ACTA DIDACTICA NAPOCENSIA

Volume 6, Number 4, 2013

WHAT SPECIFIC SCIENCE ABILITIES AND SKILLS ARE ROMANIAN STUDENTS DEVELOPING DURING PRIMARY EDUCATION? A COMPARISON WITH THE ABILITIES TESTED BY THE TIMSS 2011 INQUIRY

Liliana Ciascai, Maria-Eliza Dulamă

Abstract: The results of Romanian students at international comparative TIMSS and PISA tests have constantly proven to be unsatisfactory. The present paper aims at analyzing the school syllabi "Mathematics and Environment exploration", "Environmental Education" and "Natural Sciences" studied during primary education in Romania and the Sciences curricula on which the TIMSS inquiry is based. The goal of this comparative analysis has been to provide themes of reflection for the conceivers of school syllabi in Sciences. For analysis the Romanian school curricula of Primary level we identified that knowledge (*content domain)* and the abilities involved in building new knowledge (cognitive dimension and scientific inquiry process) are considered necessary to Fourth grade students by TIMSS curriculum. The analysis of school syllabi on which the study of science is carried out demonstrates that Romanian Fourth grade students have developed, based on these curricula, less scientific knowledge and skills than those investigated by the TIMSS inquiry. The main conclusions of this study are that the school syllabi for primary education in Romania require, without exception, re-evaluation and that the study of Sciences needs to rely on the scientific inquiry process to a large extent.

Key words: learning science, scientific inquiry, international testing, primary level.

1. Introduction

TIMSS is a project of International Association for the Evaluation of Educational Achievement (IEA), based in Amsterdam. It is managed by TIMSS & PIRLS International Study Center in partnership with a worldwide network of organizations and representatives of participant countries. IEA aims to provide political decision-makers in each country with the necessary information in identifying the weaknesses and/or strengths of their education systems, of domains requiring immediate intervention and also for the development of national strategies in the field of education.

Carried out during the Fourth and Eight grade every four years, the TIMSS inquiries collects data that allows the identification of trends in learning Mathematics and Sciences. The 2011 TIMSS testing is the last evaluation of the total of five comparative evaluations dedicated to improving the teaching and learning of Mathematics and Sciences for students from participating countries. In 2011, the TIMSS testing was attended by students from 63 countries. The results obtained by Romanian students of Fourth level in the TIMSS inquiry in Mathematics and Sciences were situated under international average, with one exception. (http://rms.iea-dpc.org/). Thus, in the last three testing sessions, Romania obtained the following scores: 470 points in 2003, 462 in 2007 and 505 points in 2011, with the international average situated at 500 points (Martin et al., 2008; Martin et al., 2012).

Received 8 December 2013

2. The Sciences curriculum of TIMSS inquiries

The TIMSS Sciences curriculum stipulates the knowledge, abilities and values in the scientific domain and their possession by students was investigated. The TIMSS inquiries focus on two dimensions: cognitive and content dimensions.

The cognitive dimension, as shown by Martin et al., (2012, p.50), refers to the set of cognitive processes involved in the learning of Sciences. Learning is placed in relation to scientific inquiry.

Recognizing the importance of scientific inquiry in the teaching and learning process, the TIMSS 2011 Science Framework takes the position that the understandings and abilities required to engage in this process should not be assessed in isolation. Rather, scientific inquiry should be assessed in the context of one or other of the TIMSS science content domains and drawing upon the full range of skills and behaviors specified in the cognitive domains (ibidem, pp.51).

The cognitive dimension is also divided into three domains: Knowing, Applying and Reasoning (Martin et al., 2012, pp.50). This division, as shown in the cited source, relies on the demands (what to know & what to do) that the students must meet by means of the items developed for the TIMSS 2011. Taking into consideration the high level of difficulty of items, the three domains suggest a hierarchy. Thus, the Knowing domain covers science facts, procedures and concepts students need to know. Applying describes the abilities involved in using knowledge and conceptual understanding to solve a science problem. The domain of Reasoning goes beyond the solution of routine science problems to encompass familiar situations, complex contexts, and multi-step problems (ibidem, pp.80).

In turn, these three domains are described with the help of 19 sub-categories which comprise 38 skills and abilities, structured as follows:

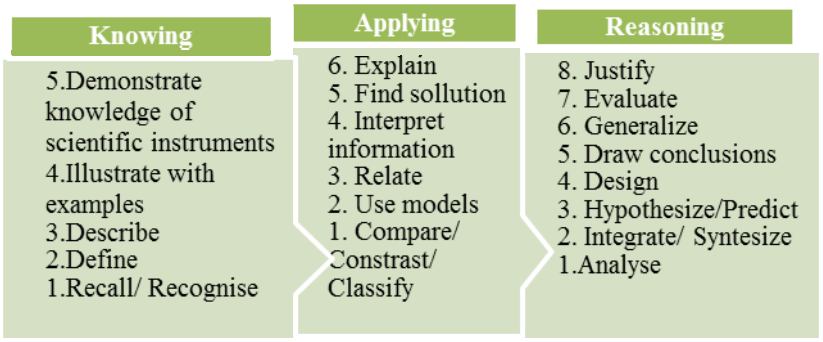

Figure 1. The hierarchy of abilities within the cognitive dimension in the TIMSS study (TIMSS 2011, Science Framework, pp.80-87)

As far as the term *inquiry* is concerned, Flick (2006) defines it as follows:

> „Inquiry refers to a variety of processes and ways of thinking that support the development of new knowledge in science. In addition to the doing of science, inquiry also refers to knowledge about the processes scientists use to develop knowledge, that is the nature of science itself. Thus, inquiry is viewed as two different student outcomes, ability to do scientific processes and knowledge about these processes. Finally, inquiry is viewed as a teaching approach that can be used to teach students the traditional subject matter of the sciences" (Flick, 2006, pp. IX-X).

