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IS ROMANIAN SCIENCE SCHOOL CURRICULA OPEN TOWARDS THE DEVELOPMENT OF SCHOOL STUDENTS' CRITICAL THINKING SKILLS?

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Abstract: Critical thinking is considered to be an important outcome that all students, regardless of their academic major, need to achieve during their undergraduate study. In additon, critical thinking allows students to respond to less-well defined problems and thus to be better prepared for both personal and professional challenges. Taking into consideration the importance of critical thinking in the learning process we have investigated, in order to identify the references to the concept of critical thinking, a number of 56 Romanian school science curricula available on the site of the Ministry of Education, Research and Innovation. The analysis has been made on two levels. The first level of analysis was the terminology level and the second level was the level of the critical thinking skills. The results show that the terminological entries (critical thinking, critical analysis, criticism etc.) are poor and the critical thinking skills are disproportionately represented in the curricula of the primary and secondary science education. The results presented in this study revealed that critical thinking is not a real concern for the authors of the Romanian science school curricula.

Key words: Critical thinking, Science, school curricula, undergraduate students

1. Critical thinking

The need to address critical thinking in science education is substantial as it creates the base for experienced and ethical consumers of scientific change (Grigg, Gunn & Pomahac, 2007)**.** The experts agreed that all students, regardless of their academic major, should achieve a number of outcomes during their undergraduate study and critical thinking was considered one of the the six major intellectual and practical skills that each student must achieve. Also, the Middle States Commission on Higher Education considers that critical thinking need to be "a major outcome of the general education curricular offerings at institutions" (2002).

Critical thinking skills allow students to assimilate more rapidly the subject-specific content of a discipline and also provide a schema that allows students to engage and respond to less-well defined problems (Tsui, 2000); thus students are better prepared for both personal and professional challenges. Critical thinking skills have also positive implications for the learning environment because students who learn in classroom environments that foster these skills begin to consider themselves active contributors to the learning process (Tsui, 2000) and thus critical thinking skills could be considered a means of empowering students to better understand the world around them (Grigg, Gunn & Pomahac, 2007)**.** Also constructing knowledge alongside professors and peers allows students to situate themselves within the learning process and this foster the development of higher order cognitive processes and mastery of subject matter (Tsui, 2000).

To think critically generally means to "reasonable reflective thinking that is focused on deciding what to believe and do" (Ennis, 1985, p.45). APA Delphy Report (quated by Facione, 1990) defines critical thinking showing that "we understand critical thinking to be purposeful, self-regulatory judgment which results in interpretation, analysis, evaluation, and inference as well as explanation of the

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evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based".

More recently, critical thinking is defined as “the use of those cognitive skills that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal-directed—the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions when the thinker is using skills that are thoughtful and effective for the particular context and type of thinking task” (Halpern, 2007).

An operational definition is provided by Ogle (1986 quated by Cretu, 2001) who considers that critical thinking means "to get ideas, to examine their implications, to make them subject to a constructive skepticism, to put them in balance with opposing points of view, to build systems of arguments that support them and give them texture and to take a position based on these structures; critical thinking is a complex process of integrating the creative ideas and resources, of reconceptualizing and of restoring the concepts and information.”

In order to define critical thinking, Klooster emphasizes its characteristics: what is and what isn’t critical thinking. Thus, we don’t talk about critical thinking in relation to memorization, to comprehension (even of the complex ideas) and to the creation of the intuitive thinking. Even though the latter are complex mental operations they are not completely conscious or deliberate. Instead, Klooster considers that critical thinking: 1) is an independent process of thinking, 2) it operates with/on existing information, 3) begins with questions, with problems to be solved and 4) seeks reasoned arguments.

