The representation of scientific literacy in egyptian science textbooks

La representación de la cultura científica en los libros de texto egipcios de las ciencias

NASSER MANSOUR

University of Exeter, UK; Tanta University, Egypt
n.mansour@ex.ac.uk

Abstract

Scientific literacy is examined in the literature from very different viewpoints and content. There is a certain amount of agreement on the need to link scientific literacy to education, since it is considered an essential tool for development in the 'knowledge society', in which science and technology are particularly important. The purpose of this study was to investigate the balance of scientific literacy themes in the Egyptian preparatory science curriculum. The three science textbooks for the preparatory stage (age 12-15) were analysed and categorized using Chiapetta's method for analysing scientific literacy. Results showed that while the preparatory science curriculum emphasized the knowledge of science and the investigative nature of science, it neglected the other aspects of scientific literacy. These included science as a way of thinking, and the interaction of science, technology and society.

Key words*: scientific literacy; Egyptian science textbooks.*

Resumen

La cultura científica se examina en la literatura desde muy distintos puntos de vista y contenido. Hay un cierto grado de acuerdo sobre la necesidad de vincular la cultura científica a la educación, ya que se considera una herramienta esencial para el desarrollo en la llamada "sociedad del conocimiento", en la que la ciencia y la tecnología son particularmente importantes. El propósito de este estudio fue investigar el equilibrio de la cultura científica en el currículo de ciencias egipcio preparatoria. Los tres libros de texto de ciencias para la etapa preparatoria (edad 12-15) fueron analizados y categorizados Chiapetta utilizando el método de análisis de la cultura científica. Los resultados mostraron que, si bien el plan de estudios preparatorio puso de relieve la ciencia el conocimiento de la ciencia y la investigación de la naturaleza de la ciencia, no tuvo en cuenta los otros aspectos de la cultura científica. Éstos *incluyen la ciencia como una forma de pensar, y la interacción de la ciencia, la tecnología y la sociedad.*

Palabras clave: *alfabetización científica; libros de texto, ciencias, Egipto.*

INTRODUCTION

Scientific literacy (SL)

Definitions abound in the literature, with no consensus on scientific literacy. The review of the term scientific literacy by Laughksch (2000) shows that underlying the terms scientific literacy are a number of different assumptions, interpretations, conceptions, and perspectives of what the term means, what introducing the concept should achieve, and how it is constituted. It is therefore not surprising that the concept of scientific literacy is often regarded as diffuse, ill-defined, and difficult to measure. Laughksch illustrates that there are a number of different factors that can influence interpretations of scientific literacy. These factors include the number of different interest groups that are concerned with scientific literacy, different conceptual definitions of the term, the relative or absolute nature of scientific literacy as a concept, different purposes for advocating scientific literacy, and different ways of measuring it.

Dimopoulos and Koulaidis (2003) defined scientific literacy in terms of citizenship as the minimal acceptable level of knowledge or skills required to function effectively in a society that was both increasingly complex and science- and technology-dependent. Collette and Chiappetta (1989) stated that scientific literacy involved a firm understanding of the nature of science and how science, technology and society influenced one another, as well as a positive attitude toward the value of science and technology.

In the United States of America, the National Science Education Standards (National Research Council, 1996, p. 22) defined scientific literacy as, "... 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". The standards also stated that scientific literacy meant that a person should be able to ask and determine answers to questions derived from curiosity about everyday experiences, and implied that such a person could identify scientific issues underlying national and local decisions and express opinions that were scientifically and technologically informed. The report by the American Association for the Advancement of Science (AAAS), Science for All Americans (AAAS, 1989), defined the scientifically literate person as "One who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognises both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes" (p. 4).

With new concepts like citizenship, scientific literacy and the knowledge society, science curricula should conform to the methodological principles of education from the perspective of SL, which seeks to help an Egyptian student to master the following skills, knowledge and values:

1 A basic cognitive structure, i.e., necessary facts and theories.
2 Scientific thinking, criticism and creativity.
3 Skilful interaction with different types of advanced technology, especially information technology.
4 Practising the main skills necessary for everyday life.
5 Continuous self-learning.
6 Mastering the tools of discussion, negotiation, cooperation with others and decision making.
7 Awareness of change and its possibilities, and openness to world cultures.
8 Positive attitudes towards developing the society and the environment.