Concerning the scientific inquiry process, the 2011 TIMSS study has sought to investigate the students' possession of skills and abilities involved in: a) formulating questions and hypotheses; b) designing investigations; c) collecting and representing data; d) analyzing and interpreting data; e) drawing conclusions and f) developing explanations based on the acquired knowledge (Martin et al, 2012, pp. 88).

The content dimension subjected to the TIMSS evaluation in 2011 covers the following domains: Life Science, Physical Science and Earth Science. The *Life science* domain is organized around the topic of living things (characteristics and life processes, interaction with the environment) and ecosystems and human health (Martin et al., 2012, pp.53-56). *Physical science* refers to concepts related to matter and energy (ibidem, pp. 57-59) and *Earth Science* to the study of Earth (ibidem, pp. 60-62).

At the level of Fourth grade, according to the International Benchmarks, the students were asked (Martin et al., 2012, pp.8): to demonstrate some elementary knowledge of life, physical, and earth sciences (the Low level); to possess basic knowledge and understanding of practical situations in sciences (the Intermediate level); to apply knowledge and understanding to explain phenomena in everyday and abstract contexts (the High level) and to apply understanding of scientific processes and show knowledge of scientific inquiry (the Advanced level).

3. The Sciences Curriculum of the Romanian primary school

The study of Natural Sciences in primary education in Romania is carried out by means of three school subjects: Mathematics and Environment Exploration (Preparatory, First and Second grade), Environmental Education (First and Second grade) and Natural Sciences (Third and Fourth grade). At present, there are four school syllabi guiding the study of Natural Sciences in primary education on the official Ministry of National Education website (www.edu.ro):

- *The school syllabus for Mathematics and Environment Exploration. Preparatory grade, First grade and Second grade.* Bucharest, 2013. Approved by Order of the Minister, No. 3418/19.03.2013.
- C.N.C. *The school syllabus for Environmental Education, First and Second grade,* Bucharest, 2003. Approved by Order of the Minister, No. 4686/05.08.2003 (Annex 5).
- M.E.C., C.N.C. *The school syllabus for the Third grade, Natural Sciences* No. 5198/ 01.11.2004.
- M.E.C., C.N.C. *The school syllabus for the Fourth grade, Natural Sciences,* Approved by Order of the Minister, No. 3919/20.04.2005.

Starting with 2013-2014 school year the first of the curriculum documents listed above is valid for Preparatory and First grade and in the following school year, new school syllabus will be issued for the Second grade. Environmental Education school subject is in liquidation being replaced by the Mathematics and Environmental Exploration school subject, for First grade since 2013-2014 school year and for the Second grade since 2014-2015 school year.

3.1. The study of Natural Sciences in Preparatory grade (6-7 years) and First grade

General competences stipulated in the syllabus for Mathematics and Environment Exploration are: 1. Using numbers in elementary calculations; 2. Emphasizing geometrical characteristics of objects found in the environment; 3. Identifying phenomena/relationships/ regularities/ structures in the environment; 4. Generating simple explanations by using elements of logic; 5. Solving problems starting from sorting and representation of data; 6. Using conventional labels for measurement and estimations (M.N.E. 2013).

In the syllabus of the Preparatory and First grade these general competences are detailed by means of specific competences. For our study we selected from the syllabi only the competences corresponding to the Natural Sciences domain. The comparison with the abilities specified in the hierarchy of the cognitive dimension used in the TIMSS 2011 study put in evidence the following findings:

- six specific competences for the Preparatory grade and seven specific competences for the First grade in the school syllabus for Mathematics and Environment Exploration can be placed on six TIMSS 2011 sub-levels:

Table 1a. The distribution of the Natural Sciences specific competences mentioned in the syllabus for the Preparatory and First grade on the levels of the TIMSS cognitive dimension

Taxonomy level	Sub-level	Competences in the school syllabus for Mathematics and Environment Exploration–Preparatory grade	Competences in the school syllabus for Mathematics and Environment Exploration–First grade
Knowing	K1. Recall/ Recognize	6.3. Recognize the days of the week and seasons.	
	K3. Describe	3.1. Describe phenomena/processes, simple repetitive structures in the environment with the purpose of identifying regularities.	4.1. Describe the results of observations, using some scientific terms, representations through drawings and logical operators "and", "or", "not".
	K5. Demonstrate knowledge of scientific instruments	6.2. Using measuring units for determining/estimating duration of familiar events.	6.2. The use of metrics to determine and compare duration of daily activities. 6.4. Identification of common measures for length, capacity (centimeter, liter) and suitable tools.
Applying	A1. Compare/ Contrast/ Classify	5.1. Sorting/classifying objects/materials etc. on the basis of a given criterion.	5.1. Sorting and classification of the data from the immediate environment on the base of two criteria.
	A5. Find Solutions	6.1. Using unconventional measurement units for determining and comparing lengths.	3.1. Solving problems by observing some regularities of the immediate environment. 6.1. Using unconventional measures to determine and compare the capacity and length.
Reasoning	R1. Analyze	4.2. Identifying relationships such as „if..., then..." between successive events.	4.2. Identify consequences of actions, events, and simple processes.

- the next three specific competences stipulated in the Romanian school syllabus: *3.2.Manifesting care for correct behavior in relation to familiar environment (Preparatory grade), 3.2.Manifesting care for correct behavior in relation to natural environment (First grade)* and *4.1. Formulating observations regarding the immediate environment by using common language, drawings and logical operators „and" and „no"(Preparatory grade)* are not listed within the TIMSS abilities. The first two competences illustrate the preoccupation of Romanian curriculum makers to enable the development of values and attitudes in Romanian students. In our opinion the Third specific competence is wrongly formulated. Common language is used by the child to communicate, but the role of the school is that of educating the child to use a scientific language as correctly as possible.

