

Assessed students' competencies in the Greek school framework and the PISA survey

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ABSTRACT

The aim of the present study is to compare the science competencies that students need to demonstrate during school examinations on the one hand and when they participate in PISA on the other. Through their comparison similarities and differences will be detected. To this end, 1.357 test item sets relative to the subject of Biology used in the Gymnasium examinations (lower secondary education) and 50 PISA science items from the category “living systems” and the context life, health, environment were analyzed. The results of the comparative analysis indicate a clear differentiation between the competencies that students need to demonstrate during the school examinations of Biology in Gymnasium and the competencies that students need to demonstrate in order to answer the PISA items correctly. The fact that students have to demonstrate unfamiliar competencies during their participation in PISA could be a factor –among others– that explains the low performance of Greek students in the PISA study.

KEYWORDS

Biology, competencies, national / global context, PISA, school-based exams

RÉSUMÉ

L'objectif de cette étude est de comparer les compétences scientifiques que les élèves doivent justifier, d'une part aux examens scolaires, et d'autre part, aux tests PISA. Les similitudes et les différences sont détectées à partir de ces comparaisons. Pour cela, 1357 groupes d'items portant sur la biologie au niveau du collège et 50 items du test PISA, provenant de la catégorie « systèmes vivants » et du contexte « vie, santé et environnement » sont analysés. Les résultats de cette analyse comparative marque une différenciation très claire entre les compétences nécessaires pour ces deux types d'épreuves. Le fait que les élèves grecs doivent posséder des compétences non familières pour réussir au test PISA pourrait être un facteur, parmi d'autres, qui explique leurs performances médiocres.

MOTS-CLÉS

Biologie, compétences, contexte national / global, PISA, examens scolaires

INTRODUCTION

The OECD-led PISA survey is an international comparative assessment seeking to evaluate the attainment outcomes of educational systems, in particular their relative strengths and weaknesses. The primary aim of the PISA survey is to assess 15-year-old students' competency at using important knowledge and skills in reading, mathematics, and science to face real-life problems and situations of future adult life, rather than at mastering a specific school curriculum (OECD, 2000, 2003, 2006a, 2007a).

PISA surveys are carried out every three years (2000, 2003, 2006, 2009) and the cognitive domains that are assessed are reading, mathematics and science. Each of these cycles assesses all three cognitive domains, putting a special focus on one of them –being the major domain– every time.

The PISA attempts, combined with the considerably increasing media and political interest which follows the publication of PISA results, have encouraged many researchers to focus on this survey and carry out relevant research. At present, most of these studies, published in English-language academic journals, have further analyzed the datasets generated by PISA, either at national or cross-national level, for identifying factors that influence students' performance. Factors like those related to students' characteristics but also to teachers or educational systems apparently have an impact on students' achievements in the PISA assessment. Some studies are more critical and examine the validity and reliability of the test items used or the methodological constraints imposed by factors such as the collection process, the analysis and the

interpretation of the PISA data (Hatzinikita, 2008; Hatzinikita, Dimopoulos & Christidou, 2008).

In discussing PISA results, one of the most valuable approaches for the participating countries stems from a consideration of the PISA framework and test items with reference to the national context and especially to the national curricula and educational process. However, the research activity on this line seems to be rather limited. Apart from a few studies focusing on teachers' views and practices of specific countries about the content/processes of PISA test items (Pinto & El Boudamoussi, 2009; Ratcliffe & Millar, 2009; Sáenz, 2009), match analysis between other crucial elements of the national curricula and the PISA approach has seldom been implemented. There is one study focused on textbooks, comparing the PISA science test items with the Greek school science textbooks in terms of the nature of textual construction (Hatzinikita, Dimopoulos, Christidou, 2008). There are also a few studies that discuss the match between the content, the processes and the format of the PISA test items and the Irish Junior Certificate syllabus / Junior Certificate examinations (Oldham, 2006; Shiel, Cosgrove, Sofroniou & Kelly, 2001; Shiel, Sofroniou & Cosgrove, 2006).

