DOES SCIENCE LITERACY COVER UNDERSTANDING? AN ANALYSIS OVER TURKISH EDUCATION CURRICULUM

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Abstract

This study covers whether science literacy is a semantic problem in terms of forming understanding; and its analysis in the context of the structure of scientific knowledge, the scientific structure of understanding and mental functions. This article will discuss science literacy but not focus on arguments as to what the topic and contents of science lessons should be. This article includes a scientific discussion on subjects and contents within the scope of Science literacy over the problem knowledge-data and Turkish national curriculum.

Keywords: science literacy, science literate, the problem knowledge-data, understanding, accurate thinking

1. THEORETICAL BACKGROUND

Although the term "scientific literacy" has been increasingly used in recent years to characterize the aim of school science education, there is still considerable uncertainty about its meaning and implications for the curriculum (Millar, 2006).

An essential aspect of scientific literacy is greater knowledge and understanding of science subject matter, that is, the knowledge specifically associated with the physical, life, and earth sciences. Scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. It also includes specific types of abilities. In the National Science Education Standards, the content standards define scientific literacy. Scientific literacy means that a person can ask, find, or determine answers to questions derived from curiosity about everyday experiences. It means that a person has the ability to describe, explain, and predict natural phenomena. Scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions. Scientific literacy implies that a person can identify scientific issues underlying national and local decisions and express positions that are scientifically and technologically informed. A literate citizen should be able to evaluate the quality of scientific information on the basis of its source and the methods used to generate it. Scientific literacy also implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (National Research Council, 1996). Characteristic of scientific literacy were itemized like in Table 1 by Thomas & Durant (1987), also Conceptions of scientific literacy in the science education literature were itemized like in Table 2 by Norris & Phillips (2003).

Science and technology literacy is defined to be the combination of skill, attitude, value, understanding and knowledge pertinent to science required for individuals to improve their skills of researching-questioning, critical thinking, problem solving and decision making; to be life-long learners; to keep their curiosity sense on their environment and world (Turkish national science & technology education curriculum, 2005). An individual who is science and technology literate understand and use the major science concept, principle, law and theories properly. He/she utilizes the skills scientific process while solving problem and making decision. He/she understands the interaction among science, technology, society and environment. He/she improves scientific and technical psychomotor skills. He/shows that he/she has scientific attitudes and values (Turkish national science & technology education curriculum, 2005). Popper (1959) uses swan sample to explain that it may not be always possible to verify correctness of universal proposition induced from special proposition in formation of knowledge (in this article, it is referred to as scientific knowledge) from the logical terms.

Negation of universal proposition obtained by special propositions requires it to be in the form of noncontradictory proposition (logically probable). Griffiths (1999) tells about simultaneity that a simple-minded observer hearing thunder a short time after lightning may believe that the source of light and sound is not simultaneous. You must take account of the time required for signal (sound, light, etc.) to reach you during observation. In that case, the one seen is not the one observed. It becomes observation just after the event ended and all data gathered and corrected. Ozenli (1999) states that both observations and others such as data flow, visual and tactual impressions (related to sense of touch), thoughts, contrary to common belief, do not constitute knowledge by themselves, and in order that they constitute a knowledge the factors of inference, thinking and decision-making are required. So he defines "knowledge" as making a correlation among sub-units of data flow and partitions (semantic correlation), using logic rules, mental mutation and recombination of those.

Ozenli (1999) describes "understanding" within the framework of cybernetics and mathematics as follows: Under the incoming information and data flow, conceptualization of the integration of regularities and cognitive modules which are seen to be independent from each other in the meta structure semantic network and thus decoding perceived code of "procedural knowledge" form transformed into "declarative knowledge" in the semantic memory unit, if this is achieved, then understanding occurs. Popper (1959) identifies the role of a scientist as to suggest proposition or proposition systems and to test those systematically. In empirical sciences especially hypothesizes and theories system are introduced and then tested by observation and experiment based on experience. According to the restriction made by Ozenli (1999), pure logic opinions don't provide us any "information" about experiment (experience) world; all information about reality both starts and ends with experiment or experience. Logic constitutes the "structure" in an "information systems".