To some extent, the school syllabus for the Preparatory and First Grade requires students' involvement in exploration activities. As an argument in favor of that, we shall list below some activities in this category as suggested by the syllabus authors (with reference to the corresponding specific competence):

- „identifying daily activities in which electricity is used". This activity presupposes exploration, but there is a lack of correspondence between this activity and the specific competence to which it corresponds in the syllabus (□3.1.Describing phenomena/processes/simple repetitive structures belonging to the environment, with the purpose of identifying regularities").

- „identifying elements/prototypes belonging to various categories (plants, animal, geometrical shapes, sets etc)". The specific competence to the development of which this activity contributes is 5.1 „Sorting/classifying objects, materials etc on the basis of a given criterion".
- „the chronological ordering of seasons/days of the week" and " setting up a weekly schedule with the help of drawings and symbols". The specific competence to which these activities are assigned is 6.2 „Using measuring units in determining/estimating duration of familiar events".

The mentioned syllabi specify topics and contexts in which the students' competences will be develope:

Table 1b. The relationship between the Content dimension in TIMSS study and the contents listed in the school syllabus for Mathematical and Environment Exploration (Preparatory and First grade)

Content domain in the TIMSS curriculum	Contents listed in the school syllabus for Preparatory grade	Contents listed in the school syllabus for First grade
	Measurements: ***Length***. Non-standard Units ***Time:*** The day, week, month: name, order. ***Seasons*****:** name, order.	**Measurements:** ***Length*** Standard units centimeter. (1m = 100 cm) Measuring instruments: ruler ***Capacity*** Nonstandard units. Standard units: liter. ***Time*** Hour (Hour, the half hour) Day, week, month, year, duration. Seasons: duration.
	Data. *Collecting and classifying data*	**Data:** *Collecting, reading and recording of data*
Life science: Characteristics and life processes of living things: - Life cycles, reproduction, and heredity. - Interaction with the environment. **Ecosystems** **Human health.**	**Life sciences:** ***The human body*** Comprising elements and their roles. The senses. Body hygiene. Food as a source of energy: the importance of food in growth and development; food hygiene. ***Plants and animals*** Comprising elements and their roles. Food as a source of energy: the importance of food in growth and development. Living conditions (water, air, light, heat).	**Life sciences:** ***The human body*** Skeleton and major organs of the body (brain, heart, lungs, stomach, kidneys), location and roles. ***Plants and animals*** The role of the base structure of plants. Animal skeleton and major organs (brain, heart, lungs, stomach, kidneys), location and roles.
Earth Science: -*Earth's structure, physical characteristics, and resources. - Earth's processes, cycles, and history. - Earth in the solar system.	**Earth Science:** ***The Earth*** The presence of water in nature in various forms (rainfall, rivers, lakes, sea etc) Natural phenomena: rain, snow, wind, lightning, thunder ***The Universe*** The Earth, the Sun	**Earth Science:** ***The Earth*** Transformations of water: freezing, melting, evaporation, boiling, condensation. ***The Universe*** Sun, heat and light source.
Physical science: - Classification and properties of matter. - Sources and effects of energy. - Forces and motion.	**Physical Science:** ***Forces and motion*** Observable effects of forces: pushing, pulling. Body motion and changing shape: distortion, breaking. ***Energy forms and transfer of***	**Physical Science:** ***Forces and motion*** Free fall of bodies. ***Energy forms and transfer of energy*** Forms of energy (light, heat, electricity),

	energy Electricity: devices using electricity and safety rules in handling electrical devices. Waves and vibration: the production of sound.	sources of energy (sun, water, wind, coal, oil) and the use of energy in practice Waves and vibration: production and propagation of sound.

As can be seen from the table 1b, there is optimal correspondence between the contents subjected to TIMSS testing and the contents of the school syllabus for Preparatory and First grade.

Concerning methodological suggestions section of the Preparatory and First grade syllabi, the authors point out: ”additionally, the focus will place on the spontaneity and creativity of answers rather than on the scientific accuracy of responses”. We wish to argue against this view, one of the reasons being that this suggestion will apply to the 2013-2014 school year for the First grade and starting to 2014-2015 school year for the Second grade. We believe that this specification leaves place for interpretation and the correct formulation of this methodological suggestion would be „the focus will be placed on the spontaneity and creativity of answers and the scientific accuracy of responses will be encouraged”.

To conclude, in the school syllabus of the Preparatory and First grade, the competences formulated in the domain of Natural sciences can be placed on one third of the 19 sub-levels of competence the possession of which was investigated in the 2011 TIMSS inquiry for Fourth grade students. As far as the contents proposed for study in Preparatory grade are concerned, they are to be found (at elementary level) between the contents that are considered relevant for Fourth grade students by the IEA.

