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# COMPARATIVE STUDY ON ROMANIAN SCHOOL SCIENCE CURRICULA AND THE CURRICULUM OF TIMSS 2007 TESTING

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**Abstract:** The results of Romanian school students in Science PISA and TIMSS testings have been and continue to be systematically slack. In the present paper we intend to do a comparative analysis of Science curriculum TIMSS 2007 and Romanian Science school curricula of 4th and 8th grades. This analysis, based on Bloom's taxonomy of cognitive domain, identifies both the common points of these curricula and the system of competencies necessary to be developed for Romanian students in order to increase their results in international testings.

**Zusammenfassung:** Die von rumänischen Schülern (Studenten) bei verschiedenen internationalen Tests (TIMSS, PISA) erzielten Ergebnisse sind derzeit schlecht und werden möglicherweise auch in Zukunft nicht befriedigend sein.Ziel dieses Artikels ist eine vergleichende Analyse des Schullehrplans zur Umwelterziehung mit den wissenschaflichen Anforderungen auf der Grundlage der Testergebnisse des TIMSS 2007, special für 4 und 8 grad. Diese Analyse zeigt als gemeinsames Ergebnis die Notwendigkeit der Wissensvermittlung in der Universität, um eine Verbesserung der in den internationalen Tests erzielten Ergebnisse zu erreichen.

**Key words:** TIMSS, environment, Science, school curricula

## 1. Introduction. What is TIMSS 2007?

TIMSS (Trends in International Mathematics and Sciences Study) and PIRLS (Progress in International Reading Literacy Study) are two directions of a complex international investigations managed by the International Association for evaluating school performance (IEA) in collaboration with a global network of organizations and representatives of participating countries.

These investigations aimed to compare the acquisitions in Mathematics, Science and Reading of students after four and eight years of training. In these testings are involved students from 40 countries, speaking about 30 different languages.

In order to inform education policy from the participating countries, this project usually collects extensive information regarding the quantity, quality and content of training in these countries. For example, TIMSS 2007, which represents the fourth international test of a comparative assessment cycle (1995, 1999 and 2001), has collected detailed information on application and implementation of curricula for Mathematics and Science. It collected information about the level of teachers preparation, the availability of teaching resources and the use of technology in teaching and learning activities, too.

In brief, the importance of international surveys of Mathematics and Science learning lies in answers provided to questions on the next directions:

a) the characteristics of learning Mathematics and Science:

- learning results:
  - How to relate the knowledge and competencies in Mathematics and Science of Romanian students with those of students from other countries?

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- What are the strengths and weaknesses in Mathematics and Science of Romanian students in comparison with those of students from other countries?

◦ curricula of Mathematics and Science:

- What are the structure and the content of Mathematics and Science school curricula in comparison with that of other participating countries?
- Which competencies in Mathematics and Science are developed to students in their first fourth and eight school years, in Romania and other countries?

◦ conducting the teaching – learning process:

- What kind of learning activities is preferred in Romania and other countries?
- What are the teaching methods usually used by Romanian teachers beside those put in practice by their colleagues from other countries?
- How much time allocates students to their homework for mathematics and Science in Romania and other countries? etc.

◦ attitudes of students, parents and policy makers belonging to the educational area:

- How much are appreciated Mathematics and Science as subject matters in Romania and other countries by students, parents and other stakeholders in education?

b) the causes of situations identified: outcomes, educational practices, etc.

"Identifying factors or combinations of factors that could influence Mathematics and Scicence learning is difficult to achieve due to the complexity of the learning process. A study conducted in a single country limits the number of factors that can be studied, the variability of each factor and the relationships between them. A cross-national comparison may reduce these limitations and difficulties and may lead to a better understanding of teaching/learning process and of factors that could contribute to a deep or superficial learning" (Noveanu, 2005).

c) requests for an education reform, which aims to prefigure at international level a kit of unique standards in Science and Mathematics curricula at primary and secondary education. These unitary standards, by their contribution to overcoming traditional practices and to orientation of teacher training, should facilitate the progress in Science teaching and learning.