In Greece, despite the fact that the performance of Greek students on the PISA survey is unflinching low as compared with other participating countries, the interest is usually confined to political and media discussions appearing mainly in the daily press, while the relevant publicly released research remains limited (Anagnostopoulou & Lakka, 2008; Apostolopoulos, Psalidas & Hatzinikita, 2008; Apostolopoulos et al., 2008; Hatzinikita, 2008; Hatzinikita, Dimopoulos & Christidou, 2008; Koumaras & Seroglou, 2008; Pramas, 2008; Pramas & Koumaras, 2004, 2008; Psalidas, Apostolopoulos & Hatzinikita, 2008; Tsiakalos, 2008).

The objective of this study is to explore the relationship between the science-related assessment competencies promoted by the Greek educational system and the PISA respectively. Assessment is a core function of the educational process. In most of the cases its purposes are related to credentials generation, educational accountability and to ensuring quality of learning (Broadwood & Black, 2004; Black & William, 2007; Liu, 2009). Furthermore, examination policies have an impact on the corresponding teaching and learning practices.

The present paper aims to investigate the degree to which Greek students are familiar with the PISA-assessed competencies of scientific literacy. Therefore, test items set at Greek school examinations are investigated, as students' assessment is a fundamental part of the educational process and students' performance on school examinations is considered the outcome of the quality and quantity of knowledge attained by the student within a given time period. Besides, the format and the content of the assessment are considered to have an impact on teaching and learning, since

teachers in Greece often teach according exclusively to the structure of the test items and assessment criteria used in written tests, in order for their students to achieve a high mark (Zisimopoulos et al., 2004). As a result, the investigation of test items set at school examinations, with regard to the level of students' competencies required for the activation and application for their successful answer, is an index showing the degree to which Greek students are familiar with specific competencies. The following comparison with the competencies assessed by the PISA through test items sets used by the survey as well as their convergences or differences with regard to the competencies Greek students are familiar with may become a factor that explains, among others, the low performance of Greek students.

In brief, the present paper aims at the comparative study between the competencies assessed in year advancement and discharge school-based examinations in Biology at lower secondary school in Greece and the PISA-assessed competencies of scientific literacy in the domain of biological systems and the context of life, health and environment.

THE PISA FRAMEWORK

The core element of PISA is the concept of literacy that is concerned with the capacity of students to extrapolate from what they have learned and apply their knowledge in novel contexts. The concept of literacy is applied in all three cognitive domains that are assessed in PISA formulating reading, mathematic and scientific literacy, respectively.

Scientific literacy, which is the focus of the present study as well as the major domain being assessed in the PISA 2006 survey, is defined as:

«An individual's scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen» (OECD, 2006a, p. 12).

The test items assessing scientific literacy in PISA 2006 are characterized by four interrelated aspects:

- the context in which tasks are embedded,
- the competencies that students need to apply,
- the knowledge domains involved, and
- student attitudes.

