following page was selected). The units of analysis selected were defined as: complete paragraphs; figures, pictures, and tables with captions or short statements; marginal comments or definitions; questions; and each complete step of a laboratory or hands-on activity. The units excluded from analysis were: goal or objective statements, title pages, titles in the units, bibliography, prefaces, glossary, vocabulary lists, unit outlines, or end of unit questions or tests.

Initially, the individual units of analysis were numbered on each page. Then, using a structured-scoring rubric, the two raters independently analyzed and coded each unit of analysis in the textbooks. The scoring rubric included the following columns: 'name of textbook,' 'title of science unit analyzed,' 'textbook page number of coding unit,' 'sequence of coding unit,' and 'number of scientific literacy theme

coded. Later, the researchers compared and contrasted their scores. Differences were resolved by negotiation that helped refine the scoring rubric.

As in accordance with the procedures described by Chiapetta, Fillman, and Sethna (2004), each unit of analysis in this study was assigned to a single category based on the strongest emphasis given in that unit. For example, some units of analysis started with knowledge of science (theme 1), continuing with an emphasis on the investigative nature of science (theme 2). In this case, it was assigned to theme 2. Similarly, some units of analysis seemed to reflect little investigative nature of science (theme 2), but included strong emphasis on the STS (theme 4). In this case, it was assigned to theme 4. The following are examples of analysis procedures by direct quotes from the textbooks. Although the following paragraph starts out by giving information about the classification of substances (theme 1), the obvious intent of this unit of analysis is to illustrate how science proceeds by reasoning and logic. Thus it was categorized as pertinent to theme 3:

**“In our environment, substances we called as object, is calssified sometimes as goods, sometimes as material and sometimes as tool.... In the case of uncertainty and disagreement, science and logic enlighten us. As Atatürk said, there is no issue which cannot be solved by logic and reasoning.” (MEB-4, p.61).**

Some units of analysis, consisting of just questions or concluding with a question, were categorized as theme 1 because of the fact that there were answers just before or after the question in the text. It would not lead children to reason or investigate. For example:

**“Do you have a friend or relative who has had a broken arm or leg? Do you know how the broken bones healed?” (MEB-4, p.27).**

**“Evaporating water spreads into air as water vapour. Water vapour in the air falls to ground as rainfall when suitable conditions exist. Did you notice the balance between rainfall and evaporation?” (Semih Ofset-5, p.42).**

At first glance, these analysis units seem to belong to theme 2, but in the next paragraphs the information was given regarding the treatment of broken bones and the water cycle. The units were, therefore, categorized as belonging to theme 1.

## Results

To check for intercoder reliability, percent agreement and Cohen's *kappa* values were calculated. Table 2 presents the intercoder agreements for the analysis of textbooks regarding the four themes of scientific literacy for the three units in each textbook and for the systematic sampling of the same textbooks. With respect to percentage agreement, two coders achieved values ranging from 76 percent to 88 percent. Cohen's Kappa values ranged from 0.61 to 0.79. Cohen's *kappa* values between 0.61 to 0.80 indicate substantial/good agreement, and values between 0.81 and 1.00 indicate very good to perfect agreement. In this study, the intercoder agreement and Cohen's Kappa values in four textbooks indicate a good level of reliability.



Table 2.

*Intercoder Agreement and Reliability Values between Two Raters Regarding the Science Literacy Themes in Four Science Textbooks.*

Textbooks	Matter		Human Body		Electricity		Systematic Sampling	
	% agree	Kappa	% agree	Kappa	% agree	Kappa	% agree	Kappa
MEB	78	.66	77	.61	81	.71	78	.67
Lider	82	.70	80	.66	83	.75	76	.62
MEB	77	.62	81	.71	86	.78	79	.68
Semih Ofset	80	.66	78	.66	88	.80	83	.74