Based on these skills, the content of the science curricula presented in textbooks should be contemporary and international, and should emphasize the interrelationships between aspects of knowledge to reflect their integration. Further, the desired curricula should tackle contemporary issues and concepts within the framework of the overall view of the phenomena that exist around the learner. In this respect, Collette and Chiappetta (1989) stated that science education must meet the challenge of improving the scientific literacy of a country's future citizens and society as a whole. A concept of scientific literacy must also recognise the range of forces for change in our society (Bybee & Ben-Zvi, 1998). Donnelly (2005) argued that the proper purpose of the school curriculum was to address directly those decisions in life that children and adults, as citizens, workers, and parents, would be required to take. However, Roth and Barton (2004) shifted the discourse about science and scientific literacy by considering three propositions. First, scientific literacy is a property of collective situations and characterisations irreducible to characteristics of individuals. Second, science is one of many resources that people can draw on everyday collective decision making processes. Third, people learn by participating in activities to take effective part of their community.

From the above it can be seen that the main aim of science education is to prepare young people to contribute, as "scientifically literate citizens", to shaping the world in which they will live. Therefore, science for citizenship is an important educational goal. This is a challenge for school science education, and raises questions as to how science education can prepare students to be scientifically literate citizens. This is discussed in terms of the role of science textbooks in the next section.

The role of textbooks in science education and scientific literacy

Science textbooks continue to be a major component of science instruction throughout the nation. Textbooks can serve learners and teachers in many ways, with learners using them as tools and tutors. They are used widely and frequently in science classrooms (Harms & Yager, 1981), where they provide most of the instructional support beyond that given by the teacher. Science textbooks also contain much of the scientific information received by students (Mayer, 1983), and this information influences the manner in which they perceive the scientific enterprise (Chiapetta, et al., 1991).

Science textbooks play an important role for middle school science teachers in the education of the students. They often form the topic outline for the curriculum, and contain a significant amount of the information that is addressed in the classroom. Many science teachers, particularly the newly-qualified, use the assigned textbook as the content outline or story line for their courses (Chiapetta, et al., 1993), and recent studies indicate that they also rely on textbooks to provide them with some or all of the pedagogical content knowledge (Stern & Roseman, 2004). In this respect, Yager (1983) notes that over 90 percent of science teachers use a textbook for 95 percent of the time; thus the textbook becomes the course outline, the framework, the parameters for the students' experience and testing, and a worldview of science.

It seems obvious that science textbooks play a crucial role in processes of teaching and learning; however, this raises the question of what constitutes a good science textbook and how it can be identified. One might answer the question by way of the list of items used by committees in the selecting of a textbook, such as content accuracy, clear definition of terms, end-of-chapter questions, pictures and diagrams, in-text laboratory activities, and so on. However, Chiapetta, et al. (1993) argued that such items did not address the most fundamental ideas about what should be evident in a middle-school science textbook, and believed that as far as the content of a science textbook was concerned, the basic question was whether or not it offered an accurate presentation of the nature of science within a context relevant to the student.

Purpose of research

The purpose of this study was to investigate the balance of scientific literacy themes in the Egyptian preparatory science curriculum in an attempt to determine whether or not this curriculum has the potential to prepare scientifically literate citizens.

Science curricula in Egypt and the context of the study

The educational system in Egypt is extremely hierarchical with the Ministry of Education (MoE) at the top. It is also well known for being bureaucratic, teacher-centred, authoritarian, and extremely competitive (Amer, 2003). The MoE is the only authority determining the educational curricula, syllabuses, methods of teaching, educational targets, and the roles of teachers and learners in Egypt (Amer). Curriculum guidelines for science are decided through a system of committees at the state level. The science subject committee includes consultants, supervisors, experts, professors of science education and experienced science teachers. Once the committee reaches agreement, the curriculum guidelines are then referred to the Supreme Council of Pre-University Education for official release. Each governorate is responsible for implementation of the guidelines.