## 2. Analysis of Science curriculum investigated by TIMSS 2007 testing

The TIMSS 2007 Science curriculum presents a hierarchy of the cognitive domain with three levels (Gonzales & all, 2008, pp 35). This hierarchy is the same for $4^{th}$ and $8^{th}$ grades:

- *Knowing.* This level addresses the facts, information, concepts, tools, and procedures that students need to know to function scientifically.
- *Applying.* Applying focuses on students' ability to apply knowledge and conceptual understanding to solve problems or answer questions.
- *Reasoning.* Reasoning goes beyond the cognitive processes involved in solving routine problems to include more complex tasks.

A comparative analysis of curriculum TIMSS 2007 and of Romanian Science curricula requires a specific instrument. This instrument could be the taxonomy of Bloom, a curriculum analysis tool very familiar to all practitioners in education:

**Table 1**. *Bloom's taxonomy*

| | |
|---|---|
| **Knowledge** | Recall previously learned material. |
| **Comprehension** | Grasp meaning, explain, restate ideas. |
| **Application** | Use learned material in new situations. |
| **Analysis** | Separate material into component parts and show relationships between parts. |
| **Synthesis** | Put together the separate ideas to form new whole, establish new relationships. |
| **Evaluation** | Judge the worth of material against stated criteria. |

The distribution of TIMSS 2007 competencies on the levels of Bloom's taxonomy can be sometimes a simple approach and sometimes a complicated one, depending on the number or type of action verbs used in formulating a competence. Identifying the Bloom level is easily achieved when in the competence description is used a single action verb (e.g. Identifying the characteristics or properties of specific organisms, materials, and processes", "Describing organisms, physical materials, and Science processes that demonstrate knowledge of properties, structure, function, and relationships", etc.) or when both verbs used concern cognitive processes that could be placed on the same level of complexity ("Recognizing and using scientific vocabulary, symbols, abbreviations, units, and scales in relevant contexts"). Identifying the taxonomic level is difficult when the description of the competence contains two action verbs related to different cognitive processes as level of complexity. This is the case of the competence "Making or identifying accurate statements about Science facts, relationships, processes, and concepts" which could be formulated at two different Bloom levels:

- Knowledge: "Identifying accurate statements about Science facts, relationships, processes, and concepts"
- Sinthesys: "Elaborating accurate statements about Science facts, relationships, processes, and concepts".

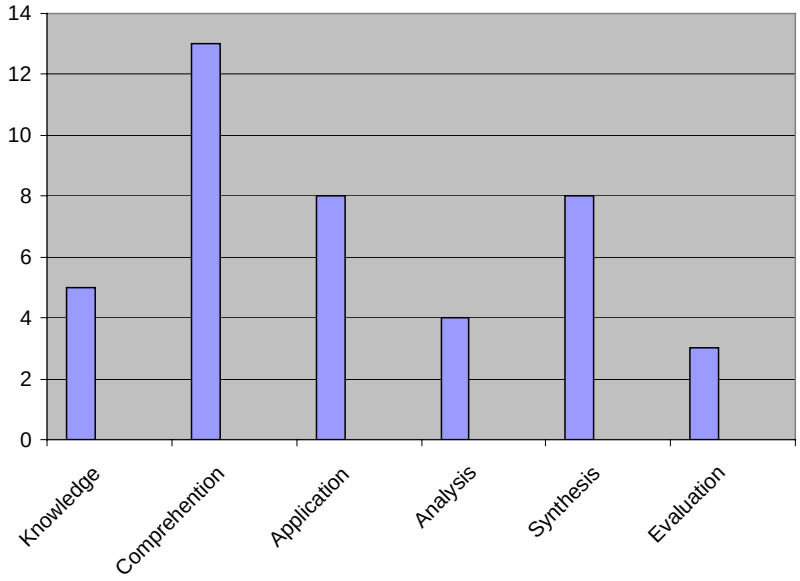
In the first case "identifying" means recognizing, a not very complicated process by comparison with "making" which suppose constructing and evaluating.