As a definition of science, it can be referred to "systematic information obtained by experiment and observation, and their analysis" (Ozemre, 2002). To Ozenli's (1999) mind, this definition may be acceptable in daily life, but it does not reflect the real definition of science. Many science disciplines describe what science is from their own point of view and consequently we get lots of definitions, nevertheless the definition is one actually and this definition does not vary by distinct science units. Science is "an activity which is a manifestation of mind's supernatural merit and abilities, having the capacities of self-konpraansiyon, self-reference and self-construction". We exclude accurate thinking and philosophical thinking. Preferring scientific thinking rather than accurate thinking, we move away from explaining a proposition by its own proposition. In that case, it is required to describe what accurate thinking is scientifically. Accurate thinking can be in question only when key words used in the definition of science and "discovery of their own mental foliation structures" and effective excitations that will make the transitions between "mental flyers" possible are achieved. In order to achieve this, one should use "Operational research, cybernetic, mathematical logic and scientific methodology" (Ozenli, 1999). Wisdom requires understanding and understanding requires consciousness, and all individuals have the same mind level as a potential ability. What distinguishes individuals from themselves in the process as well as from each other is mental functions and its quality. On the other hand, mental functions comes out as polyneuronal activities (Ozenli, 1999).

2. LINGUISTIC

Literate (adjective and noun): having the skill of reading and writing, educated, improved one's knowledge by studying, scholar (Topaloğlu, 2005). Being able to read and write, scholar (Doğan, 2003; TDK, 1998). Learned how to read and write, being able to read and write (Püsküllüoğlu, 1999). Literacy (noun): the state of being literate (Topaloğlu, 2005; Doğan, 2003; Püsküllüoğlu, 1999). In the context of broad definition, literacy includes having the ability to read the literature of a language, perceive the items read and comprehend. Knowing how to read and write adequately in order to communicate with others as well as being able to know and speak a language. In accordance with the definition of UNESCO, literacy is the ability to define, understand, interpret, create, communicate, compute and use printed and written materials associated with varying contexts. Literacy involves a continuum enabling an individual to achieve his/her goals by developing his/her knowledge and potential, and to participate fully in the wider society (http://tr.wikipedia.org/wiki/Okuryazarl%C4%B1k).

In a general context, understanding is to perceive something not only externally but also internally; to recognize the core of something and its meaning as a whole context. To see as the consequence of an event or proposition, a pre-existing law or formulate. Feeling that something understood cannot be otherwise. Understanding (noun):

To comprehend what something is and implies, to get a new information as a consequence of combining earlier information with new ones, to learn by asking (TDK, 1998).

Science (noun, lexical meaning): Regular information seeking to draw a conclusion through setting a part of universe or events as the subject and employing the reality and the methods based on experiment. Methodical and systematic information having the characteristics of validity and precision. An information acquisition and methodical research process which starts out with a will to learn a specific matter and to turn toward a specific aim (TDK, 1998).

Gülensoy (2007) identifies the etymon of the word "anlamak" as follows: anla- understand, comprehend. As we can see, the etymon of "anlamak" is anla and refers to comprehend. He gives the etymon of the word "bilim" as bil- and bilgi (information) and bilmek (to know) is derived from this word (Some Turkish academicians uses the word "bilim" in Turkish for "science" while others use "ilim"). He identifies bilim and ilim as a conjugate for "science". The meaning of ilim, which is an Arabic word, is the "knowledge" (Ozemre, 2002).