FIGURE

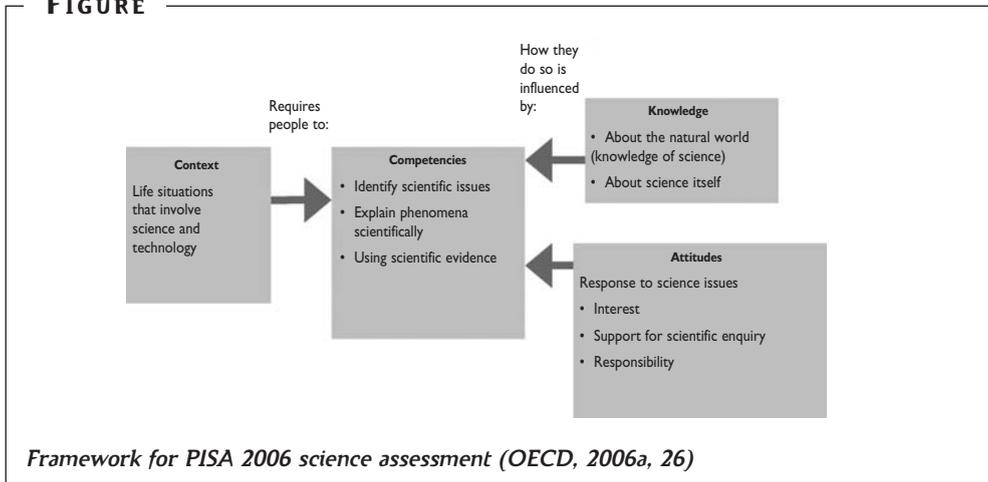


Figure 1 points out the priority that is given to the competencies in the framework of scientific literacy adopted by PISA. The three competencies listed in Figure were selected because of their importance to the practice of science and their connection to key cognitive abilities such as inductive and deductive reasoning, systems-based thinking, critical decision making, transformation of information, construction and communication of arguments and explanations based on data, thinking in terms of models, and use of science (OECD, 2007a). In the following paragraphs the scientific competencies assessed in PISA 2006 are presented in brief using relevant examples.

The competency “*Identifying scientific issues*” includes recognizing questions that could be investigated scientifically and identifying keywords to search for scientific information on a given topic. It also includes recognizing key features of a scientific investigation, i.e. what things should be compared, what variables should be changed or controlled, what additional information is needed, or what action should be taken so that relevant data can be collected. Identifying scientific issues requires students to possess knowledge about science, but may also assume knowledge of science (OECD, 2006a, 2007a).

Example 1 invites students to identify a question that cannot be investigated scientifically. The item mainly assesses knowledge about science, but also assumes knowledge of living systems (molecular genetics).

Students demonstrate the competency “*Explaining phenomena scientifically*” by applying appropriate knowledge of science in a given situation. The competency of explaining phenomena scientifically includes describing or/and interpreting phenomena and functions, predicting changes, and may also involve recognizing appropriate descriptions, explanations and predictions. The competency requires students to draw on their knowledge of science to answer the relevant items correctly (OECD, 2006a, 2007a).

EXAMPLE 1

PISA test item from the framework for the PISA 2006, assessing the competency “Identifying scientific issues”

Catching the killer

Read the following newspaper article, and answer the questions that follow.

DNA TO FIND KILLER

Smithville, yesterday: A man died from multiple stab wounds in Smithville yesterday. Police say that there were signs of a struggle and that some of the blood found at the scene of the crime did not match the victim's blood. They suspect that this blood came from the killer.



Photo of typical DNA profiles from two people. The bars are different fragments of each person's DNA. Each person has a different pattern of bars. Like fingerprints, these patterns can identify a person.

Question

Which one of the following questions cannot be answered by scientific evidence?

- A. What was the medical or physiological cause of the victim's death?
- B. Why was the victim stabbed many times?
- C. Is taking cheek scrapings a safe way to collect DNA samples?
- D. Do all identical twins have exactly the same DNA profile?

Source: OECD (2006a). Assessing scientific, reading and mathematical literacy-A framework for PISA 2006. Copyright OECD 2006, p. 28.

For example, the question in Example 2 requires students to recall their knowledge of science, in particular knowledge of genetics referring to virus mutation, in order to select the appropriate explanation among the suggested alternatives.

The competency “Using scientific evidence” includes the interpretation of scientific findings in order to draw conclusions and express statements. It also involves identifying the assumptions made in reaching a conclusion. Reflecting on the societal implications of scientific or technological developments is another important aspect of this competency. The items assessing the competency using scientific evidence can involve knowledge of science, or knowledge about science, or both (OECD, 2006a, 2007a).

The item in Example 3 assesses the competency “Using scientific evidence”. Students are required to draw conclusions based on the evidence presented in the

EXAMPLE 2

PISA test item assessing the competency "Explaining phenomena scientifically"

Mousepox

There are many types of pox viruses that cause pox diseases in animals. Each type of virus usually infects only one animal species. A magazine has reported that a scientist has used genetic engineering to modify the DNA of mousepox. The altered virus kills all the mice it infects.

The scientist says research on modifying viruses is necessary in order to control pests that damage human food. Critics of the research say viruses could escape from laboratories and infect other animals. They are also worried that a modified pox virus for one species could infect other species, especially humans.