Science has been a basic subject in the central National Curriculum (NC) since the 1960s, having traditionally included integrated science at primary and preparatory levels and separated science – chemistry, physics and biology – at the secondary level. The structure of the science curriculum since 1994 as shown in **Table 1** shows that science on preparatory stage is integrated curriculum.

Table 1

Science in the Egyptian national curriculum

Stage	Grade	Curriculum
Primary	1,2,3	No science curriculum
	4,5,6	Integrated science
Preparatory	7,8,9	Integrated science
Secondary	10,11,12	Separated science - chemistry, physics and biology

This study focused on the content analysis of the science textbooks that were recently introduced as resources for both teachers and students at the preparatory school level. The preparatory science level included three textbooks which split in two terms on each grade. All published by the MoE, the book sector in Egypt. **Table 2** shows the textbooks that were analysed:

Table 2

Preparatory Stage Science Textbooks in Egypt

Grade	Textbook title	Year of publication
7	Science and the Future (term 1)	2006-2007
	Science and the Future (term 2)	2006-2007
8	You and Science (term 1)	2006-2007
	You and Science (term 2)	2004-2005
9	Science and Man's Life (term 1)	2005-2006
	Science and Man's Life (term 2)	2004-2005

INVESTIGATION METHODOLOGY

Quantitative content analysis was used to establish scientific literacy in the preparatory science curricula. Content analysis is a technique for gathering and analysing the content of text. In content analysis, a researcher uses objective and systematic counting and recording procedures to produce a quantitative description of the symbolic content in a text (Neuman, 1997).

This study used the method of Chiapetta et al. (1991) to analyse quantitatively the content of science textbooks with regard to scientific literacy. This is a valid method for examining the presentation of aspects of scientific literacy in science textbooks. Chiapetta et al. identified four aspects of SL that depended on analysis of the shared elements within the definitions and frameworks of scientific literacy, and improved the reliability of the procedures by carefully defining the descriptors for the four categories to facilitate identification of the themes of SL. Many studies have used this method and confirm its validity and reliability (e.g., Fadl, 1995; Boujaoude, 2002; Chiapetta et al., 1993; Chiapetta et al., 1991). The four aspects of scientific literacy used included:

1. Knowledge of Science (KoS)
2. The Investigative Nature of Science (NoS)
3. Science as a Way of Thinking (WoT)
4. Interaction of Science, Technology and Society (STS)

Two investigators, the researcher and a preparatory level science teacher, worked together on the content analysis. The science teacher had over 10 years experience of teaching the preparatory science curriculum at the 7th, 8th and 9th grade levels.

To ensure the validity and reliability of the results of the content analysis, the two investigators met to agree about the unit analysis and to discuss the method of Chiappetta et al. (1991), in order to reach a common understanding of its component and sub-components. They agreed on the units of analysis that appeared in the pages of science textbooks that would be used for analysing content themes. These were complete paragraphs, figures, tables with captions, marginal comments, and complete procedures for hands-on-activities. Following the meeting, they jointly analysed 10 pages of the 7th grade science textbook according to the four aspects of scientific literacy. This was done to ensure consistency of analysis. They then chose a 20 percent random sample of each chapter of the textbook pages of each preparatory science textbook (grades 7-9). Each of the two assessors (the researcher and the preparatory science teacher) independently analysed and classified the textbooks into one of the four categories of scientific literacy (Chiappetta et al., 1991). The results of this analysis are represented in Table 4.

To achieve a good level of agreement between the two coders and to obtain high analytical reliability, recourse was made to the recommended use by Cohen (1960) and Chippetta et al. (1991) of the Kappa statistic. The Kappa statistic has a range between -1 and +1, and Kappa statistics between 0.40 and 0.75 indicate fair to good agreement (Chiappeta, et al., 1993). As shown in Table 3 the results of the current study calculated the overall Kappa (Kappa) to be more than 0.80, and the Kappa statistics indicated a high degree of agreement between the two researchers in categorising the content in the three science textbooks grades.