Applying the above-mentioned procedure we identified in the TIMSS curriculum a number of 41 competencies. These competencies are distributed on the Bloom's taxonomy of cognitive domain as presented in Figure 1.

Analysis of the competencies distribution on the Bloom's taxonomy put in evidence the concern of the authors of TIMSS 2007 curriculum for the levels of comprehention, application, analysis and synthesis. A possible explanation of this distribution can be found in the authors' interest for developing students' competencies necessary to master the scientific process:

- formulate a scientific problem or question;
- substantiate and clarify the problem by collecting data through observation and measurement;
- identify a relation (dependencies, correlations) between different variables;
- formulate a hypothesis that "explains" the observed relations;
- formulate inferences and predictions based on these assumptions;
- design an experiment to test the hypothesis or the prediction based on the hypothesis;
- achieve the experiment in controlled conditions (using an experimental and witness group);
- distribute experimental results in text, tables or figures;

- analyze results and formulate conclusions concerning the hypothesis: the hypothesis is supported by experimental results (hypothesis is true) or reject hypothesis (hypothesis is false or partly true);
- use symbolic and graphic languages for the presentation of information obtained;
- extend knowledge by applying the findings to new situations, by extrapolation, generalization, networking, etc.




**Picture 1.** *The distribution of TIMSS 2007 competencies on the Bloom cognitive domain level**s***

This interest is fully justified. In the last 25 years the international documents in the field of education has specified the necessity to familiarize students with the scientific process. For example, Desaulesm (in Giordan & Girault, 1994, pp 3) pointed out the fact that "research results show us that students have not learned the spirit of Science. Instead of increase, the interest in Science decrease... Not only our students do not have anything in their head but their head it's also bad modeled".

## 3. Analysis of Environmental Education curriculum and Science curriculum at primary level

In Primary School Romanian pupils study Environmental Education ($1^{th}$ and $2^{th}$ grades) and Science ($3^{th}$ and $4^{th}$ grades).

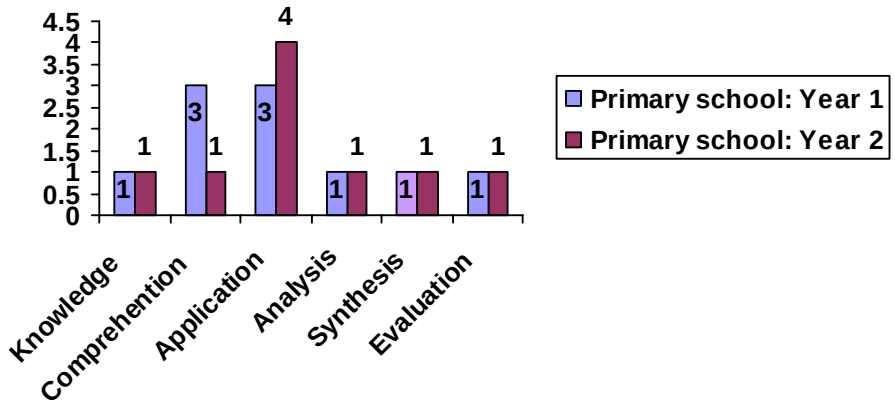
An analysis of Environmental Education school curricula for $1^{th}$ and $2^{th}$ grades allows the following findings (MEdC, 2003, p. 3-7):

a) the core-objectives are preferentially centered on observation, exploration, understanding and communication of knowledge:

- Developing the competencies of observation, exploration and understanding of the reality of the environment;
- Knowing, understanding and using of specific terms in communication for describe phenomena observed in the environment;

- Developing of positive attitudes towards the environment, by stimulating the interest in maintaining a balanced environment and exercise habits of care and protection thereof.

b) The reference objectives are distributed on the following levels of cognitive domain of Bloom's taxonomy:




**Picture 2**. *The distribution of competencies of Environmental education curriculum on the levels of Bloom's taxonomy*

Identifying the taxonomic level of competencies mentioned in the Environmental Education curricula was also difficult sometimes due to vague wording used by each curriculum authors. For example, we placed the objective "Identify ways that can contribute to maintaining a healthy environment" on the taxonomic level of evaluation taking in consideration the fact that any type of construct involves decisions on its appropriateness of the order stated: "a healthy environment." In some extent, the description of learning activities facilitated the decision on the taxonomic level of the objective analysed.