#### *Science as a Body of Knowledge*

Table 3 below presents coverage of the four themes of scientific literacy in grade 4 and grade 5 science textbooks for the units of matter, human body, and electricity. Turkish upper primary level science textbooks appear to devote the most coverage to 'the knowledge of science.' Textbooks analyzed committed about half of the text material to 'the knowledge of science.' As seen from Table 3, 'the knowledge of science' had the most coverage in the human body unit in grade 4 textbooks at about 50-55 percent. Contrary to grade 4 textbooks, the human body unit in grade 5 textbooks had the least coverage of 'knowledge of science' at 35-38 percent. However, when the mean percentages of the three units were considered, it is seen that the knowledge of science is almost equally represented in all of the textbooks, at around 43-47 percent. These findings are in accordance with the previous studies conducted by Fillman (1989), Chiappetta et al. (1991b), and Chanjavanakul (2012), but Chiappetta and Fillman (2007) reported that more recent biology textbooks have a better balance of scientific literacy than those analyzed 15 years ago.

These results indicate that Turkish science textbooks still distort how science works by not integrating disagreements among scientists or scientists's personal thoughts that humanize science and science education (Clough & Olson, 2004). As seen in the following statements, the textbooks present much scientific knowledge as absolutely objective and as the end products of science, even though the scientific community still continue to debate the classification of living things and the states of matter. The textbooks do not provide any information about how the knowledge was developed, how scientists used to classify the living things, or various current claims of scientists on the states of matter.

"We can classify the living things into four groups based on their similarities and differences. These are [...]" (Semih Ofset-5, p.138).

“We have learnt that matter has three states [...]” (MEB-4, p.68).

Table 3.

*Percentage of Coverage of Four Themes of Science Literacy in the Three Units in the Turkish Science Textbooks Used at Grade 4 and 5.*

Science themes	Literacy	Percentage coverage of four themes in units in the MEB textbook used at grade 4			
		Matter	Human Body	Electricity	Mean
Knowledge		46.2	52.4	38.3	45.6
Investigation		33.1	32.2	20.3	28.5
Thinking		1.5	0	0.8	0.8
STS		19.1	15.4	40.6	25.0
Percentage coverage of four themes in units in the Lider textbook used at grade 4					
4					
		Matter	Human Body	Electricity	Mean
Knowledge		49.7	56.3	37.1	47.7
Investigation		34.6	29.5	24.7	29.6
Thinking		1.6	0	0	0.5
STS		14.1	14.2	38.1	22.1
Percentage coverage of four themes in units in the MEB textbook used at grade 5					
5					
		Matter	Human Body	Electricity	Mean
Knowledge		49.1	38.9	43.3	43.8
Investigation		35.1	24.3	35.6	31.7
Thinking		0.6	0	2.2	0.9
STS		15.2	36.8	18.9	23.6
Percentage coverage of four themes in the Semih Ofset textbook used at grade 5					
5					
		Matter	Human Body	Electricity	Mean
Knowledge		49.6	35.7	56.6	47.3
Investigation		37.7	29.4	35.8	34.3
Thinking		0.8	0	0	0.3
STS		11.9	34.9	7.5	18.1

#### *The Investigative Nature of Science*

As seen in Table 3, the textbook units devote a substantial amount (20 to 37 percent) of their content to ‘the investigative nature of science,’ engaging the student in the processes of science, such as inferring, measuring, experimenting, answering charts/tables, recording data, observing, etc. The unit ‘matter’ in the Semih Ofset has the highest coverage at 37.7 percent, and the unit ‘electricity’ in the MEB-4 textbook has the least coverage at 20 percent. The unit ‘matter’ in all textbooks, the unit ‘human body’ in the MEB-4 textbook, and the unit ‘electricity’ in grade 5 textbooks appear to dedicate over 30 percent of their content to the investigative nature of science.

It is obvious that the investigative nature of science has had the most balanced distribution in the science textbooks analyzed. On average, the three units of all

textbooks dedicated about one-third (percentage of 28 to 34) of their content to this theme. However, it is worth stating that the level of inquiry might be a matter of discussion here. Textbooks include many simple lab activities, which require students to follow the steps and answer low level cognitive questions, rather than raising questions to be investigated, encouraging them to predict the results of a similar experiment, or using the same method in similar contexts. For example, the answer to the following first question does not require a high level of reasoning, but the latter question better illustrates the investigative nature of science:

“When the corn was put into the water, did the water lose its properties? How do you understand this?” (MEB-4, p.94).