Table 3

Kappa statistics between the two investigators for the Analysis

Textbook	Kappa
Grade 7	0.80
Grade 8	0.86
Grade 9	0.81

RESULTS AND DISCUSSION

The main purpose of this research was to investigate the balance of scientific literacy themes in the Egyptian preparatory science curriculum presented in textbooks. The findings of the study show that this curriculum emphasises KoS (aspect 1) and *the investigative* NoS (aspect 2), but neglects *science as a* WoT (aspect 3), and *the interactions of* STS (aspect 4). Table 4 and **Figure 1** show that the material devoted to *KoS* is the predominant theme in comparison with the other themes of the scientific literacy. KoS presented in preparatory science textbooks seems to account more than the half of the content. It ranges from a mean of 52,5% to 79%. The material devoted to *'The Investigative* NoS ranges from a mean of 13% to 22,5%. The material devoted to '*science as* WoT ranges from a mean of 1,4% to 16. The material devoted to STS ranges from a mean of 0.6 to 13. Similar findings in the Egyptian context emerged from Fadl (1995)'s examination of a secondary chemistry textbook. Farag (1996) who evaluated a preparatory science curriculum also identified a lack of content provision of scientific concepts to show the dynamic relations among the elements of scientific literacy.

Table 4

Percentage of aspects of scientific literacy found in three preparatory science textbooks

Textbook	**Investigator**	**Aspects of SL**			
		Knowledge of science (KoS) %	**Nature of science (NoS) %**	**Science as a way of thinking (WoT) %**	**Science, technology & society (STS) %**
Grade 7	A*	52.0	18.0	16.7	12.3
	B**	53.0	19.0	15.0	13.6
	Mean	**52.5**	**18.5**	**16.0**	**13.0**
Grade 8	A	77.0	23.0	0	0
	B	69.0	27.0	2.8	1.2
	Mean	**73.0**	**22.5**	**1.4**	**0.6**
Grade 9	A	81.0	11.7	3.0	4.3
	B	77.0	14.3	5.4	3.3
	Mean	**79.0**	**13.0**	**4.2**	**3.8**
Overall mean		**68.17**	**18.0**	**7.2**	**5.8**

A*: the researcher

B**: the science teacher

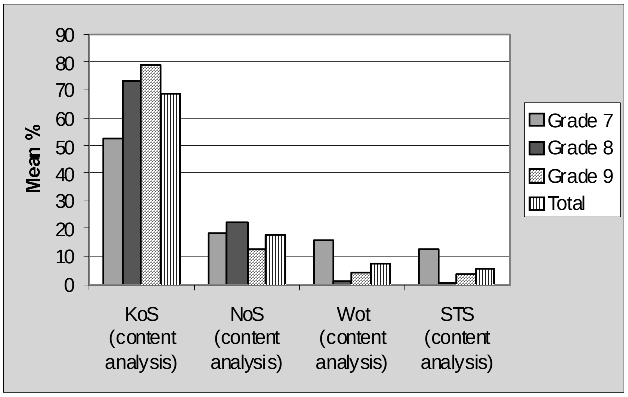

Figure 1. Comparisons of each aspect of SL on each grade.

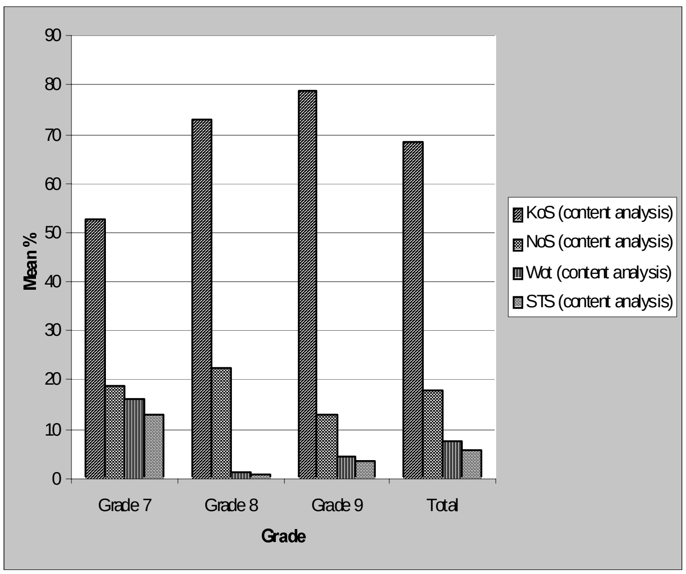

Figure 2. The mean of the four aspects of scientific literacy in 7th, 8th and 9th grade science textbooks.

