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Analysis of High School Physics, Chemistry and Biology Curriculums in terms of Scientific Literacy Themes*

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Abstract

The purpose of this study is to analyze 9th grade physics, chemistry and biology curriculums, which were implemented by the Ministry of Education since the academic year 2008-2009, in terms of scientific literacy themes and the balance of these themes and also to examine the quality of statements about objectives. Physics, chemistry, and biology curriculums were examined and coded independently by two coders who were faculty members in the branch of chemistry, physics and biology education. Cohen's kappa statistic results showed that there was high degree of consistency between coders. Analysis results revealed that the theme the knowledge of science in the chemistry curriculum and the theme the investigative nature of science in the physics and biology curriculums were well emphasized; however, the theme the science as a way of thinking was not adequately emphasized in each of the three curriculums. The findings of the study show that nature of science should be more emphasized in science curriculum to help each of citizens in our country become lifelong learners and have an adequate level of scientific literacy.

Key Words

Scientific Literacy, Science Curriculums, Nature of Science, Content Analysis.

The term "scientific literacy" has become increasingly significant in discussions of the aims and purposes of school science education over the past two decades (American Association for the Advancement of Science [AAAS], 1993; Bybee, 1997; Gehrke, Knapp, & Sirotnik, 1992; National Research Council [NRC], 1996; Shwartz, Ben-Zvi, & Hofstein, 2005). *The 1990 UNESCO World Conference on Education for All* argued that science education should promote "a world community of scientifically and technologically literate citizens" (Millar, 2006). So, it is seen that many countries give priority to dimensions of scientific literacy in science reforms and development of science curriculum (AAAS, 1990; Driver, Leach, Millar, & Scott, 1996; Koballa, Kemp, & Evans, 1997; Millar & Osborne, 1998). By this way the argument for a broadening of the science curriculum to better meet the needs of all students has shifted from the call for a science for all students (Fensham, 1985) to the call for a scientific literacy focus (Bybee; Goodrum, Hackling, & Rennie, 2001; National Science Teachers Association [NSTA], 1982, 1992). In the basis of philosophy of reform movements in curriculum related with science courses which started in 2004 in Turkey, field literature related

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with curriculum reforms and philosophy of the curriculums are closely examined and it is aimed to train our students as individuals who have not only acquired knowledge but also thinking process. When the grade dispersion of our students in situation determination studies such as PISA and TIMMS are closely examined, unfortunately it is seen that Turkish students are inefficient in thinking processes especially in scientific process skills (Bağcı-Kılıç, 2003; Kalender & Berberoğlu, 2009). Therefore, in the recent Elementary Education Science and Technology Curriculum the vision of "every citizen to have scientific and technological literacy" is taken as a basis and scientific literacy is defined as "synthesis of skills, attitudes, understanding and knowledge necessary to develop individuals' investigate, critical thinking, problem solving and making decision skills, to become life-long learning individuals and maintain their sense of interest in their environment and the world"(Talim ve Terbiye Kurulu Başkanlığı [TTKB], 2005). The change of Elementary Education Science and Technology Curriculum makes it necessary to change curriculums in physics, chemistry and biology courses in secondary education under the effect of these reforms. So, starting from 9th grade physics, chemistry and biology curriculums in 2008-2009, all curriculums of secondary education started to be renewed gradually by Board of Education.

In this study, it is aimed to analyze 9th grade physics, chemistry and biology curriculums in terms of scientific literacy themes and the balance of these themes and also to examine the quality of achievement expressions of objectives related with dimensions of scientific literacy emphasized in scientific researches.

Method

A framework to analyze the Physics, Chemistry, Biology curriculums

A framework which we thought to reflect all dimensions of scientific literacy used in this study for content analysis of 9th grade Physics, Chemistry and Biology Curriculums in Turkey. While being analyzed within this framework, the dimensions of scientific literacy is considered within four themes : *i*) *the knowledge of science*, *ii*) *the investigative nature of science (scientific inquiry)*, *iii*) *science as a way of thinking (related to nature of science)*, *iv*) *interaction of science, technology and society.*

These dimensions of scientific literacy within the framework explained above are used by Chiappetta, Sethna, and Fillman, (1991; 1993) in analysis of different textbooks of Physics, Chemistry and Biology in America. Also, BouJaude (2002) used this framework in analyzing Lebanese science curriculum in terms of balance in scientific literacy themes.