“If smaller pieces of these substances were put into water, would you be able to separate them by the use of the floating separating method?” (Lider-4, p.90).

#### *Science as a Way of Thinking*

Science as a way of thinking was an almost non-existent theme in the four textbooks analyzed and seemed to receive only slight attention from textbook authors. The electricity unit in the MEB grade 5 textbook possesses too little text, but it had the highest percentage among the units in the four textbooks at 2.2 percent. The following was the only reference in the MEB grade 4 textbook for the unit electricity:

“Electricity is easily transferred and can turn to the other forms of energy. Therefore it has a wide range of usage field. Scientists keep searching to obtain electricity by using new methods” (MEB-4, p.217).

It should be noted that the little textual material devoted to ‘science as a way of thinking’ in textbooks shows up more generally in the statements – referring to Atatürk’s words – or emphasizing the importance of scientific enterprise.

“Scientific measurements are based on the principle of rationalism. They are more reliable and coherent than assumptions and guesses. During history, many grand individuals viewed science and rationalism as a guide. Atatürk emphasized science and rationalism saying that my spiritual heritage is science and rational.” (Semih Ofset-5, p.66).

“Just before starting an experiment, we can guess wrongly about the boiling point of pure water. A guess is an approximate value that is decided upon based on some data. Thus we need to experiment in order to obtain accurate knowledge [...] Scientific work consists of studies which are based on experiment, observation and measurement [...]” (MEB-5, p.83).

Actually, the present textbooks include potential textual material for meaningful presentation of ‘science as a way of thinking.’ However, as clearly seen in the statements below, they seem to disregard this detail in the text. Whereby they only refer to scientists’ inventions, what was found, and when it was found, rather than addressing the historical development of an idea, the experiences, and work of a scientist. They neglect referring to the inquisitiveness of scientists.

“The batteries, indispensable in daily life and used very commonly, were invented by Italian physician Alesandro Volta in 1880.” (Lider-4, p.207).

“The Dutch scientist Antonie van Leeuwenhoek was the first person to observe microbes due to his invention of the microscope.” (MEB-4, p.195).

“The thermometer was invented by the Italian scientist Galileo Galilei in 1952” (MEB-4, p.86).

It is very obvious from the texts above that the messages about the scientists and inventions appear in the form of definition or explanation. As Nadeau and Desautels (1984) emphasized, these give students a naive idea of science, in spite of the fact that there are many scientists who had interesting life stories with regard to their contribution of the development of those scientific topics.

It is interesting that science, as a way of thinking, was not represented at all in the units of ‘human body’ of all four textbooks. Regarding this subject matter, Clough and Olson (2004) state that science textbooks ignore human influences in research process. Rather, they portray science as simply a long list of conclusions by sanitizing the process of science through knowledge-based statements. For example they found, “In 1953 Watson, Crick, and Wilkins discovered the structure of DNA and in 1962 were awarded the Nobel Prize” (p.2). Such phrases seriously distort the nature of science by ignoring alternative ideas or neglecting the crucial role of Rosalind Franklin and others in reaching this achievement.

These findings regarding ‘science as way of thinking’ illustrate that grade 4 and 5 science textbooks do not provide a balanced view of scientific literacy to Turkish students. The textbook authors, should not only try to integrate science as a way of thinking into the textbooks, but should also pay particular attention to infusing all subcategories of this theme into the textual material. For example, they should include how a scientist experiments, the historical development of a scientific idea, the cause and effect relationship, the empirical nature of science, the use of assumptions, evidence and proof, scientific methods, etc. A good textbook is required to cover a large range of subcategories for a particular theme of scientific literacy.

#### *Interactions Among Science, Technology and Society*

The textbook units analyzed displayed great differences in terms of their coverage of the interaction among science, technology, and society. As seen from Table 3, the units analyzed devoted about 7.5 to 40.6 percent of their content to this. It is interesting that the unit ‘electricity’ had the largest coverage (38-40 percent) in grade 4 textbooks but much lower coverage in grade 5 textbooks for this theme. Similarly, although the STS theme has the largest coverage in the text of the unit ‘human body’ at grade 5 textbooks, it nearly has the least coverage in grade 4 textbooks for the same unit.