Table 4 and **Figure 2** highlighted some interesting results:

1. There was no balance in the presentation of the aspects of SL among the three grades. The focus of the textbooks (more than the half of the content) on science as knowledge, the nature of science, and science as a way of thinking, as well as the interaction of science, technology and society had the fewest representations in these textbooks.
2. The content of the 7th grade science textbook represented the highest balance in aspects of the scientific literacy. Representation of the four aspects KoS, NoS, WoT and STS in the 7th grade science textbook was 52,5%, 18,5%, 16% and 13%, respectively.
3. The content of the 8th grade science textbook represented the lowest balance compared with the other two, grades 7 and 9. Representation of the four aspects KoS, NoS, WoT and STS in the 8th grade science textbook was 73%, 22,5%, 1,4% and 0,6%, in sequence. This textbook focused on two aspects of SL - 'KoS and NoS' and ignored the other two - 'WoT and STS'.
4. There was no balance in the aspects of SL in the 9th grade science textbook where the focus was on the KoS aspect. Representation of the four aspects KoS, NoS, WoT and STS on the 8th grade science textbook was 79%, 13%, 4,2% and 3,8%, respectively.

With regard to *the investigative* NoS (aspect 2) and *science as a* WoT (aspect 3), it is clear that the science curriculum did not represent them well, in that it presented the problems but also provided the answers. For example, in experiments the curriculum not only informs the students of the nature of the experiment, but gives the procedures, observations and results as well. Therefore, no room is left for students to think or inquire. In this respect, NSTA (1992) promoted the idea that science programmes "should help students to answer questions, not presenting assertions or authority-determined answers, but allowing them to propose and pursue the ideas, concepts, and information. Teachers should encourage students to ask how we know, why do we believe, what does it mean" (NSTA, 1992, 15-16). This result is supported by Afifi (1998) who analysed six units selected randomly from 12 units in three preparatory science textbooks in grades 7-9 in Egypt, and found that inquiry skills, as the most important aspect of scientific literacy, were totally ignored in designing the curriculum and rarely referred to the historical nature of science or the work of individual scientists, which should be considered one of the most important aims of teaching science. In this respect, McComas (2008) illustrates the importance of integrating examples of the historical nature of science on the science curriculum. He states "Incorporation of rich historical episodes into the science classroom can humanize science by raising instruction from the mere recitation of facts to its exploration as an authentic and exciting human adventure" (p. 262). He cites from Chalmers (1999) tells the story of how Galileo quantified his observations by recording data. He observed and recorded the positions of the moons or "starlets" of Jupiter to demonstrate that they were really orbiting the planet and were carried along with it in its own orbit around the Sun. This was a very important observation that would be hard to interpret in any way except to show that these observation that would be hard to interpret in any way except to show that these moons were orbiting another heavenly body. McComas explains this story provides straightforwardly students with an important nature of science lesson that makes the point that observation (as empirical evidence) is vital in science (p. 253).

Regarding *the relationship between* STS (aspect 4), the study's findings indicated that the science curriculum neglected this aspect especially in the 8th and 9th grades. These results coincided with other studies, such as those of Al-Nimr (1991) and Al-Mihy (1993) who affirmed that Egyptian science curricula tackled the relationship between science, technology and society very poorly and superficially. The content analysis of the Egyptian preparatory science curriculum conducted by Al-Nimr (1991) also showed that the preparatory science curriculum did not contribute effectively to the STS approach. He found that the STS issues in the three textbooks for grades 7, 8 and 9 were 4,8%, 3,5%, and 7%, respectively (Al-Nimr, 1991). Similar findings were reported by Al-Mihi (1993) who analyzed issues related to STS in light of the needs of secondary school pupils, and concluded that the secondary science curriculum did not fulfil the needs of pupils for an adequate understanding of the application of science and technology within society. The current study also agrees with Lumpe et al. (1998) who argued that textbooks play a major role in shaping science teaching today, and concurs with other studies indicating that many popular science curriculum series do not include active learning approaches and do not devote sufficient coverage of STS issues (see, e.g., Chiappetta *et al*., 1991, 1993; Lumpe & Beck, 1996). In this respect, Bybee and Mau (1986) recommended an increasing emphasis on STS issues from the lower to higher levels on science education at schools, stating that STS issues should account for 11-15% on the science curriculum.