3.2. Analysis of the former school syllabus for the subject Environmental Education (First grade)

The school syllabi for the subject Environmental Education were issued in 2003 and they are centered on objectives (framework objectives and reference objectives). In relation with the poor results obtained by Romanian students in TIMSS tests we also analyzed the former science syllabus of the First grade (2012-2013), more precisely:

a) the abilities asked to first grade students;

Table 1c. The distribution of the abilities listed in the former school syllabus for Environmental Education (First grade) on the levels of the TIMSS cognitive domain

Cognitive level	*Sub-level*	First grade syllabus*
Knowing	*K1. Recall/ Recognize*	1.2. to identify the characteristics of bodies in the physical environment; 1.4. to observe and name phenomena in the environment; 1.5. to indicate some phenomena in the environment; 3.3. to specify body hygiene rules and food hygiene rules on the basis of information input;
	K2. Define	2.1. to use language that is specific to natural sciences in describing living creatures, phenomena of the environment; 2.3. to use symbols and information referring to phenomena observed in the environment;
	K3. Describe	1.1. to describe characteristics of the social and cultural environment; 1.3.to enumerate characteristics that are specific to animals in the close environment;
Applying	*A1. Compare/ Contrast/Classify*	
	A5.Find Solutions	
Reasoning	*R2. Integrate/ Synthesize*	3.1. to identify ways in which they can contribute to maintaining a healthy lifestyle for plants and animals
		3.2. to participate in activities for caretaking and protection of living

	creatures;
Scientific inquiry process	2.2. to formulate questions regarding observed phenomena.

*C.N.C. *School syllabi for Environmental Education, first and second grade,* Bucharest, 2003.

b) the topics specified in the school syllabus:

Table 1d. The relationship between the contents investigated by the 2011 TIMSS test and the contents listed in the former school syllabus for Environmental Education (First grade)

Content domain in the TIMSS curriculum	Contents listed in the former school syllabus for Environmental Education for first grade
	Elements of the social and cultural environment
Life science: Characteristics and life processes of living things: - Life cycles, reproduction, and heredity. - Interaction with the environment. **Ecosystems** **Human health.**	***Plants and animals***: - Observation of plants/animals in the immediate environment of the child and /or in the classroom. - Recognize and name the parts of a plant (root, stem, leaves, flowers, fruits)/the body of an animal (head, trunk, limbs). ***Health education:*** - Body hygiene. - Food hygiene. - Daily schedule of students.
Physical science: - Classification and properties of matter. - Sources and effects of energy. - Forces and motion	***Natural phenomena*** -Natural phenomena: rain, snow, wind, lightning, thunder - recognizing them in nature or by means of teaching materials. - Seasons: names of seasons, months' seasons, features (natural phenomena, changes in the living world of people and activities specific to each season).
Earth Science: - *Earth's structure, physical characteristics, and resources. - Earth's processes, cycles, and history - Earth in the solar system	
	Environment and its protection - Actions doing by children that harm plants and animals. - The contribution of children to protect the environment.

*C.N.C. School syllabus for Environmental education (first and second grade), Bucharest, 2003.

As we can see in the Table 1.c and 1.d, the former school syllabus for the First grade totally neglected Applying level and the domain of Earth Science. Reasoning level and Life science and Physical science domains were also less represented.

3.3. Analysis of school syllabus for the subject *Environmental Education* (Second grade)

The analysis of school syllabus for the subject Environmental Education (Second grade), from the perspective of the 2011 TIMSS hierarchy of the cognitive dimension, allows for the following observations:

a) framework objectives aim at the following performances:

- The development of abilities such as observation, exploration and understanding of realities in the environment;
- Knowledge, understanding and usage of specific terms in communication, to describe phenomena observed in the environment;
- Forming a positive attitude towards the environment by stimulating interest for maintaining a balanced environment and by practicing habits of caring for and protecting the environment.

b) reference objectives are specified in Table 3 as being placed on the taxonomy level of the cognitive domain used in the TIMSS inquiry:

Table 2a. The relationship between the abilities investigated by TIMSS 2011 and the abilities listed in the school syllabus for Environmental Education (Second grade)

Cognitive level	*Sub-level*	Second grade syllabus**
Knowing	*K1. Recall/ Recognize*	1.3. to observe and name the effects of natural phenomena on living creatures;
	K2. Define	2.1. to use language that is specific to natural sciences in describing living creatures, phenomena of the environment; 2.3. to use symbols and information referring to phenomena observed in the environment;
	K3. Describe	1.1. to describe characteristics of the natural environment;
Applying	*A1. Compare/ Contrast/Classify*	1.2. to identify similarities and dissimilarities between creatures living in the close environment; * to identify similarities and dissimilarities between creatures living in various geographical areas;
	A5. Find Solutions	3.3. to enumerate and describe some of their own actions in maintaining hygiene of the house and classroom;
Reasoning	*R2. Integrate/ Synthesize*	3.1. to identify ways in which they can contribute to maintaining a healthy environment;
		3.2. to participate in activities for caretaking and protection of the environment;
	Scientific inquiry process	2.2. to formulate questions regarding observed phenomena.

*C.N.C. *School syllabus for Environmental Education, First and Second grade,* Bucharest, 2003.

The analysis of school syllabus of the Second grade has revealed the fact that students are less encouraged to exemplify the acquired knowledge regarding the environment (concepts, phenomena and processes). The school syllabus for the Second grade does not reveal preoccupation for developing students' competences in classifying phenomena, processes etc. Additionally, students in the Second grade are not asked to use models, even though modeling is a basic method in scientific discovery and reasoning by analogy is familiar to young students. Regarding the cognitive level of application in the above mentioned syllabus, there is no reference to the formation and development of abilities such as: relating facts, events, processes; interpreting information, explaining facts, finding solutions. The taxonomy level of reasoning is also poorly represented in the syllabus. As revealed by the syllabus analysis (using the 2011 TIMSS cognitive domains hierarchy as an instrument), Romanian students are not encouraged to analyze facts, phenomena and processes, to formulate hypotheses, to design, to elaborate conclusions, to argue these conclusions or to evaluate them.

The objective *3.2. Participation in actions for care taking and protecting living things* is difficult to integrate in the TIMSS hierarchy. The purpose of introducing this objective in the school syllabus aims at encouraging the involvement behavior of students in the protection of the environment.

As far as the contents studied during Second grade is concerned, their relationship to the TIMSS content domains demonstrates poor correspondence between the two.