There was considerable variation between units in the same textbooks, such as that Semih Ofset has the smallest coverage at 7.5 percent in the electricity unit, but a much larger coverage regarding the STS at 34 percent in the human body unit. Compared to Lider and Semih Ofset Publishing, the MEB textbooks seem to devote a little more space to the STS. The variety in the units seems to be due to the nature of the topic, for example the unit ‘human body’ includes much information about nutrition, balanced diet, vitamins, human health, diseases, food safety, careers, etc.

Therefore, this theme of scientific literacy naturally covers a large amount of the text, without the need for particular attention to be given by textbook authors.

“With the development of food technology, new careers developed such as dietician, cook, food expert...” (MEB-5, p.29).

“In the past, sailors used to suffer from scurvy which prevented their wounds from healing. The prevalence of scurvy was due to the sailors being at sea for months without taking any fresh fruits or vegetables, and becoming deficient in vitamin C” (Semih Ofset-5, p.18).

Similarly, the unit for electricity in grade 4 textbooks provides a large amount of information about the importance of electricity in daily life, electrical equipment, and the safety usage of electrical devices, but the same unit in grade 5 textbooks focuses heavily on electrical circuits, and therefore, has a low coverage of this theme. On the other hand, these findings reveal that even though there are great variations between units, the textbook authors seem, to some extent, to follow the discourse of national reform documents in science education with regard to the interaction among science, technology, and society. These results are quite encouraging, compared to the research findings of Chiappetta et al. (1991b) and Chanjavanakul (2012).

#### *General Coverage of Four Themes of Scientific Literacy in the Science Textbooks*

As seen in Table 4 below, the coverage of the four themes of scientific literacy in the science textbooks based on the analysis of systematically selected pages, are in coherence with the average values obtained from the analysis of the three units of the textbooks. There are a few slight differences, which need to be mentioned here. First, the MEB-5 textbook seemed to have a little larger portion (27%) of the STS compared to the average of the three units covered (23.6%). This resulted from a higher number of references given about the STS, especially in the units ‘living things’ and ‘light and voice’ in the MEB-5 textbook.

Table 4.

*Percentage of Coverage of Four Themes of Science Literacy in Four Science Textbooks.*

<i>Themes of science literacy</i>	<i>Mean percentage coverage of four themes of science literacy</i>			
	<i>Grade 4</i>		<i>Grade 5</i>	
	<i>MEB</i>	<i>Lider</i>	<i>MEB</i>	<i>Semih Ofset</i>
<i>Knowledge</i>	44.5	47.2	42.0	43.2
<i>Investigation</i>	31.5	31.1	29.9	35.2
<i>Thinking</i>	0.6	2.2	1.1	1.6
<i>STS</i>	23.4	19.5	27.0	20.0

Similarly, the Lider-4 textbook devoted a slightly higher percentage (2.2) of its coverage to ‘science as a way of thinking’ compared to 0.5 percent in the three units. This stems from the scattered existence of this theme of scientific literacy. Many units

in textbooks did not devote any space to scientific thinking. The science textbooks could play a critical role in the development of scientific literacy if they portray science as a human endeavor, which reflects the experience of scientists. However, the science textbooks focus mainly on the teaching of science concepts and process skills, paying meager attention to the history and the nature of science (Chiang & Guo, 1996). As seen from Table 4, science as a body of knowledge is still a prevalent theme in the four science textbooks, with the smallest percentage (42%) in the MEB-5 textbook and the largest percentage (47.2%) in the Lider-4 textbook. It should be noted that the MEB-5 textbook appears to have a little more balanced coverage of the four themes of scientific literacy compared to the other three textbooks.