The above analysis demonstrates the interest of school curricula authors to develop for Romanian students a wide range of competencies, distributed at all levels of Bloom taxonomies. Also, it should be noted their concern to maintain school students' interest to ask questions about phenomena studied and the request adressed to students to evaluate and synthesize their knowledge.

Analysis of science curricula of 3$^{th}$ and 4$^{th}$ grades allow to find that the core - objectives of these curricula are very closed to those of the Environmental Education curricula (MEdC, 2004, pp. 4-8; MEdC, 2005, pp. 4-8):

- Understanding and use in communication of the specific science terms and concepts;
- Training and building competencies of experimentation and exploration/investigation of reality, using specific tools and processes;
- Develop interest and responsibility for maintaining a balanced environment, suitable for life.

The reference objectives of Sciences curricula, distributed on the levels of Bloom's taxonomy, are presented in Figure 3.

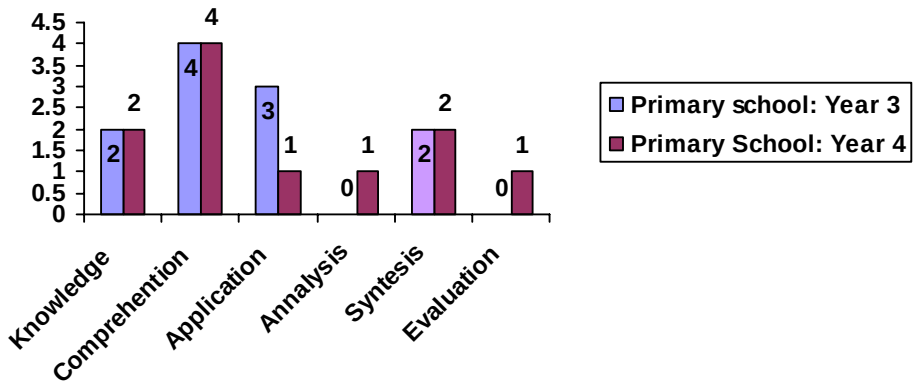



**Figure 3.** *The distribution of Science curriculum competencies on the levels of Bloom's taxonomy*

The histogram indicates an unbalanced distribution of competencies required of students, both in 3th grade and 4th grade. This distribution puts in evidence the little interest of the authors of these curricula for the last three levels of Bloom taxonomies because of their complexity.

## 4. Analysis of Science curricula in secondary cycle

In secondary cycle Romanian students study the next school subjects presented in the following table:

**Table 2.** *School science subjects studied in secondary school and the period of its study*

| School Subject | 5th grade | 6th grade | 7th grade | 8th grade |
|---|---|---|---|---|
| Biology | ////////////////////// | ////////////////////// | ////////////////////// | ////////////////////// |
| Physics | | ////////////////////// | ////////////////////// | ////////////////////// |
| Chemistry | | | ////////////////////// | ////////////////////// |

Most of the key competencies for secondary grades remain the same across all years of study. In a generalized version, they are:

- Knowledge and understanding of phenomena (physical and chemical), of specific terminology and concepts (Physics, Chemistry and Biology), of the specific methods of Physics and of specific principles of Biology;
- Develop the competence of analysis and problem solving (this competence is mentioned only for Physics);
- Develop the competence of exploration/investigation of reality (Physics, Chemistry and Biology) and experimentation (Physics), through the use of tools and procedures specific for Physics and through the solving of problems that are specific to the fields of Chemistry and Biology;
- Develop the competence of communication using language specific to Physics, Chemistry and Biology;
- Acquiring a critical attitude towards the effects of science on technological and social development and the development of interest towards protecting the environment (Physics);
- Acquiring of values and attitudes regarding the impact of Biology and Chemistry on nature and society.