Table 2b. The relationship between the contents investigated by the 2011 TIMSS test and the contents listed in the school syllabus for Environmental Education (Second grade)

Content domain in the TIMSS Curriculum	Contents listed in the school syllabus for Environmental Education for Second grade
	Elements of the natural environment Landforms: mountains, plains.
Life science: Characteristics and life processes of living things: - Life cycles, reproduction, and heredity. - Interaction with the environment.	***Plants and animals*** Similarities and differences between plants and animals. - *Similarities and differences between some plants and animals in other geographical areas. - Influence of environmental factors on plants and animals. - The effects of natural phenomena on living things. - Changes in plant and animal life caused by the seasons.

Ecosystems **Human health.**	- Human activities specific to each season, on rural or urban environment. ***Health education*** - Hygiene of the house. - Hygiene of the classrooms.
***Physical science*:** - Classification and properties of matter. - Sources and effects of energy. - Forces and motion.	
Earth Science: - *Earth's structure, physical characteristics, and resources. - Earth's processes, cycles, and history. - Earth in the solar system.	
	The environment and its protection. - Actions of children that harms the natural environment. - Protecting the environment by children.

*C.N.C. School syllabus for Environmental education (First and Second grade), Bucharest, 2003.

The contents studied by Romanian students are not the most representative nor are they correlated with one another. Also, their formulation is less suggestive.

The school syllabi for the Second grade totally neglect the domain of Earth Science and briefly touch upon *Physical Science* and *Life Science*.

The syllabi contain a number of inappropriate formulations of objectives, such as: "participates in actions for caretaking of living creatures and the environment". This formulation does not specify the conditions of the actual performance: the student will participate in these actions under the guidance of the teacher or he/she will project and carry out the actions independently. The specification of the content is also carried out by means of brief and indistinct formulations, as seen in the examples above.

3.4. Analysis of school syllabi for the subject Natural Sciences (Third and Fourth grade)

The school syllabi for the subject Natural Sciences (Third and Fourth grade) were issued in 2004 and 2005, respectively. Both syllabi employ the concept of objectives. The framework objectives specified in the syllabus are the following:

1. Understanding and using terms and concepts specific to natural sciences in communication.

2. Forming and developing skills and abilities for experimenting and exploring/ investigating reality by using specific devices and procedures.

3. Developing interest and responsibility in maintaining a clean, balanced natural environment that cradles life.

The reference objectives derived from the framework objectives are listed in Table 3.a.:

Table 3a. The distribution of the reference objectives stipulated in the school syllabi for Natural Sciences (Third and Fourth grade) on the levels of the TIMSS cognitive domain

Cognitive level	Sub-level	Third grade*	Fourth grade**
Knowing	*K3. Describe*	1.3. to communicate various observations and comparisons regarding studied bodies and experiments carried out in various forms;	1.2.to describe the relationships between systems present in the environment; 1.3 to communicate observations regarding the relations between components of a system and/or

			between various studied system in various forms;
	K5. Demonstrate knowledge of scientific instruments	1.4 *to describe simple scientific procedures used in experiments; 2.2 to make measurements using conventional and unconventional instruments, to compare results with students' own estimations;	
Applying	*A1. Compare/ Contrast/ Classify*	1.1 to indicate similarities and dissimilarities between objects on the basis of students' own observations; 1.2 to put objects, bodies, phenomena and events in order on the basis of given criteria;	
	A2. Use Models	2.1 to record graphically observations of phenomena and processes in the environment;	2.5 *to represent familiar aspects of the environment through modeling;
	A4. Interpret Information		3.1.to interpret the succession of phenomena and processes occurring in nature; 2.2. to emphasize regular aspects of phenomena on the basis of measurements and to present the results adequately;
Reasoning	*R1. Analyze*		1.1.to identify relationships between component parts of a studied system;
	R2. Integrate/ Synthesize	2.6 *to make toys/objects by mimicking objects in the environment;	
	R3. Hypothesize/ Predict		1.4 *to formulate hypotheses with the help of scientific procedures;
	R4.Design	2.3 to carry out simple experiments on the basis of a work plan;	2.3 to carry out simple experiments on the basis of given hypotheses;
	R8. Justify		3.2 *to appreciate the importance of protecting students' own body from potentially harmful factors of the environment;
	Scientific inquiry process	2.4 to apply observation as a tool of scientific knowledge;	2.4 to apply scientific procedures in students' own activity;
	Values and attitudes	2.5 *to abide by communication and behavior rules as negotiated in the development of group activities; 3.1. to be aware of the effects of human activity on the environment.	3.1 to be aware of the effects the environment on students 'own body.

*M.E.C., C.N.C. School syllabus for the Third grade. Natural Sciences. Bucharest, 2004.
** M.E.C., C.N.C. School syllabus for the Fourth grade. Natural Sciences. Bucharest, 2005

In the school syllabi for the Third and Fourth Grade, concerning the level of *Knowing* there is no coverage of the sub-levels *Recall/Recognize, Define* and *Illustrate by example*, the latter being extremely important not only in learning sciences but also in the study of any discipline.

In the cognitive domain of *Application*, the authors of the school syllabi for Sciences did not consider important to emphasize abilities such as *Relate, Interpret information, Find solution* and *Explain*. Additionally, abilities such as *Analyze, Formulate hypotheses and conclusions*, *Make generalizations, Evaluate* and *Ague in favor of* are missing completely from Romanian syllabi.

There is also poor correlation between the content propose to be study in the Romanian syllabi and those subjected to testing in the 2011 TIMSS study.

The contents studied in the Third and Fourth grade are organized under the form of topics and sub-topics. The topics studied in the Third and Fourth grade are:

- Characteristics and properties of bodies;
- Transformations of bodies and materials;
- Human beings and the environment.