### Conclusions and Recommendations

An examination of the Turkish upper primary level science textbooks revealed that they have little balance in their approach to the four themes of scientific literacy. Almost half of the textual material in these science textbooks appears to emphasize science as a body of knowledge. The science textbooks seem to devote approximately one-third of their presentation to teaching science through investigation and about one-fourth/fifth of their coverage to the interactions among science, technology, and society. However, science as a way of thinking was almost a non-existent paradigm in the four textbooks analyzed. Although there are no big differences among the four textbooks, the MEB upper primary level science textbooks have a slightly better balance of the four themes of scientific literacy, compared to the Lider and Semih Ofset publications – especially with regard to the STS. The findings regarding the STS theme indicate that some positive change has occurred in the textbooks, but this change is still incommensurate since there is no balanced integration of this theme throughout the textbooks. If the science textbooks are to be truly responsive to the recent science education reforms and help students to be good decision makers regarding science and technology-related issues, a more balanced spread of the STS in the textbooks should be ensured.

It is evident from the findings that teaching science as a way of investigation is relatively balanced in both the units analyzed and general textbook analysis. This can be considered a positive change, and it implies that the textbook authors are aware that science is not just a list of facts to learn or memorize (Chiappetta & Fillman, 2007). This may also mean that the textbook authors give importance to inquiry teaching, engaging students in conducting hands-on or mental activity, questioning, gathering information, etc. However, the level of inquiry in the present textbooks appears to be questionable, and thus may be a focus of future research.

Although scientific literacy was stated as the vision for the Turkish elementary science curriculum and by many others in the world, the current textbooks still devote too little space to science as a way of thinking and thus disregard an important theme of science literacy. Given that textbooks continue to have influence on science learning, and often become part of the curriculum in the classroom (Otero, Leon, & Graesser, 2002), it is not an exaggeration to assert that they might actually play a significant role regarding the status of scientific knowledge and how that

knowledge evolves (McComas & Olson, 2000). These textbooks must convey a significant message to students to improve scientific literacy.

Textbook-oriented teaching is still common in the science classrooms at all levels. Teachers and students naturally assume information in textbooks is an accurate portrayal of science. This provides science textbooks with “a powerful influence over how teachers teach science and how students perceive science and scientific practices” (Reiff, Harwood, & Phillipson, 2002, p.3). Considering students and most teachers are largely dependent upon textbooks in the classroom, the role of textbooks cannot be disregarded in the success of science education reform efforts. For teachers, it may be difficult to change teaching habits and to practice the requirements of new curriculum. However, as Stake and Easley (1978) emphasized, textbooks are actually the easiest way to support a nationally-imposed new curriculum. If textbooks are to play a more constructive role in enacting curriculum reform, it is important that scientific literacy content be included in its textbooks.

Turkey has a centralized education system, and all teachers follow the national curriculum and science textbooks approved by the MEB. Teachers have no influence in curriculum development or choice of textbooks. However, the MEB is aware of the need to improve educational quality. To increase the success of the recent educational reforms, they should widely share responsibility with teachers and teacher educators, especially about revision of science textbooks (Irez, 2008; Kahveci, 2009).

The question “How can a science textbook achieve a high relevant standard?” is difficult to explain briefly because it comprises many aspects, such as the level of inquiry, readability, accuracy, meaningful presentation of pictures and diagrams, etc. However, as Chiappetta et al. (1993) pointed out, one of the most fundamental questions regarding the content of a science textbook is: Does the science textbook under consideration contain a reasonable balance of scientific literacy themes? Certainly, a better representation of scientific literacy in the textbooks will not guarantee that a majority of students will develop a meaningful understanding of scientific literacy but can act as a significant catalyst or accelerant in this process (Chiappetta & Fillman, 2007). Therefore, the science textbooks in Turkey should have a better balance of the four themes of science literacy – in particular with regard to *science as a way of thinking* – devoting more space to how scientific enterprise operates. The history of science may really contribute to an improvement of a **student’s scientific literacy. However, it is tough to come across references relating to the history of science regarding the development of scientific ideas in the textbooks analyzed. By examining the life and times of scientists, the history of science may “humanize the subject matter of science, making it less abstract and more engaging for students” (Matthews, 1994, p.50).**