The reference objectives that specify, by derivation from the core-objectives, the competencies required to be developed to 15 years aged students are shown in the figure below, distributed on the levels of Bloom's taxonomy:

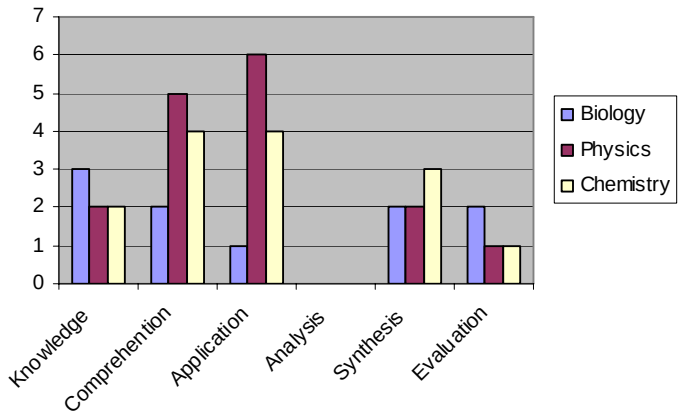



**Figure 4.** *Distribution on the levels of Bloom's taxonomy of the competencies required to 8th grade students at Biology, Physics and Chemistry*

This distribution supports the idea of the preferential interest of curricula authors for the competencies situated on the first three levels of Bloom taxonomies. The level of analysis is missing and this fact can't be explained because it is necessary to develop student capacities to analyse a system, for example, and to find out their components and the relationships between them, etc.

## 5. Comparative analysis of the TIMSS 2007 curriculum and science curricula of 4th and 8th grades

Romania hasn't participated in TIMSS 2007 testing of students of 4th grade. In the testing of 8th grade students Romania occupied the 28th place, being surpassed by 27 countries and surpassing other 20 countries.

The table below show the scores obtained by Romanian students by comparison with the first three places occupied by Singapore, Chinese Taipei and Japan and with the last position occupied by Ghana (Gonzales & all, 2008, pp 32, 37):

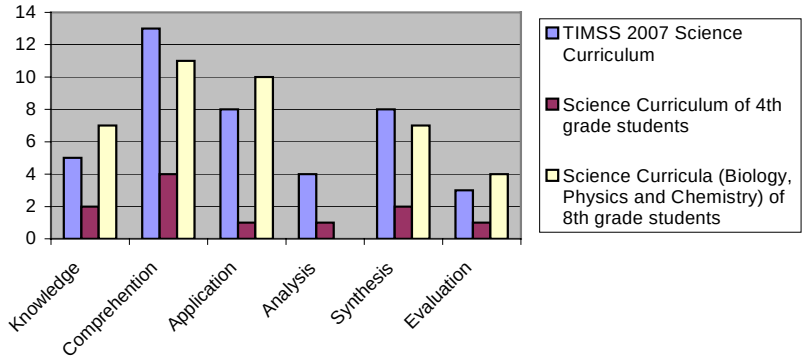
**Tabelul 3**. *The Romanian position in TIMSS 2007 testing (selection)*

| | | Cognitive domain | | | | | |
|---|---|---|---|---|---|---|---|
| Country | Average score | Biology | Chemistry | Physics | Knowing | Applying | Reasoning |
| TIMSS scale average | 500 | 500 | 500 | 500 | 500 | 500 | 500 |
| Singapore564 | 567 | 564 | 560 | 575 | 567 | 554 | 564 |
| Chinese Taipei 51 | 557 | 549 | 573 | 554 | 560 | 565 | 541 |
| Japan | 554 | 553 | 551 | 558 | 555 | 534 | 560 |
| ... | | | | | | | |
| Romania | 462 | 459 | 463 | 458 | 470 | 451 | 460 |
| ... | | | | | | | |
| Ghana | 303 | 304 | 342 | 276 | 291 | 316 | + |

There are not significant differences between the results of 8th school students at Biology, Physics and Chemistry. Despite the fact that Applycation level has a good representation in the science curricula of 8th grade, the worst results were obtained at this cognitive the level.