Sample

In order to make content analysis of 9th grade Physics, Chemistry and Biology Curriculums, theorical framework in which scientific literacy themes and statements are defined is introduced to a group of six people composed of two experts in Physics, Chemistry and Biology education. Later, the six people read the curriculums independently. Content analysis sections of the curriculum: *1*) General purpose *2*) Curriculum philosophy and vision *3*) Basic structure *4*) Educational objectives *5*) Measurement and evaluation approach *6*) Two units of each of the curriculum.

Coding

Curriculums are analyzed independently by two chemistry, two physics, and two biology educators and coded according to a system explained below and on which six people formerly agree:

For instance; the expression "comprehends the importance of observation and experiments in interpreting the universe correctly" is coded as "C3, KÖP, BSB, s.12". Here C3 means 3rd statement, in the C theme, KÖP means Chemistry Curriculum; BSB means scientific process skills and s.12 shows the page in which of the expression is in the curriculum.

Table 1.
Intercoder Agreement for the Physics, Chemistry and Biology Curriculums with Regard to four Themes of Scientific Literacy

Curriculums	Percent Agreement	Kappa
Physics-9	85	0.83
Chemistry-9	90	0.89
Biology-9	87	0.85

Note: This coding was produced from two raters for each curriculum.

Table 1 presents the intercorder agreements for the analysis of the Physics, Chemistry and Biology Curriculums regarding four themes of scientific literacy. The percentages of agreements ranged from %85 to %90 and the cappa coefficients ranged from 0.83 to 0.89. These statistics suggest a high degree of agreement among the raters in categorizing the content message in the Physics, Chemistry and Biology curriculums. Rubinstein and Brown (1984 cited in Chiappetta et al., 1991), state that kappas between 0.40 and 0.75 indicate fair to good agreement.

Findings

At the end of document analysis of Physics Curriculum four themes of scientific literacy percentage distributions are given in Table 2. When Table 2 is the most emphasized themes are *the investigative nature of science theme* (43%) and *interaction of science, technology and society* (25%) respectively.

Table 2.
Percentage Distribution of the Themes of Scientific Literacy in Physics Curriculum

the knowledge of science (%)	the investigative nature of science (%)	science as a way of thinking (%)	interaction of science, technology and society (%)
15	43	17	25

In Physics Curriculum there are statements such that "knowledge and skill objectives are determined by adopting the approach that is heavily based on events and phenomenon to which all individuals may probably experience during their life". The results of analysis also support the fact that the curriculum makers have achieved their goals. However, Physics Curriculum lacks of emphasizing the *science as a way of thinking* theme which enables students' to develop understanding about contemporary paradigms of science. The percentage of the expressions which represents scientific literacy themes in Chemistry Curriculum were given in Table 3. As indicated in Table 3, *the knowledge of science* (47%) and *the investigative nature of science* (25%) themes were more emphasized than the themes of *science as a way of thinking* (11%) and *interaction of science, technology and society* (15%) in the Chemistry Curriculum.

Table 3.
Percentage Distribution of the Themes of Scientific Literacy in Chemistry Curriculum

the knowledge of science (%)	the investigative nature of science (%)	science as a way of thinking (%)	interaction of science, technology and society (%)
47	25	11	15

Biology Curriculum analysis (Table 4) shows that *the investigative nature of science* theme with a 40% percentage is the most emphasized and *interaction of science, technology and society* theme with a 28% percentage and *science as a way of thinking* theme with a 14% percentage are less emphasized in the curriculum.