In conclusion, the scientific literacy coverage of the Turkish upper primary level science textbooks appears to still be in conflict with reform efforts and widely held beliefs about science literacy all over the world. In order to make a significant contribution to the success of educational reform by improving students’

understanding of the science literacy themes (Ball & Cohen, 1996), science educators and textbook authors should work together on deciding how to present the scientific literacy themes in science textbooks. In this study, the units examined for the themes of science literacy were restricted to 'human body,' 'matter,' and 'electricity.' Therefore, a complementary study analyzing the other units in upper primary level science textbooks may provide a more complete picture of scientific literacy themes covered throughout the textbooks. The results of this study are also limited specifically to the present upper primary level science textbooks. An analysis of previous science textbooks may provide useful insights regarding the trends in the science textbooks over the years. Furthermore, this study is restricted to the issue of the quantity of material, and it does not address the quality of textual material for the scientific literacy themes. The next research question might be, "How well do these textbooks present scientific literacy?" However, this study may be considered a start at improving the level of scientific literacy in upper primary level science textbooks in Turkey, and it may be useful for international comparisons. It is hoped that, in the light of the findings of this study, the imbalanced coverage of the scientific literacy themes – especially the inadequate treatment of scientific thinking in upper primary level Turkish science textbooks – will be improved in "subsequent editions so that students are helped, not hindered, in their efforts to become scientifically literate" (Gibbs & Lawson, 1992, p.138). This change may improve students' understanding of how science works, their scientific way of thinking for individual and social purposes and, finally, contribute to develop scientifically literate citizens who are ready for the challenges of the 21<sup>st</sup> century.

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### İlköğretim 4 ve 5. Sınıf Fen ve Teknoloji Ders Kitaplarının Bilimsel Okuryazarlık Temaları Açısından İncelenmesi

#### Atıf:

- Çakıcı, Y. (2012). Exploring Turkish upper primary level science textbooks' coverage of scientific literacy themes. *Eğitim Araştırmaları-Eurasian Journal of Educational Research*, 49, 81-102.

#### (Özet)

##### Problem Durumu

Özellikle son 30 yılda, bilimsel okuryazarlık tüm dünyada ulusal eğitim sistemlerinin en önemli amacı olarak ifade edilmekte ve eğitimle ilgili reform hareketlerinde her bireyin bilim okuryazarı olarak yetiştirilmesi vurgulanmaktadır. Bilgi toplumuna sahip olma ve bireylerin bilimsel okuryazarlığını artırma konusunda dünyada pek çok araştırma, reform ve yenilik yapılmasına ve bu konuda birtakım olumlu gelişmeler de sağlanmasına rağmen, daha yapılması gereken çok şeyin olduğu herkes tarafından bilinmektedir. Bunlardan biri de ders kitaplarının öğrencilerin bilimsel okuryazarlığını ne kadar desteklediğidir. Ders kitaplarının, eğitimin tüm kademelerinde yaygın bir şekilde kullanıldığı, öğretmenin hangi konuyu nasıl öğreteceği konusunda oldukça belirleyici olduğu ve öğrencilerin de bilgi için başvurdukları temel kaynak olduğu fen eğitimi alanında yapılan araştırmalar tarafından ortaya konmuştur. Fen ve Teknoloji ders kitaplarının eğitim-öğretim sürecinin her kademesinde kritik bir role sahip olduğu göz önüne alındığında mevcut ders kitaplarının fen eğitimi alanında yapılan yenilikler ışığında dikkatli bir şekilde analizinin yapılması, hem ders kitaplarının etkinliğinin artırılmasına hem de bu alandaki değişim çabalarına ders kitaplarının daha fazla katkıda bulunmasına yardımcı olabileceği eğitimciler tarafından hemfikir olunan bir konudur.

Bilimsel okuryazarlığın dünya çapında bir slogan haline gelmesi, fen eğitimcileri tarafından özellikle 1980'li yıllardan itibaren bilimsel okuryazarlığın kapsamı ve tanımı konusunda çeşitli düşüncelerin ortaya atılmasına neden olmuştur. Bilimsel okuryazarlığın ne ifade ettiği konusunda tam bir fikir birliği olmamakla birlikte, akademisyenlerin bilimsel okuryazarlık ile ilgili ifadelerinde genel olarak vurgulanan ortak konular; 'bilgi birikimi olarak bilim', 'bilimin araştırmacı doğası', 'düşünmenin bir yolu olarak bilim' ve 'fen-teknoloji-toplum-çevre etkileşimleri'dir.