In the same purpose of defining critical thinking NPEC (2000 quating Jones et al.) and Facione (1990) operate with seven major categories:

- *Interpretation Skills*: Understanding and expressing the meaning and the significance of a variety of experiences, situations, data, events, judgments, conventions, beliefs, rules, procedures or criteria.
- *Analysis Skills*: Identifying the explicit and implicit features of a statement, concept, description or other forms of representation that express beliefs, judgments, experiences, reasons, information, or opinions.
- *Evaluation Skills*: Assessing the credibility of a statement or of other representations and the strength of the arguments or of the actual or intend inferential relationships among statements, concepts, descriptions, questions or other forms of representation.
- *Inference Skills*: Identifying the elements needed to draw reasonable conclusions and forming hypotheses.
- *Explanation skills:* Stating the results of one's reasoning and justifying that reasoning in terms of the considerations upon which one's results were based.
- *Self-regulation*: Monitoring self-consciously one's cognitive activities, the elements used in those activities and the results elicited.

The Foundation for Critical Thinking identifies 35 strategies, grouped in three categories:

- *affective strategies* (thinking independently, exploring thoughts, underlying feelings and conversely, developing intellectual perseverance, developing confidence in reason etc.);
- *cognitive strategies - macro-abilities* **(**refining generalizations and avoiding oversimplifications, comparing analogous situations: transferring insights to new contexts, developing one’s perspective: creating or exploring beliefs, arguments, or theories etc.)
- *cognitive strategies - micro-skills* **(**comparing and contrasting ideal with actual practice, thinking accurately about thinking: using critical vocabulary, identifying the significant similarities and differences etc.)

Regarding critical thinking skills and dispositions Ennis (1987, apud Akshir Ab Kadir, 2007) identifies 12 critical thinking skills and 12 abilities. Facione (1990) proposes a list of six skills and 19 affective

dispositions. The list of Facione is used in this study for the analysis of the Romanian science curricula.

Table 1. Consensus List of the Critical Thinking Cognitive Skills and Sub-Skills (Facione, 1990, p. 6)

Skill	**Sub-Skill**
1. Interpretation	Categorization Decoding Significance Clarifying Meaning
2. Analysis	Examining Ideas Identifying Arguments Analyzing Arguments
3. Evaluation	Assessing Claims Assessing Arguments
4. Inference	Querying Evidence Conjecturing Alternatives Drawing Conclusions
5. Explanation	Stating Results Justifying Procedures Presenting Arguments
6. Self-Regulation	Self-Examination Self-Correction

While there is no universal agreement regarding the definition of the critical thinking, several definitions mention the same subset of skills necessary to enhance critical thinking instruction in the classroom. These definitions include "clarity of thought, intellectual integrity, problem identification and solution, respect for evidence, internal coherence, intellectual standards, metacognition, questioning, deductive and inductive reasoning, argument mapping, and ethical reasoning, to name a few" (e.g., Facione, 2007; Fisher and Spiker, 2000; Ennis, 1987; Kennedy, Fisher, & Ennis, 1991; Paul and Elder, 2004 *apud* Grigg, Gunn & Pomahac, 2007).

Brookfield (apud Fish, 1995) offers a number of strategies which facilitate critical thinking, presented in this study in an adapted approach (generalized):

- the acceptance and encouragement of the diversity of beliefs and of different opinions;
- the resistance towards the artificial solutions and results;
- the skepticism regarding the "final" solutions;
- the flexibility and spontaneity;
- the risk taking;
- the openness towards the critical analysis;
- the refusal of seeking a given solution and the attempt to demonstrate something;
- the renunciation of perfectionism;
- the recognition of the limits of human knowledge;
- the reflection of the processes and attitudes which one confronts.

Paul and Elder (2001) determine the stages that are needed in order to become a "critical thinker". Accepting that by his nature the man is a thinker, we can talk about "the thinker who doesn't reflect" on what he undertakes. Its main feature is the limitation to his own point of view, which leads him to misconceptions. The next stage is the stage of the thinker who accepts the "challenge" because he recognizes his ignorance, his prejudice and the need to educate the thinking. Stage three is called "the beginner thinker", who not only recognizes his ignorance and the need to educate thinking but, moreover, he is willing to act with this purpose. The "becoming thinker" is the thinker who regularly prepares himself, who reflect on what he is going to do, on what he is doing and on what he had accomplished. The thinker who is perseverant in reflecting is the "critically advanced thinker".