Humans are infected with a pox virus called smallpox. Smallpox kills most people it infects. While it is thought that this disease has been eliminated from the general population, smallpox virus samples are kept in laboratories around the world.

Question

Critics have expressed concern that the mousepox virus could infect species other than mice. Which one of the following reasons is the best explanation for this concern?

- A. The genes of smallpox virus and the genes of modified mousepox virus are identical.
- B. A mutation in mousepox DNA might allow the virus to infect other animals.
- C. A mutation could make the mousepox DNA identical to smallpox DNA.
- D. The number of genes in mousepox virus is the same as in other pox viruses.

Source: OECD (2009). Take the Test: Sample Questions from OECD'S PISA Assessments. Copyright OECD, p. 228.

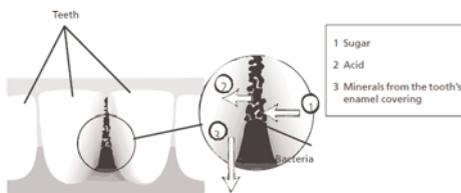
EXAMPLE 3

PISA item assessing the competency "Using scientific evidence"

TOOTH DECAY

Bacteria that live in our mouths cause dental caries (tooth decay). Caries have been a problem since the 1700s when sugar became available from the expanding sugar cane industry. Today, we know a lot about caries. For example:

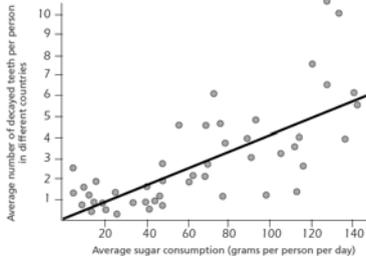
- Bacteria that cause caries feed on sugar.
- The sugar is transformed to acid.
- Acid damages the surface of teeth.
- Brushing teeth helps to prevent caries



Question 2

The following graph shows the consumption of sugar and the amount of caries in different countries.

Each country is represented by a dot in the graph.



Which one of the following statements is supported by the data given in the graph?

- A. In some countries, people brush their teeth more frequently than in other countries.
- B. The more sugar people eat, the more likely they are to get caries.
- C. In recent years, the rate of caries has increased in many countries.
- D. In recent years, the consumption of sugar has increased in many countries.

Source: OECD (2009). Take the Test: Sample Questions from OECD'S PISA Assessments. Copyright OECD, p. 224-225.

graph relating the consumption of sugar to dental caries in different countries, and then to select the statement which is relevant to their conclusion (the more sugar people eat, the more likely they are to get caries).

METHOD

For the purposes of the present study test items set at the school-based year advancement and discharge examinations in Biology at lower secondary school in Greece and publicly released PISA test items related to the domain of biological systems and the context of life, health and environment were analyzed.

More specifically, 1357 examination test items in Biology of the 1st and 3rd grades of lower secondary school (545 test items of year advancement examinations of the 1st grade and 812 test items of discharge school-based examinations of the 3rd lower secondary school grade) from different regions of the country (West-Central Greece, Attica, the Peloponnese and the Dodecanese) and in different school years (1997 – 1998 until 2006 – 2007) were analyzed. The selection of school examination test items set at lower secondary school level (students aged 12-15) is based on the fact that this age group corresponds to the population to be addressed by the PISA survey. Therefore, the competencies assessed by PISA are expected to be acquired during the attendance of lower secondary school. Moreover, Biology is included in the curriculum of the the 1st and the 3rd grades of the lower secondary school in Greece.

The study of the PISA-assessed competencies was based on the analysis of 50 publicly released science test items from the cognitive domain of biological systems and the context of life, health and environment. Since these items are released so as to be read by all interested parties as exemplars, it could be reasonably argued that they are quite representative and reflective of the rationale promoted by PISA.