Ülkemizde de 2004 yılında uygulamaya konulan yeni program yapılandırma yaklaşımına göre hazırlanmış, sorgulayıcı öğretime yönelik uygulamalara vurgu yapılmış ve sonuçta her öğrenciyi bilimsel okuryazar bireyler olarak mezun etmeyi programın vizyonu olarak belirlemiştir.

#### *Araştırmanın Amacı*

Bu çalışmada, ilköğretim 4 ve 5. sınıf Fen ve Teknoloji ders kitapları bilimsel okuryazarlık temalarının dengeli bir dağılımını içerip içermedikleri açısından incelenmiştir: (1) Bilimsel bilgi/Bilgi birikimi olarak bilim, (2) bilimin araştırma/cı doğası, (3) düşünmenin bir yolu olarak bilim ve (2) bilim, teknoloji, toplum etkileşimleri.

#### *Araştırmanın Yöntemi*

Fen ve Teknoloji ders kitaplarının bilimsel okuryazarlık temaları bakımından incelenmesinde, içerik analizi metodu kullanılmıştır. Ders kitaplarının incelenmesi, Chiapetta, Fillman ve Sethna (1991a) tarafından geliştirilen ve 2004 yılında aynı araştırmacılar tarafından yenilenen prosedürlere göre gerçekleştirilmiştir. Bu çalışmada, Milli Eğitim Bakanlığı (MEB) tarafından 2011-2012 eğitim-öğretim yılında ilköğretim 4 ve 5. sınıflarda okutulması uygun görülen Fen ve Teknoloji ders kitaplarının analizi gerçekleştirilmiştir. MEB 2011-2012 akademik yılı için, 4. sınıflar için Lider Yayıncılık ve MEB Yayını'nı 5. sınıflar için ise Semih Ofset ve MEB Yayını'nı uygun görmüştür. Ders kitaplarından incelenecek olan bölümler iki şekilde seçilmiştir. Öncelikle ders kitaplarından biri kimya ile ilgili olan bir ünite 'Maddenin Değişimi ve Tanınması', biri biyoloji ile ilgili olan bir ünite 'Vücudumuz Bilmecesini Çözelim' ve biri de fizik ile ilgili olan bir ünite 'Yaşamımızdaki Elektrik' olmak üzere toplam 3 ünitenin bilimsel okuryazarlık temaları bakımından analizi yapılmıştır. Üniteler arasında bilimsel okuryazarlık temalarının dağılımı büyük farklılıklar göstermesi nedeniyle, ayrıca ders kitaplarından yaklaşık olarak yüzde yirmisine denk gelen bir bölüm sistematik örnekleme yöntemiyle (sonu 5 ya da 0 ile biten sayfalar) seçilerek analiz edilmiştir. Analizler iki araştırmacı tarafından bağımsız olarak yapılmış ve kodlayıcılar arasındaki güvenilirliğin testi için Cohen Kappa katsayısı hesaplanmıştır. Kodlayıcılar arasında uyum değerleri yüzde 76 ile 88 arasında değişirken, Cohen Kappa değerleri 61 ile 79 arasında bulunmuştur. Bu sonuçlar, kodlayıcılar arasında iyi düzeyde tutarlılığın sağlandığını göstermektedir.

#### *Araştırmanın Bulguları*

Araştırma sonuçları, ilköğretim 4 ve 5. sınıf Fen ve Teknoloji ders kitaplarının bilimsel okuryazarlık temalarının dengeli bir dağılımını içermediğini ortaya çıkarmıştır. Ders kitaplarındaki içeriğin yaklaşık olarak yarısı 'bilgi birikimi olarak bilim' temasını yansıtmaktadır. Ders kitaplarındaki içeriğin yaklaşık olarak üçte biri 'bilimin araştırma doğası'nı vurgularken, dörtte/beşte biri kadarı ise 'bilim-teknoloji-toplum etkileşimleri'ne vurgu yapmaktadır. Ders kitapları arasında bilimsel okuryazarlık temalarının dağılımı bakımından önemli farklılıklar olmamakla birlikte, MEB yayınlarının Lider ve Semih Ofset yayınlarına kıyasla biraz daha dengeli bir dağılıma sahip olduğu söylenebilir.