3. OVERVIEW OF TURKISH NATIONAL EDUCATION SYSTEM

Science and Technology curriculum in Turkey has been prepared within the framework of the vision to train and educate all students as science and technology literate, and this curriculum is still used. Unit titles of this curriculum program is shown in Table 3, and Table 4 displays the aim, focus and subject titles of the Unit of Matter Structure and Properties as indicated in the program, which is one of the 7th grade units. The concept map shown below is also as in the program.

4. DISCUSSIONS

Man is a biological system that can think. This acceptance contains subjective understanding as a prerequisite. Yet, it is also clear that this acceptance does not cover scientific (accurate) understanding. The first distinction between scientific understanding and subjective understanding starts with the limitation that the data perceived through observations and senses are necessary but not sufficient for organizing knowledge, a limitation brought about by Popper, Griffiths and Ozenli regarding the knowledge. It is highly likely that students will acquire subjective understanding when the education is carried out within the scope of the definitions of science literacy. Science literacy does not include the structure to allow for scientific understanding instead of subjective understanding. A discussion on content of science literacy may confront this definitional opposition to this view. This article will not discuss the content of science literacy. This article will include a discussion on confronting the definitional opposition and on whether the content of curriculums prepared within the scope of science literacy will generate scientific understanding or not. As the sample curriculum, we chose Turkish National Curriculum, which has been prepared within the scope of science literacy.

Interchangeably use (confusing) of science and scientist, a commonly encountered problem in issues related to science, presents itself between science literacy and science literate. The fact that these concepts are confused with each other is obvious from the definitions used in science education. Qualities such as researching-questioning, critical thinking, problem solving and decision-making and being life-long learner can be used for defining science literate not science literacy. Here, an approach maintaining that there is an attempt to explain the definitions of these concepts in terms of learners and/or an approach maintaining that these concepts are purposes of science literacy indicate that the definition is limited to a wrong and insufficient approach. When one examines the comparison between science and scientist from a scientist's point of view, the principles simplicity and correspondence are peculiar to science. They cannot be attributed to a scientist. Mental functions or quality, on the other hand, are peculiar to scientist not to science. When we try to define the scientist with a change of verb from the definition of science or science with a change of verb from the definition of scientist without considering such comparisons between science and scientist (Science is a mental activity.

When we label the person carrying out this activity as scientist and the outcome as knowledge, the definition of science, scientist and knowledge are in compatible with each other ontologically. However, there are epistemological differences. One cannot always maintain the ontological assumption that the definition of science is also the definition of scientist and knowledge), not only the mistakes specified above (in terms of simplicity, correspondence and mental functions) will be made but also they may be diversified.

There are similarities between the mistakes made while changing the verb of the definition of science or scientist in order to transfer the definition of one to another and the mistakes made while changing the verb of the definition of science literacy or science so as to transfer the definition of one to another. When we transfer the definition of science literacy to science literate, we can see that these definitions are weak, insufficient and wrong. Furthermore, the lack of an agreed-upon definition of science literacy indicates that the definitions are weak and insufficient.

When evaluated linguistically, science literacy can be said to bring about a situation similar to bilim-ilim discussion in Turkey. When we accept ilim as Turkish equivalent of science, bilim includes knowledge but not understanding. When we examine the root of the word, it can be observed that understanding is not derived but only provided in return for knowledge. Understanding is derived from the verb "understand" and comprehension is presented as its equivalent. In that case, incorporating "understanding" into the word bilim cannot prove more than a pragmatic approach. Pragmatic approaches tell us that we are not within the boundaries of science. If we accept ilim as Turkish equivalent of science, this word is derived from Arabic and means accumulated knowledge (Ozemre, 2002). Since all cumulative knowledge cannot be scientific, there may be an opposition to accepting it as equivalent of science. However, although the etymological content of this word does not exclude knowing and understanding, it does not tell us anything about them, either. This allows us to make semantic definition of the word ilim and it is used as equivalent of knowing+understanding as different from its etymological meaning. Insistence on accepting bilim as Turkish equivalent of science and holding the demand for protecting the language due to its Turkish root as a reason for this leads Turkish language into incapability. Accepting ilim as a Turkish equivalent of science, on the other hand, is not an effort to put foreign words in Turkish but a temporary situation until a word which includes knowing+understanding is composed.