The analysis of the items used the competencies listed in Table 1. These competencies are expected to be demonstrated by the students in order to answer the items set at the Biology examinations in the Greek lower secondary school as well as at the PISA survey. This list of competencies was based on the theoretical framework about scientific literacy used by the PISA (OECD, 2006a), the Greek curricula related to lower secondary school Biology (Presidential Decree 371, Official Gazette 241, v. I, 20/9/1996) and literature related to assessment (e.g. Dimitropoulos, 1989; Bloom et al., 1956).

TABLE 1

List of assessed students' competencies

Competencies
Recalling declarative knowledge
Describing and/or explaining phenomena
Identify scientific issues
Using scientific evidence
Combination of the above competencies

The competency of “Recalling declarative knowledge” involves the recall of scientific terminology, definitions, formulas and recognition of phenomena, functions and their appropriate descriptions.

The competency of “Describing and/or explaining phenomena” involves the description and/or interpretation of phenomena and functions as well as the prediction for possible changes. It should by all means be noted that, according to the PISA theoretical framework, the competency of “Describing and/or explaining phenomena” is included in the competency of “Explaining phenomena scientifically” (see Figure 1), since this competency also involves the identification of appropriate descriptions (see section “Theoretical Framework”). However, in the framework of the present paper, when the test item requires the recognition of appropriate descriptions, the competency of “Recalling declarative knowledge” is considered as an assessed competency, according to Bloom’s Taxonomy (Bloom et al., 1956), while when it asks for the description of phenomena and functions, the “description” is considered as the assessed competency.

As for the competencies of “Identifying scientific issues” and “Using scientific

evidence”, they were determined according to the PISA theoretical framework (see section “The PISA framework”).

The analysis of representative examples of test items set at the year advancement and discharge school-based examinations in the Biology of the 1st and the 3rd grades with regard to the assessed competencies is presented below.

EXAMPLE 4

Biology test item set at the end-of-year advancement examinations intended for 7th grade, assessing the competency “Recalling declarative knowledge”

6. Fill in the blanks with the appropriate words:

- a. Lungs and _____ are animal's organs supplying oxygen to blood.
- b. Arteries and veins communicate with each other by _____ .
- c. The _____ remove waste products from the mammal's blood.
- d. The water and the minerals dissolved in are conveyed inside the plant body via _____.
- e. All _____ and mammals have four-chambered heart.

Source: http://www.pdestereas.gr/allowindex/TRAPEZA_THEMATON/Themata_2005/BIOLOGY/BIOLOGIA_A_GYMNASIOY

The assessed competency in Example 4 is “Recalling declarative knowledge”, as the question requires students to recall the appropriate scientific terminology (organs and organisms) and fill in the blanks.

EXAMPLE 5

Biology test item set at the end-of-year advancement examinations intended for 7th grade, assessing the competency “Describing or/and explaining phenomena scientifically”

4. a) Describe two differences between plant and animal cells.
- b) What is the role of mitochondria in a cell?

Source: http://www.pdestereas.gr/allowindex/TRAPEZA_THEMATON/Themata_2005/BIOLOGY/BIOLOGIA%20A%20GYMNASIOY%202005/20.pdf

Students are required to recall knowledge referring to plant and animal cell morphology, and to detect and describe two morphological differences so as to answer the first sub-question. Then, students have to draw on their knowledge about a cell's structure and function, in order to explain the functional role of mitochondria and answer the second sub-question. So, the assessed competency in Example 5 is the competency of describing and the competency of explaining phenomena and functions.

EXAMPLE 6

Biology test item set at the end-of-year discharge examinations intended for 9th grade, assessing the competency "Using scientific evidence"

4th ITEM

If one of two brothers has black hair and the other blond hair, what is the hair colour are their parents? Justify your answer. It is given that the gene responsible for black colour is predominant. (Use the appropriate symbols for allele and the genotypes of children and their parents)!

Source: http://www.pdestereas.gr/allowindex/TRAPEZA_THEMATON/Themata_2006/C_Gymnasiou_Biologia/1.pdf

The item in Example 6 assesses the competency "Using scientific evidence". Students are required not only to recall knowledge relevant to heredity, but also to use the given data (children's hair colour, gene responsible for black colour is predominant) in order to draw conclusions about parents' hair colour.