A part of the contents subjected to the 2011 TIMSS evaluation have has a correspondent in the Third and Fourth grade school syllabi. The common topics are specified in the Table 3b.

Table 3b. Common topics in 2011 TIMSS curriculum and school syllabi for Sciences (Third and Fourth grade)

TIMSS 2011:	School syllabus for the Third grade	School syllabus for the Fourth grade
Life Science: ***Characteristics and Life Processes of Living Things.*** 3. Relate major structures in animals to their functions (e.g., stomach – digests food, teeth – break down food, bones - support the body, lungs - take in air); 4. Relate major structures in plants to their functions (e.g., roots - absorb water, leaves - make food).	**Characteristics and properties of bodies**. The role of basic structures in living organisms: a) the role of observable component parts in plants: root, stem, leaf, flower, fruit, seed; b) the role of observable component parts and internal organs in animals and humans: head, trunk, limbs, sensory organs, stomach, lungs, heart, kidneys, skeleton.	
Life Science: ***Life Cycles, Reproduction, and Heredity*****.** **1.** Trace the general steps in the life cycle of plants (germination, growth and development, reproduction, seed dispersal) and animals (birth, growth and development, reproduction, death); recognize and compare life cycles of familiar plants (e.g., trees, beans) and animals (e.g., humans, houseflies, frogs).		**Transformations of bodies and materials:** Life cycles: birth, growth and development, reproduction, death. Life cycles of organisms (plants, butterflies, frogs, humans).
Physical Science: ***Energy — Sources and Effects*** Recognize that hot objects can heat up cold objects; explain that heating up means an increase in temperature; identify examples of common materials that easily conduct heat. Physical Science: Forces and Motion 1. Identify familiar forces that cause objects to move (e.g., gravity on falling objects, push/pull forces); compare effects of greater or lesser forces on an object; describe how the relative weight of objects can be determined using a balance.		**Transformations of bodies and materials:** •* Heating and cooling down; absorbed heat and released heat. • Forces determining movement of bodies (gravity, pushing and pulling forces). Movement and rest.

*M.E.C., C.N.C. School syllabus for the Third grade. Natural Sciences, Bucharest, 2004.

** M.E.C., C.N.C. School syllabus for the Fourth grade. Natural Sciences, Bucharest, 2005.

3. General findings

Finally, we are raising the question of how many of the competences subjected to evaluation by the TIMSS inquiries are being formed and developed in Romanian students during their five years of primary education.
In order to provide an answer to this question we shall resort to two graphical representations (only for illustration reasons). Is is important to specify that the next histograms refferes only to the mentioned school syllabi in use.

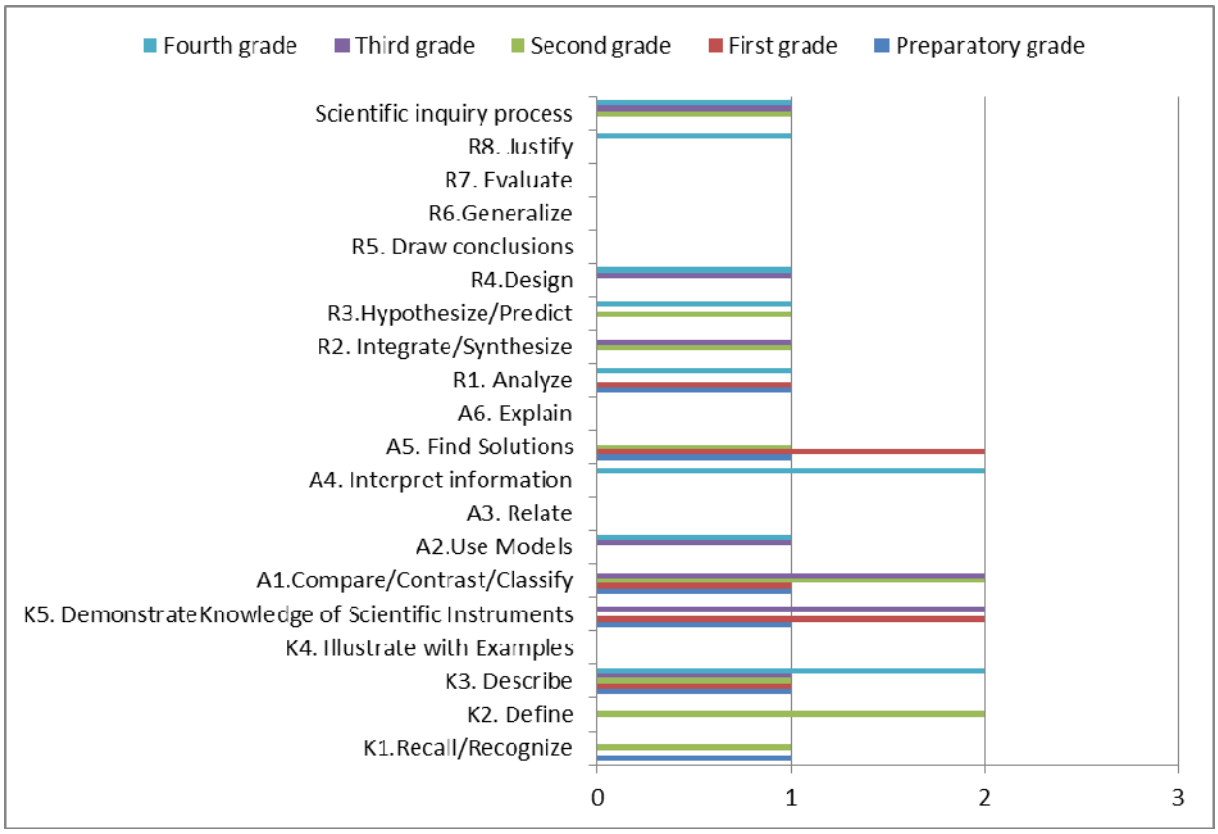

Figure 2. The distribution of students' abilities developed in the Romanian Primary science education system on the levels of the cognitive domain of TIMSS 2011