The reason for accepting it as a temporary equivalent is that it is possible to make a semantic meaning out of this word. It is a necessity to accept ilim as Turkish equivalent of science. It is up to linguists to compose a Turkish equivalent of science and not to try to use Turkish-origin bilim which cannot be an equivalent of science. These debates concern Turkish people. However, arguing that science literacy (literate or literacy in a more general sense) does not include understanding in a scientific sense bear resemblances to linguistic debate in Turkey over the equivalent of science. In the event that the word literacy (being literate) is attached different meanings in different languages, if the equivalent of a word includes being literate and that word is attached meanings at a higher epistemological level than being literate, this results from the weakness of that language. When looked in terms of lexical meaning, literacy is prerequisite for knowing but not the knowing or understanding (within the framework of cybernetic and mathematical logic) itself. Attaching "knowing" or "knowing+understanding" to this word does not compose a semantic meaning but proves a pragmatic approach at best, as is the case for the debate in Turkey.

The study used science curriculum in Turkey as sample of science literacy. When we take the units related to physics in Table 3 as sample and examine the unit "Structure and properties of Matter" for 7^{th} grades chosen among these units (Table 4), we can see that in order to enable the students to gain an understanding, firstly the subject of a unit should reinforce itself and then the units within the same discipline should reinforce each other. And then, correlated units of different grades should reinforce each other at a level that will lead to understanding. The concept map for the unit "Structure and properties of Matter" for 7^{th} grades constitutes a good sample for a better understanding of this. The concepts specified as (a) in the concept map require knowledge about chemistry, those specified as (b) knowledge about quantum mechanic and those specified as (c) knowledge about both quantum and relativity. Without the necessary knowledge for the subjects included in the concept map, the students will not be able to understand (in the semantic meaning way specified above) and know (in the same way as specified above) these subjects.

The knowledge and understanding in this unit is subjective on the part of students. They are likely to tend to gain misunderstandings (subjective) through the knowledge free of its structure occurring to them (subjective). An instruction carried out without providing the students with the necessary content knowledge shows us that there is a knowledge-data problem in question. When assessed scientifically, what is achieved as a result of scientific effort is knowledge. Yet, it is data when looked on the part of person. At this point, it is necessary to bring a limitation to human aspect; if data does not require conscious phase in order to generate understanding when conceived by the person, that data constitutes the knowledge for that person and this person is the specialist in that field. Data is not knowledge for everyone.

It can be said that during an instruction carried out within the framework of the definition of science literacy the students are required to understand the subjects chosen as sample at a level determined again within the framework of science literacy. In that case, a problem arises in terms of the objectives of education. The purpose of education and things which education provides the students with by necessity are kind of information which they have to know and learn. And we cannot call a student as "knowledgeable" or "understood" simple because he/she knows what he/she has to know and learn! One should not confuse literate students with understood ones. Otherwise, the students would lack the opportunity to go through the necessary phases and they start to decline with increasingly outdated knowledge (Ozenli,1999). Being literate and learning are different concepts. National educational policy of a country should be planned on the basis of modern Science and technical potential in a way that will develop a "learned" society and this should be applied by developing a methodology for transferring these into students' memory. The efforts made for the sake of a "literate" society are not in compatible with the concept national education and is also a betrayal towards it (Ozenli, 1994).