EXAMPLE 7

Biology test item set at the end-of-year advancement examinations intended for 7th grade, assessing combination of competencies

1. Why does a cell need energy? In which organelle is energy used by the cell produced?

Source: http://www.pdestereas.gr/allowindex/TRAPEZA_THEMATON/Themata_2005/BIOLOGY/BIOLOGIA%20A%20GYMNASIOY%202005/14.pdf

The item requires students to explain the role that energy plays in cellular function on the one hand, and to name the organelle in which energy is produced (mitochondria) on the other hand. So, two competencies are assessed in this item, explaining functions and recalling declarative knowledge. Therefore, the item is classified as assessing combination of competencies.

RESULTS

Research results are presented in three successive sections. The first and the second sections present the distribution of test items set at school examinations in Biology and PISA items respectively, according to students' assessed competencies. The third section presents the results obtained from their comparison.

a. Assessed competencies in test items of school examinations in lower secondary school Biology in Greece

The results obtained from the analysis of the test items set at the year advancement

and discharge school-based examinations in lower secondary school Biology, with regard to the competencies being assessed, namely the competencies the students should demonstrate in order to provide the correct answer, are presented in Table 2.

The study of Table 2 reveals that the competency usually assessed by the examination items is the recall of declarative knowledge (42.7%) and this involves items of both the 1st (42.6%) and the 3rd lower secondary school grades (42.9%). Furthermore, from the analysis it emerged that a considerable number of test items (35.6% for the 1st grade and 31.53% for the 3rd grade) involve test items assessing more than one competency. It should be stressed that the vast majority of test items assessing more than one competency (92% for the 1st grade and 86.33% for the 3rd grade) assess the competency of “Recalling declarative knowledge” coupled with a different competency. It all comes to show that the vast majority of test items at Biology examinations assess, at least, the competency of recalling and reproducing declarative knowledge.

The next more frequently occurring competency is “Describing and/or explaining phenomena”, with approximately the one fifth (19.4%) of the examination items (21.1% of 1st grade test items and 18.23% of 3rd grade test items) being focused on it.

Unlike the abovementioned competencies, the competency of “Identifying scientific issues” is probably not assessed at the year advancement and discharge school-based Biology examinations in lower secondary school. Similarly, the competency of “Using scientific evidence” is almost skipped from the examination items of the 1st lower secondary school grade (0.7%), whereas it appears in a low number of test items in the 3rd lower secondary school grade (7.4%).

b. Assessed competencies in PISA test items with regard to biological systems and the context: health, life and environment

At first, it should be noted that when the PISA survey is structured, special care is taken so that the test includes an appropriate balance of items assessing the various competencies of the scientific literacy framework (OECD, 2006a, p. 40). However, in the present study only publicly released test items from the cognitive domain of biological systems and the context of life, health and environment were analyzed rather than all the items assessing scientific literacy in the PISA survey. Moreover, the competency of “Recalling declarative knowledge”, which is herein considered a discrete competency, does not appear in the PISA theoretical framework. Thus, the results presented in Table 2 with regard to the assessed competencies in PISA test items related to the biological systems and the context: health, life and environment, as well as the ensuing comparative comments, should be “read” according to this methodological choice (see section Method).

The results of Table 2 illustrate an emphasis on the assessment of the competency of “Using scientific evidence” as compared with the other competencies, since approximately one third of the items (36%) are focused on the assessment of this competency.

The next more frequent competencies are those of “Identifying scientific issues” and “Describing and/or explaining phenomena”, which are assessed in nearly one fourth of the items (24%).

It also becomes obvious that the assessment in the PISA framework, unlike the abovementioned competencies, does not put particular emphasis on the competency of “Recalling declarative knowledge”, since only a low percentage of items assess this competency (10%). Finally, there are only a few PISA items requiring a combination of competencies (6%).