Araştırma sonuçları 'bilim, teknoloji toplum etkileşimleri' teması ile ilgili ders kitaplarında olumlu bir değişim olduğunu ortaya koymakla birlikte, bu temanın üniteler arasında oldukça farklı dağılım göstermesi, ders kitabı yazarları tarafından göz önüne alınması gereken önemli bir husustur. Ders kitabı yazarları fen eğitimi alanındaki reformlarla birlikte hareket etmek ve öğrencilerin bilimsel okuryazarlığını geliştirmeye daha fazla katkı sağlamak için bu konuya ders kitaplarında hem biraz daha fazla yer vermeleri hem de bu temanın tüm ders kitabı boyunca daha dengeli bir dağılımını sağlamaya özen göstermeleri gerekmektedir. Ders kitabı analizleri, 'bilimin araştırmacı doğası' temasının ders kitaplarında yeteri kadar yer verildiğini ve iyi bir dağılım gösterdiğini ortaya koymaktadır. Bu durum sorgulayıcı öğretim açısından olumlu bir nokta olmakla birlikte, sorgulayıcı öğretim seviyesi bakımından mevcut ders kitaplarının dikkatli bir incelemesinin yapılmasının bu temayla ilgili niceliksel olarak ortaya konan olumlu bulguların niteliksel olarakta değerlendirilmesine yardımcı olacaktır.

Diğer taraftan, 'düşünmenin bir yolu olarak bilim' incelenen 4 ve 5. sınıf Fen ve Teknoloji ders kitaplarında neredeyse hiç yer almayan bir olgu durumundadır. Bu temaya vurgu yapmak ya da öğrencilerin dikkatini bilimsel bilginin nasıl ortaya konulduğuna çekmek için ders kitaplarında pekçok örnek olmasına rağmen bilimsel bilgilerin düz bir şekilde sunulduğu görülmektedir. Bir buluşun kim tarafından ne zaman yapıldığından ziyade, o buluşun yapılmasına kadar o buluşla ilgili hangi bilimsel bilgilerin kimler tarafından, hangi ortamlarda, nasıl ortaya konulduğuna biraz değinilmesi öğrencilerin bu temayı anlaması ve onların bilimsel okuryazarlığını desteklenmesi bakımından son derece önemlidir.

#### *Araştırmanın Sonuçları ve Öneriler*

Bu araştırmanın sonuçları, 2004 Ulusal Fen Eğitimi Reform dokümanlarında yer alan ve her öğrenciyi bilimsel okuryazar bireyler olarak mezun etmeyi vurgulayan Fen ve Teknoloji Programı'nın vizyonu ile çelişmektedir. Bu çalışmanın bulguları ışığında, bilimsel okuryazarlık temalarının dengesiz dağılımı, özellikle bilimin doğası ile ilgili olan 'bir düşünme biçimi olarak bilim' teması yeni hazırlanacak ders kitaplarında giderilmeye çalışılmalıdır. Böylece ders kitaplarının öğrencilerin bilimsel okuyazarlık durumlarını engelleyici değil, hızlandıran bir katalizör konumuna gelmeleri mümkün olacaktır. Eğer öğrencileri, 21. yüzyılın zorluklarına ve meydan okumalarına göğüs gerebilen, fen ve teknoloji ile ilgili konulara hassasiyet gösterip bilimsel düşünebilen, akılcı kararlar alabilen, yaratıcı çözümler üretebilen, bilimsel okuryazar bireyler olarak yetiştireceksek, bu süreçte ders kitapları gözardı edilemeyecek kadar önemli bir role sahiptir.

**Anahtar Sözcükler:** Bilimsel okuryazarlık, fen ve teknoloji ders kitapları, ders kitabı analizi, ilköğretim 4 ve 5. sınıf.