As a final discussion, it can be thought that interpretation made without considering different definitions and sub-dimensions of science literacy are imperfect, insufficient and even wrong. This approach will be answered in the following way: A physicist never takes the views put forward by astrologists into account. If we/she is concerned with them, it is simply a hobby. This is not a scientific effort. The reason for this is that a physicist is well aware of the fact that any star cluster in space, one of primary approaches of astrology and such, affects human life in two ways. One of them is gravitational and the other one is electromagnetic. Astrologists go ahead with birth date or the worlds' position at that time or such but a physicist knows that any object looked at had already existed before we realized it and it is constantly effective. He/she knows that emergence of the effect claimed by astrologists is caused by the world's moving around its orbit. He/she starts calculating this effect by measuring the distance between the world and object in question. Then, he/she calculates the ever-effective change in world's different positions. Once he/she has taken into account the effects on humans (or the world) and all other gravitational and electromagnetic effects, he/she does not desire to study the views and reasons held by astrology (or such) since he/she anticipates that the astrology (or such) does not have a scientific structure. Just as a physicist is not interested in analyzing the internal structure of disciplines such as astrology, whose starting points, definitions and contents are insufficient or wrong, we have not been interested in sub-dimensions of science literacy.

5. CONCLUSION AND SUGGESTIONS

Under the discussion heading of this study, Science literacy (Science literate) was criticized in the sense of definition and linguistics. As can be seen from the two dimensions of science literacy discussed, there have been mistakes in its definition. Learned individuals should be raised instead of insisting on raising science literate. The key to raising learned individuals is to define the education with cybernetic and mathematical logic at first and then to construct it within this framework. The principle role in this construction will without doubt be up to operational research. It is of great importance to analyze the knowledge within an epistemological framework in order to enable the students to gain an understanding in a scientific way. Yet, it is a prerequisite to reveal the mental functions of individuals and design subjects/units within this framework. Through an instruction lacking these or with definitions such as science literacy, one cannot expect to raise learned individuals but rather those specified in the definition of science literate and science literacy in linguistic section. The purpose of this study has tried to indicate that one cannot expect to raise knowledgeable and understood individuals through an instruction carried out within the framework of the definition of science literacy.

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Table 1 Characteristic of scientific literacy (from Thomas & Durant, 1987)

- An appreciation of the nature, aims and limitations of science; a grasp of "the scientific approach"- rational argument, the ability to generalize, systematize and extrapolate; the roles of theory and observation
- An appreciation of the nature, aims, and limitations of technology, and of how these differ from those of science
- A knowledge of the way in which science and technology actually work, including the funding of research, the conventions of scientific practice, and the relationships between research and development
- An appreciation of the inter-relationships between science, technology, and society, including the role of scientists and technicians as experts in society and the structure of relevant decision-making processes
- A general grounding in the language and some of the key constructs of science
- A basic grasp of how to interpret numerical data, especially relating to probability and statistics
- The ability to assimilate and use technical information and the products of technology: "user-competence" in relation to technologically advanced products
- Some idea of where or from whom to seek information end advice about matters relating to science and technology

Table 2 Conceptions of scientific literacy in the science education literature (from Norris & Phillips, 2003)

- Knowledge of the substantive content of science and the ability to distinguish science from nonscience
- Understanding science and its applications
- Knowledge of what counts as science
- Independence in learning science
- Ability to think scientifically
- Ability to use scientific knowledge in problem-solving
- Knowledge needed for intelligent participation in science-based social issues
- Understanding the nature of science, including its relationships with culture
- Appreciation of and comfort with science, including its wonder and curiosity
- Knowledge of the risks and benefits of science
- Ability to think critically about science and to deal with scientific expertise

Table 3 Science units in Turkish national education curriculum (from national science & technology education curriculum, 2005)