TABLE 2

Examination test items in Biology of lower secondary school in Greece and PISA science test items from the cognitive domain of biological systems and the context of life, health and environment: percentages of assessed competencies

ASSESSED COMPETENCIES	EXAMINATION TEST ITEMS IN BIOLOGY OF LOWER SECONDARY SCHOOL			PISA SCIENCE TEST ITEMS (biological systems end context: health, life, environment) (N=50)
	1st Grade (N= 545)	3rd Grade (N= 812)	Total (N=1357)	
Recalling declarative knowledge	42,6%	42,9%	42,7%	10,0%
Describing and/or explaining phenomena	21,1%	18,2%	19,4%	24,0%
Identify scientific issues	0,0%	0,0%	0,0%	24,0%
Using scientific evidence	0,7%	7,4%	4,7%	36,0%
Combination of the above competencies	35,6%	31,5%	33,2%	6,0%

c. Test items in lower secondary school Biology examinations & Test items of the PISA survey: comparison between assessed competencies

From Table 2 it becomes clear that in order for the students to answer the PISA items, they have to demonstrate competencies different from those required to be applied for the appropriate answer to the test items in the year advancement and discharge school-based examinations of Biology at lower secondary school. In other words, there are critical “tensions” between PISA-assessed competencies and competencies assessed in the Greek school framework.

In particular, the competency of “Using scientific evidence”, which is assessed more frequently than the other competencies in PISA items (36%), is rarely required (4.7%) to be applied by Greek students in order for them to answer the test items of their school examinations.

On the contrary, the competency of “Recalling declarative knowledge” appears to be the focal pole for the majority of test items set in lower secondary school Biology in Greece –taking also into account the percentage of similarly oriented test items, which assess more than one competency–, while the PISA survey seems to put much less emphasis on this competency (10%).

Likewise, while the competency of “Identifying scientific issues”, which forms a fundamental constituent of scientific literacy, according to the PISA survey, is the second most frequently occurring competency in PISA items (24.00%), it is not required to be applied by the students in none of the analyzed examination test items of the sample.

As for the competency of “Describing and/or explaining phenomena”, it is realized that it appears to be relatively equally significant to both the examination test items (19.4%) and the PISA items (24%).

CONCLUSIONS

The main finding of the present paper is an emerging “tension” between the assessed competencies, which are therefore promoted, in the educational process in Greece with regard to the subject of Biology at lower secondary school level, and the competencies assessed by PISA with regard to biological systems.¹

More specifically, in order for the Greek students to answer the PISA items on biological systems, they have to demonstrate competencies different from those required for the appropriate answer to the items of the year advancement and discharge school-based examinations in Biology at lower secondary school.

1 “Tension” is also traced in the test items set at school examinations in Greece and at PISA items, concerning the format of the items (Anagnostopoulou, 2008). All PISA items include an introductory text representing the framework of the daily life into which the negotiated test item is incorporated. But this element, as also revealed by the suggestive examples presented herein, is absent from the test items of school examinations.

In addition, in lower secondary school test items the inclusion of illustrations is extremely limited, while in PISA items images participate to a significant degree and play a fundamental role in drawing and processing information (Anagnostopoulou, 2008).

Finally, as regards the type of test items, their majority in lower secondary school Biology consists of open constructed response items or short constructed response items, while the majority of PISA test items consist of simple multiple-choice items as well as complex multiple-choice items which require students to respond to a series of related “Yes/No” questions.

The competency usually required by lower secondary school students in order for them to answer the examination test items is that of “Recalling declarative knowledge”. But this competency is required to be applied in a particularly limited number of PISA items.

In contrast, “Using scientific evidence”, a competency extensively promoted by the PISA is hardly exploited at school Biology examinations in the 3rd and almost not at all in the 1st lower secondary school grade. This limited familiarization of Greek students with the competency of “Using scientific evidence” is also recorded in other research papers, in which it becomes clear that the Greek school does not familiarize the students with the scientific processes of interpreting scientific evidence and drawing conclusions (Apostolopoulos, 2007; Apostolopoulos, Psalidas & Hatzinikita, 2008; Psalidas, 2007).

A similar “tension” is traced with regard to the competency of “Identifying scientific issues”, where PISA acknowledges its significance and assesses it in a considerable number of items, while school examinations appear to ignore it.