Table 4.
Percentage Distribution of the Themes of Scientific Literacy in Biology Curriculum

the knowledge of science (%)	the investigative nature of science (%)	science as a way of thinking(%)	interaction of science, technology and society (%)
18	40	14	28

When we comparatively examine the percentage distribution of the Physics, Chemistry and Biology Curriculums with regard to scientific literacy themes, it is found that *the knowledge of science* theme is emphasized more than it is necessary in chemistry curriculum. Also, it is revealed that investigative *nature of science* theme is emphasized sufficiently in physics and biology curriculums but *science as a way of thinking* theme is not adequately emphasized in each of the three curriculums.

Table 5.
Percentage Distribution of the Themes of Scientific Literacy in Physics, Chemistry and Biology Curriculums

Scientific Literacy Themes	Curriculums			
	Physics-9 (N=441) %	Chemistry-9 (N=233) %	Biology-9 (N=396) %	Mean
the knowledge of science	15	47	18	**27**
the investigative nature of science	43	25	40	**36**
science as a way of thinking	17	11	14	**14**
interaction of science, technology, and society	25	15	28	**23**

N: Number of statements

Discussion

The purpose of this research study was to investigate the balance of scientific literacy themes in the new 9th grade Chemistry, Physics and Biology Curriculums which started to be implemented in 2008 in Turkey in an attempt to find out whether or not these curriculums have the potential to prepare scientifically literate citizens.

In this study, result of analysis showed that in the new 9th grade Physics, Chemistry and Biology Curriculums, the themes *the knowledge of science, the investigative nature of science* and *interactions of science, technology and society* were well emphasized but *science as a way thinking* theme was not adequately emphasized. *Science as a way of thinking* theme was too little emphasized in all of the three curriculums, it was emphasized 17% in Physics Curriculum, 11% in Chemistry Curriculum and 14% in Biology Curriculum.

With the help of data obtained and discussions in this study, it can be made some general conclusions about science curriculums. After 1960s, scientists and philosophers have started to answer questions such as "what is science?", "what is not science?", "How science works?", "How does the thinking process of a scientist work?" with a different paradigm understanding. Because the contemporary epistemological views of science place great emphasis on the tentative, historic, and humanistic features of scientific knowledge that attempt to associate scientific issues, and practices with the larger social and cultural contexts, this new paradigm doesn't match with the positivist picture of science (Abd-El-Khalick, Bell, & Lederman, 1998; Abd-El-Khalick & Lederman, 2000; Bell, Abd-El-Khalick, Lederman, McComas, & Matthews, 2001; Hodson, 1993; Jenkins, 1996). Therefore, in the recent years, the importance given to development students' thinking processess is increasingly (Abd-El-Khalick & Lederman; Akerson, Abd-El-Khalick, & Lederman, 2000; Bağcı-Kılıç, Haymana, & Bozyılmaz, 2008; Bell et al.; BouJaoude, 2002; Gess-Newsome, 2002; Hodson; İrez, 2009; Jenkins; Schwartz, Lederman, & Crawford, 2004; Köseoğlu, 2006) and it is highlighted that *science as a way thinking* theme should be more emphasized in science curriculums and text books (BouJaoude; Chiappetta et al., 1991, 1993; Chiappetta & Fillman, 2007; İrez; McComas, Clough, & Almazroa, 1998; McComas & Olson, 2000; Wilkinson, 1999). When we examine other countries' national science curriculums with the aspects of basic philosophy and understanding, it is seen that most of their general educational goal is in the direction of creating scientific literate population. For example, various elements such as expressions and activities related with inquiry and nature of science are densely emphasized in Science curriculums of England, Canada and Science Education Standards in America (AAAS, 1993; California Department of Education [CDE], 2000; Donnelly, 2006; Department for Education, 2007; Government of Sackatchewan, 1992). In this context, even if the results obtained from analysis of the 9th grade Physics, Chemistry and Biology Curriculums in the present study, especially in terms of scientific literacy themes, seem to be more promising than the ones in previous science curriculums, it was found that various themes of scientific literacy were not clearly expressed in a balanced way, and particularly, understandings regarding the nature of science were quite inadequate in curriculums. These results indicate that it will be hard to make our teachers and students get the understandings about contemporary paradigms of science even after 2010s, which began to influence the world after 1960s, and there is a danger that they still keep the positivist perspective of science.

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