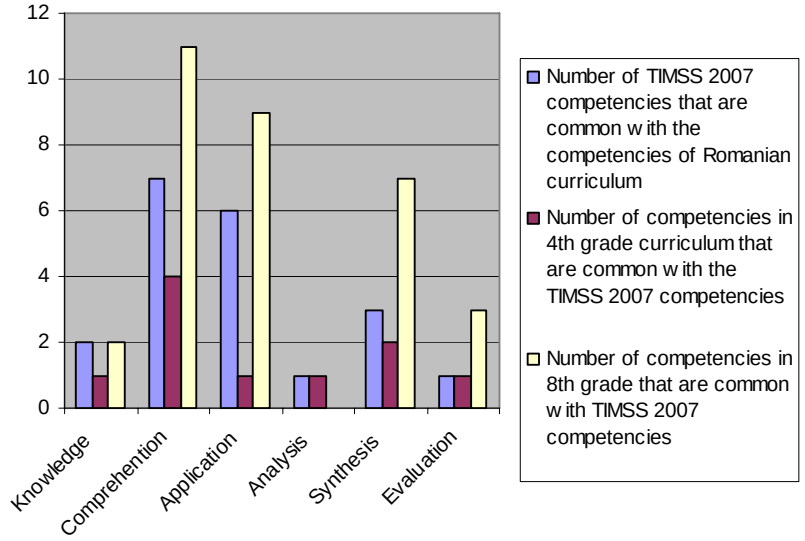
The comparison performed concerning TIMSS 2007 curriculum and the school science curricula for 4th grade and 8th grade illustrate the differences between these curricula as regards of total number of competencies and of number of common competences in these curricula.

The total number of competencies identified in the TIMSS 2007 curriculum is 41; in the science curriculum of 4th grade are mentioned 11 competencies and in curricula of science school subject (Biology, Physics and Chemistry) of 8th grade the total number of competencies is 39. In the next figure it is presented the distribution of these competencies on the levels of Bloom's taxonomy.




**Pictue 5.** *Comparative presentation of the distribution of competencies on the levels of Bloom's taxonomy of cognitive domain*

As it was noted in the figure below there are a low number of common competencies in the TIMSS 2007 curriculum and the Romanian Science curricula. In fact, 53.65% of TIMSS 2007 competencies have not a correspondent in the Romanian Science curricula of 4th and 8th grades.




**Picture 6.** *Number of common competencies in the mentioned curricula*

The biggest number of competencies considered valuable by the TIMSS 2007 investigation but absent in the Romanian curricula are those placed on the levels of analysis, synthesis and evaluation:

- analyzing problems to determine the relevant relationships, concepts, and problem-solving steps;
- making associations or connections between concepts in different areas of science;
- demonstrating understanding of unified concepts and themes across the domains of science;
- providing solutions to problems that require consideration of a number of different factors or related concepts;
- evaluating the impact of science and technology on biological and physical systems;
- evaluating alternative explanations and problem-solving strategies, etc.

23 teachers of Physics, Chemistry and Biology which teach students of 8$^{th}$ grade were asked to justify the absence of TIMSS 2007 competencies in the Romanian science curricula. Without exception, all subjects invoked the big complexity of cognitive processes involved by these competencies. They also specified that the students of 8$^{th}$ grades aren't able to perform so profound analysis (9 teachers) or interdisciplinary connections (12 teachers) or both (5 teachers). These responses conduct to the next question: are Romanian students less capable to carry out complex cognitive processes then their collegues from Japan or Singapur, etc.? This is unlikely.

Consequently the development of such competencies, that require a deep involvement of teachers, should be clearly specified in Romanian science curricula. Once listed in the school, teachers will be forced to put into practice activities that lead to the development of absent competencies.

## Conclusion

The difference between the numbers of competencies involves by TIMSS 2007 and the number of competencies developed to students of 8$^{th}$ grade can be a cause of poor performance of the Romanian students testing. An adjustement of the Romanian science curriculum with TIMSS 2007 curriculum represents a first step to put into practice.

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