The limited familiarization of Greek students with the competencies of “Using scientific evidence” and “Identifying scientific issues” could be possibly connected with the performance of Greek students in PISA 2006. In this PISA cycle, Greek students tend to achieve relatively higher performance in items requiring the scientific explanation of the phenomena as compared with items requiring the application of the competencies of “Identifying scientific issues” and “Using scientific evidence”.²

Nevertheless, as for scientific literacy, the identification of scientific issues and the use of scientific evidence for drawing conclusions are equally important. A student who has mastered a scientific theory but who is unable first to recognize a science problem and then to interpret findings in ways relevant to the real world, will make limited use of science in adult life. Thus, s/he is not considered as scientifically literate (OECD, 2007a, p. 62).

The special consideration given to the recall of declarative knowledge in the framework of school assessment in Greece is also advocated by findings from other research papers, which ascertain that in the majority of assessments of science test items at lower secondary school the students are asked to provide in writing declarative knowledge. It is concluded that the process of memorization is encouraged and praised through this practice (Lakasas, 2008; Vlachos, 2004). But even in the higher educational level in Greece, the Upper Secondary School, school assessment is focused

2 As regards Greece, and particularly competencies demonstrated by Greek students, there is a small advantage in the scientific explanation of phenomena (3.1 points higher than the overall science score of Greek students), while a comparative disadvantage is recorded in the identification of scientific issues and the use of scientific evidence (4.6 and 7.9 points lower than the overall science score of Greek students, respectively) (OECD, 2007b).

on the competency of “Recalling declarative knowledge”. A typical case of this predominance involves the competencies assessed in the entrance examinations for admission in tertiary education. According to a relevant study³ on the test items set in Physics, Chemistry and Biology in these examinations, (a) in theoretical items the students are usually asked to write memorized extracts included in their one and only textbook of Physics (Ravanis, 2003), (b) the assessed competencies in Chemistry do not benefit the scientific thinking and the scientific method for studying reality (Stavridou & Stefanides, 2003) and (c) the test items tend to ask from the candidates to elaborate, in the form of an essay, on their knowledge and, therefore, they lead them to memorization through which the candidates can achieve the “fully appropriate” answer (Savvakis, 2003).

Consequently, memorization is considered to be one of the most important problems of the Greek educational system. Although the students may “learn” some concepts by memorization, this type of learning will not be meaningful and will not improve their procedural knowledge. The reason why procedural knowledge should be improved is that when the students participate in the construction of knowledge, they gain the tools required for the better understanding of the phenomena and the competency to explain them by elaborating and controlling their own ideas. The competency to produce declarative knowledge depends on the course to knowledge, which in turn depends on the competency to produce and control assumptions (Zogza, 2006).

Therefore, the Greek students, being familiar with the mechanical memorization and reproduction of declarative knowledge when they are assessed at lower secondary school, find it extremely difficult to demonstrate other competencies, such as the identification of scientific issues and the use of scientific evidence to draw conclusions, during their assessment within the PISA framework. The PISA survey focuses on the assessment of competencies that the educational process, and particularly examinations, at lower secondary school level in Greece, fail to develop in students. After all, it is not surprising that Greek students are unable to identify and apply the competencies required for solving the PISA items.

Therefore, the overemphasis given by the Greek school to the reproduction of curriculum extracts and the memorization from the one and only textbook may be considered as one of the most important factors interpreting the low performance of Greek students in the PISA survey.

The findings of the present study are fairly strong indications of the differentiations

3 The study sample involved Physics, Chemistry and Biology test items set, in which Upper Secondary School graduates were examined, in the framework of the entrance examinations for admission to tertiary education in the academic years between 1961 and 2001.

among the competencies promoted by the Greek educational system from the PISA-assessed competencies of scientific literacy. These indications, which resulted from the study of examination test item sets of Biology with regard to the PISA items on biological systems, should by all means be further validated so that they could become potential elements shaping educational policies. More specifically, it is necessary that similar research should be conducted in order to study school examination and PISA test item sets from all science domains (Physics, Chemistry) –apart from Biology on which the present paper is focused—in order to develop a more comprehensive picture of science-related competencies:

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