As can be seen in Figure 2, almost one third of the 19 TIMSS sub-levels lack coverage in abilities in the Sciences school syllabi. Other five sub-levels display poor coverage with one or two abilities

Table 4. The distribution of students' abilities developed in the Romanian primary Science education system on the levels of the TIMSS cognitive domain

Sub-nivel taxonomic	Preparatory grade	First Grade	Second grade	Third grade	Fourth grade	Total
Knowing	3	3	4	3	2	15
Applying	2	3	3	3	3	14
Reasoning	1	1	2	2	4	10
Scientific inquiry process	0	0	1	1	1	3

Table 4 clearly demonstrates the predominance in the science school curricula of Primary level of the abilities placed on the levels of Knowing and Applying (TIMSS curricula) and the less importance given to learning science by inquiry in the new syllabi for Preparatory, First and Second grade.

Finally, we have to mention the fact that the identification of the sub-levels domain in the TIMSS taxonomy to which an ability/skill in the Romanian school syllabi could be assigned has proved difficult at times because of the vague formulations employed by the authors of the Romanian school

syllabi. In order to make a successful match, we have resorted to the list of activities specified in the school syllabi for each type of formulated objective/competence.

4. Conclusion and suggestions

The poor results obtained by Romanian students in international Science tests and the analyses carried out in the current study identify the Sciences curricula for primary education as a possible cause for these results.

Romanian science school syllabi (and particularly Second grade syllabus) are still dominated by a static vision in what students have to do in learning Science (i.e. by objectives that require declarative knowledge).

In opposition, the 2011 TIMSS curriculum proposes a dynamic vision regarding students learning and involvement abilities in constructing their own knowledge (the cognitive processes developed in students). This curriculum emphasizes scientific inquiry, in direct relation with the proposals of many specialists in the field (Alberta Learning, 2004; Bybee, 2002; Cleverly, 2003; Flick & Lederman, 2006; Jorgenson et al., 2004; Justice et al., 2007; NRC, 1996; Prince & Felder, 2006; Spronken-Smith et al., 2007; Spronken-Smith, 2007; Sutman, Schmuckler & Woodfield, 2008; Westwood, 2008, p.28).

Consequently, we are taking into consideration the list of abilities involved in performing scientific inquiry (Bybee, 2006):

> „Identify questions that can be answered through scientific investigation.
> Design and conduct a scientific investigation.
> Use appropriate tools and techniques to gather, analyze, and interpret data.
> Develop descriptions, explanations, predictions and models using evidence.
> Think critically and logically to make the relationships between evidence and explanation.
> Recognize and analyze alternative explanations and predictions.
> Communicate scientific procedure and explanations.
> Use mathematics in all aspects of scientific inquiry" (Bybee, 2006, p.4).

These abilities are listed in the TIMSS curriculum as abilities of the cognitive dimension and they are used in defining the process of scientific inquiry. The list proposed by Bybee can be considered a description of the competence profile a student should possess in Sciences. These competences must be built and consolidated in time. The modeling of these behaviors with the help of the teacher should start very early.

The Curricula and the practices in other countries demonstrate that even young children are capable of carry out particular scientific processes such as scientific inquiry (Department of education, England, 2013; Ministry of Education, Singapore, 2013). Ignoring or simply not employing these abilities under the excuse that the primary students are "too young" results in a delay in the acquisition of scientific processes in higher grade and naturally leads to poor test results in international tests (PISA, TIMSS). Consequently, we are facing dire need to revise Sciences school syllabi not only for Primary education, and to adapt them to international practices and standards.

References

[1] Alberta Education. (2004). *Focus on inquiry: A teacher's guide to implementing inquiry-based learning.* Edmonton, AB: Alberta Education. [Available online at: http://www.learning.gov.ab.ca/k_12/curriculum/bySubject/focusoninquiry.pdf], Retrieved December, 11, 2013.

[2] Bybee, R.W. (2002). *Learning Science and the science of learning*. USA: National ScienceTeachers Association.

[3] Bybee, R.W. (2006). Scientific inquiry and science teaching. In: L.B. Flick, & N.G. Lederman (eds.). *Scientific Inquiry and Nature of Science. Implications for Teaching, Learning, and Teacher Education*. Netherlands: Springer, 1-12.

[4] Cleverly, D. (2003). *Implementing inquiry-based learning in nursing*. London, NY: Routlege, Taylor & Francis e-Library.

[5] Department of Education, (September 2013). *The national curriculum in England Key stages 1 and 2 framework document*. [Available online at: https://www.gov.uk/government/publications/national-curriculum-in-england-primary-curriculum], Retrieved December, 11, 2013.

[6] Flick, B. (2006). Developing understanding of scientific inquiry in Secondary students. In: L.B. Flick, & N.G. Lederman (eds.) *Scientific Inquiry and Nature of Science. Implications for Teaching, Learning, and Teacher Education*. Netherlands: Springer, 157-172.

[7] Flick, & N.G. Lederman (eds.) *Scientific Inquiry and Nature of Science. Implications for Teaching, Learning, and Teacher Education*. Netherlands: Springer.

[8] Jarman, R., McClune, B. (2007). *Developing Scientific Literacy Using News Media in the Classroom*. New York: Open University Press. McGraw-Hill Education

[9] Johnston, J. (2004). The value of exploration and discovery. *Primary Science Review*, Nov/Dec 2004, 21.