4th Grade Units	5th Grade Units	6th Grade Units	7th Grade Units	8th Grade Units
Solving Our Body Puzzle	Solving Our Body Puzzle	Reproduction, Growth and Development in Human Beings	Systems In Our Body	Cell Division and Heredity
Knowing matter	Matter Change and Introduction	Force and Movement	Force and Movement	Force and Movement
Force and Movement	Force and Movement	Granular Matter Structure	Electricity in Our Life	Matter Structure and Properties
Light and Sound	Electricity in Our Life	Electricity in Our Life	Matter Structure and Properties	Sound
Our Planet- Earth	Earth, Sun and Moon	Systems In Our Body	Light	State of Matter and Heat
Touring and Knowing the World of Living Beings	Touring and Knowing the World of Living Beings	Matter and Heat	Human and Environment	Living Beings and Energy Relations
Electricity in Our Life	Light and Sound	Light and Sound	Solar System and Beyond: Space Puzzle	Electricity in Our Life
		What Constitutes Earth Crust?		Natural Processes

Table 4 A unit related to Physics which is one of the units in 7th grade in Turkish national education curriculum (from national science&technology education curriculum, 2005)

Unit 4: Matter Structure and Properties		
Learning Field: Matter and Change		
Unit Aim	Unit Focus	Purposed Subject Titles
The aim of this unit is to enable students to learn symbols of elements and formulas of compounds; to comprehend that an atom is composed of proton, neutron and electron; to classify the chemical bonds; to explain the dissolution by solvent-solute relationship.	This unit focuses on the improvement of students' scientific process skills such as observing, comparing, classifying, inferring, estimating and modeling in the context of atom structure and chemical bond concepts.	•Elements and Symbols •Structure of Atom •Layer Electron Array and Chemical Properties •Chemical Bond •Compounds and Formulas •Mixtures

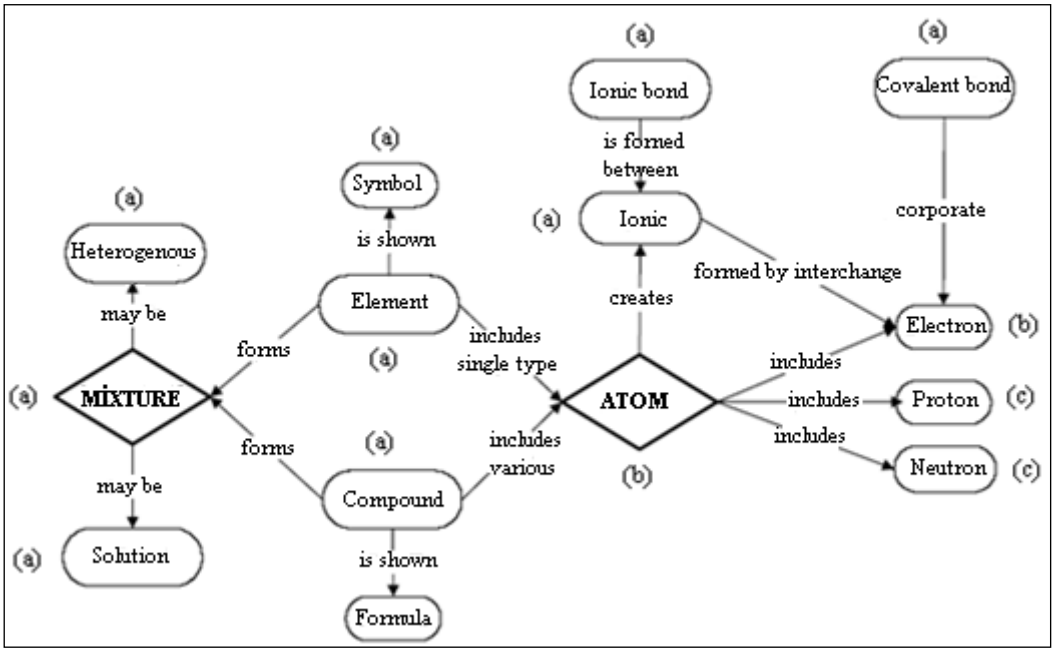

Figure 1. 7 th Grade Concept map for the Unit of Matter Structure and Properties (from national science&technology education curriculum, 2005)