IMPLICATIONS

Since the current Egyptian science curriculum does not provide a balance of scientific literacy themes, this affects students' scientific literacy, and suggests the need for the current preparatory science curriculum to be developed to enable students to achieve such literacy (NSC, 1999; Elwisimi, 1998; Afifi, 1998). In this respect, some possible ideas to put forward for achieving this include the use of children's scientific books to provide pupils in preparatory education with some elements of scientific literacy (Elwisimi, 1998). The findings of this study agree with the suggestion by Tairab (2006) that the current science textbooks need to be reconsidered in order to realise the stated learning outcomes. While there is a possibility of developing some dimensions of scientific literacy using the existing textbooks (see Figure 5), there is a need to establish channels of communication among science educators, science teachers, students, parents and textbook authors to maximize the usefulness of these textbooks. The study by UNESCO (2005) also recommended that educators in Egypt should review scientific and technological literacy teaching materials in light of new innovations, taking into account the viewpoint of teachers, students, and specialists.

The findings also indicate that there is a huge gap between theory and practice in educational policy in Egypt regarding science education. Although the NSC study (1999) stated that science education should produce scientifically-literate individuals who would understand the nature of science and the relationship between STS, there was no clear vision as to what should be done, in terms of how concepts of the nature of science or STS could be integrated into the content of the science curriculum. Would this mean that textbooks would have to be rewritten? Would science educators, decision makers or teachers need to be involved in practical work? What procedures might contribute to such a broad goal?

The challenge for science curriculum developers and decision makers is to find a reasonable balance between science content and other important goals of science teaching (DeBoer, 2000). By finding this balance, science in the preparatory stage can play an essential role in helping students to make the right decision concerning their secondary education and their future careers. At the end of the preparatory stage some students will find the study of science sufficiently compelling to pursue scientific careers; others will provide leadership in their communities regarding science-based issues (DeBoer, 2000). In this sense, Tairab (2006) argues that, in the absence of any consideration of science as a way of understanding the world through reflection and understanding of cause and effect relationships, the learning of key concepts and ideas intended for developing scientific literacy will be limited. Students need to be equipped with the tools to understand their world and these tools can be developed through inductive and deductive activities and an understanding of the role of evidence in knowledge construction.

The findings of the content analysis of the science textbooks show that the science as knowledge has formed the backbone of the textbooks in general and in the 9th grade in particular, and that this in turn might reflect on the students' scientific skills. This is very likely to continue to be the case in the future, as long as the educational system in Egypt encourages a competitive environment within schools by focusing on exam results at the end of the preparatory stage that mainly test the students' memorisation of knowledge. This is perhaps explained by the importance of students' final academic test scores as a determiner of admission to the general secondary school certificate (GSSC), and perhaps eventually to university education. So, the nature of the curriculum and the number of years of schooling are necessary but insufficient conditions for the development of scientific literacy. Teaching, assessment, and the quality of textbooks used are also important factors that need to be considered (Boujaoude, 2002).

CONCLUSIONS

Scientific literacy is social reconstruction lies more in learning about science than it does in learning science. Science curriculum based on only presenting science knowledge as the findings of this study showed, not on how we obtain this knowledge and how we use it make argue nation about science education in our society is not going to provide scientific literacy. It is not my intent to argue that knowledge of the major concepts, ideas and theories of science is unimportant. In contrast, an innovative science curriculum considering a balance of the scientific literacy aspects is needed. This curriculum can enable students to understand the significance of knowledge presented by others and it can enable them to evaluate the validity and reliability of that knowledge and to understand why scientists often disagree among themselves. For the new curriculum to do this, it is required a science teacher who aware with his roles toward scientific literacy. Without this teacher, the innovative curriculum will be ignored.

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Received: 26-12-2009 / Approved 08-05-2010