[10] Justice, C., Rice, J., Warry, W., Inglis, S., Miller, S., Sammon, S., (2007). Inquiry in Higher Education: Reflections and Directions on Course Design and Teaching Methods. *Innovative Higher Education* (2007) 31, 201–214.

[11] Lidsey, S. (2011). *Scientific Literacy. A Symbol to Change.* In: Clift, R., Kane, R., Lunenberg, M., Clarke, A., Freeman, F., Mok, Mo Ching, van Manen, M. Scientific Literacy Under the Microscope. A Whole School Approach to Science Teaching and Learning. (John Loughran, Kathy Smith & Amanda Berry, eds.) Monash University, Australia

[12] Martin, M.,O., Mullis, I.V.S., Foy, P., Olson, J. F, Erbru, E., Preuschoff, C., Galia, J. (2008). Timss 2007. *International Science Report*: *Findings from IEA's in International Mathematics and Science Study at the Fourth and Eight Grade*. International Association for the Evaluation of Educational Achievement (IEA).

[13] Martin, M.,O., Mullis, I.V.S., Foy, P., Stanco, G.M. (2012). *Timss 2011 International Results in Science*. TIMSS & PIRLS International Study Center. Lynch School of Education, Boston College.

[14] McNeely, M.E., (ed.). (1997). *Guidebook To Examine School Curricula. TIMSS as a Starting Point to Examine Curricula*. Institution Office of Educational Research and Improvement (ED),

[15] Washington, DC. [Available online at: http://files.eric.ed.gov/fulltext/ED410128.pdf], Retrieved October 14, 2013.

[16] M.E.N. Prog*rama scolara pentru disciplina Matematica si explorarea mediului. Clasa pregătitoare, clasa I şi clasa a II-a*. Aprobată prin ordin al ministrului Nr. 3418/19.03.2013. Bucureşti 2013. [Available online at: http://www.edu.ro/index.php/articles/c539/], Retrieved December 7, 2013.

[17] M.E.C. C.N.C. *Programa scolara de Cunoasterea mediului clasele I – a II-a*. Programa a fost aprobata prin Ordin al Ministrului Educatiei nr. 4686 / 05.08.2003 (Anexa 5). Bucuresti, 2003. [Available online at: http://www.edu.ro/index.php/articles/curriculum/c539+588+547+/], Retrieved December, 21, 2013.

[18] M.E.C., C.N.C.*Programe şcolare pentru clasa a III-a. Ştiinţe ale naturii*. Aprobată prin ordin al ministrului Nr. 5198 / 01.11.2004, Bucuresti. [Available online at: http://www.edu.ro/index.php/articles/curriculum/c539+588++549/], Retrieved December 20, 2013.

[19] M.E.C., C.N.C. *Programa şcolare pentru clasa a IV-a. Ştiinţe ale naturii*. Aprobată prin ordin al ministrului Nr. 3919/ 20.04.2005.[Available online at: http://www.edu.ro/index.php/articles/curriculum/c539+588++549/], Retrieved October 25, 2013.

[20] Minstry of Education, Singapore. Curriculum Planning & Development Division (2013). Science Syllabus Primary. 2014. [Available online at: http://www.moe.gov.sg/education/syllabuses/sciences/files/science-primary-2014.pdf], Retrieved December, 12, 2013.

[21] Mullis, I. V.S., Martin, M. O., Olson, J. F, Berger, D. R, Milne, D., Stanco, M. G., 2008. *TIMSS 2007 Encyclopedia: A Guide to Mathematics and Science Education Around the World (*Volumes 1 and 2), Edited by, Publisher: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.

[22] OECD (2007).*PISA 2006. Science Competencies for Tomorrow's World, Vol. 1. A profile of student performance in reading and mathematics from PISA 2000 to PISA 2006*. OCDE Publishing, France: Paris.

[23] OECD (2010), *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science*(Volume I). [Available online at: http://dx.doi..org/10.1787/9789264091450-en], Retrieved December 8, 2013.

[24] Prince, M.J., Felder, R.M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases.*Journal of Engineering Education*.[Available online at: www.ncsu.edu], Retrieved August 14, 2012.

[25] Spronken-Smith, R., Angelo, T., Matthews, H., O'Steen, B., Robertson, J. (2007). How effective is Inquiry-Based Learning in Linking Teaching and Research? *International Colloquium on International Policies and Practices for Academic Enquir*y, Marwell, Winchester, UK, April 19-21.

[26] Spronken-Smith, R., 2007. Issues in Teaching through Inquiry. *Joint Centre for Active Learning and Centre for Learning and TeachingSeminar*, [Available online at: www2.glos.ac.uk/offload/ceal/celt**Inquiry**.ppt], Retrieved September 12, 2012.

[27] Sutman, X.F., Schmuckler, J.S. & Woodfield, J.D. (2008). *The science quest: using inquiry/ discovery to enhance student learning, grade 7–12*. Published by Jossey-Bass, A Wiley Imprint, USA.

[28] Warner, A.J., Myers, B.E. (2011). *Implementing Inquiry-Based Teaching Methods*. University of Florida. This document is AEC395, one of a series of the Department of Agricultural Education and Communication, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date: September 2008. Reviewed April 2011. Visit the EDIS website [Available online at: http://edis.ifas.ufl.edu], Retrieved December 14, 2013.

[29] Westwood, P. (2008). *What teachers need to know about teaching methods*? Camberwell, Vic.: ACER Press

Authors

Ciascai Liliana, Babes-Bolyai University, Cluj-Napoca, Romania, e-mail: liliana.ciascai@ubbcluj.ro

Dulamă Maria-Eliza, Babes-Bolyai University, Cluj-Napoca, Romania, e-mail: dulama@pcnetcluj.ro