Finally, the last stage belongs to the "master of thinking" for whom the critical thinking represents the "second nature".

Table 2. *The stages that are needed in order to become a "critical thinker" (Paul & Elder, 2001*)

↑	„The master thinker”
	„The critically advanced thinker”
	„ The becoming thinker”
	„The beginner thinker”
	„The thinker who accepts challenges”
	„The thinker who doesn’t reflect”

In conclusion, critical thinking represents the superior level of thinking which is based on skills and attitudes or dispositions and whose diversity remains an open question.

2. The Romanian Science School Curricula: short presentation

The Secondary education in Romania includes pupils aged between 3 and 19 years old. The students follow 14 grades of study, grouped in five cycles. Sciences are grouped in the area of Mathematics and Natural Sciences and are studied in the first four cycles:

Table 3. Curriculum cycles of Romanian education system

Curriculum Cycle	**Basic acquisition**			**Development**				**Observation and orientation**		**Reinforcement**		**Specialisation**	
	Kinder-garden	Primary School				First cycle of lower secondary school				Lyceum lower cycle		Lyceum upper cycle	
Grade	Preparation year	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
The title of the school subject	Knowledge of the environment			Science (as integrate curriculum)		Biology, Physics, Chemistry and Science (as integrate curriculum)								-

The major learning objectives of the curriculum cycles are (CNC, 2000):

- Basic acquisition: *the pupil’ adjustment to the requirements of the School system and initial literacy.*
- Development: *the development of the basic skills necessary for pursuing one’s education*.
- Observation and orientation: *to guide/ the guidance of the pupils in order to optimize their school options and subsequent professional careers.*
- Reinforcement: *the in-depth study in the chosen profile and specialization ensuring at the same time a general instruction based on the common core and on the options in the other curricular areas*.
- Specialisation: *the accomplishment of the pre-specialization with a view to the efficient integration in the specialized higher education or on the labor market.*

These learning objectives represent the base for the formulation of the main learning objectives of the subjects of each school. For instance, the main objectives of the discipline “Science” in the Development curricular cycle are not different from the main objectives of the Biology in the sixth

grade regarding typology but they are different regarding the complexity of the capacities aimed to be form.

Table 4. The main objectives of the subjects of Sciences (thirth grade) and Biology (sixth grades) (CNC)

	The main objectives of the discipline of Science (thirth grade)	**The main objectives of the discipline of Biology (sixth grades)**
The knowledge, the understanding and the application	1. The understanding and the usage in the communication of the specific terms and concepts of natural science.	1. The knowledge and the understanding of the terminology, of the concepts and of the principles specific to biology. 2. The development of the communication capacitity using the correct language that is specific to biology.
The experimentation, the exploration and the inquiry.	2. The formation and development of the capacities and abilities of experimentation and investigation of the reality, using specific tools and procedures.	3. The development of the capacities of investigation in order to solve problems which are specific to Biology.
The attitude and the relation with the environment	3. The development of interest and of responsability in order to maintain a balanceable environment, which is favorable for living.	4. The development of attitudes and abilities regarding the impact of biology on nature and society.

It should be noted that in the Romanian education curricula the structure of school curriculum varies according to the school cycle. The principal difference consists in the mode of specifying the outcomes: the school curricula of the I-VIII grades is centred on skills (described by "objectives") while the curricula of IX-XII grades presents the competences (key and specific competences) that students have to possesse at the and of a school year. Thus, the structure of sylabus includes:

1. The school curriculum presentation - describing the principles underlying the curriculum;

2. The list of the framework objectives/key competences - these outcomes are subordinated to those of the curriculum's cycle.

3. The benchmarks/the specific competences – describe skills that have to be achieved by students. The outcomes are presented in relation with the teaching content.

4. The curricular performance standards – supports the teacher in assessing the performance of their students.
6. The methodological suggestions – provides the teacher the necessary strategies for working in the classroom.

3. The analysis of the Romanian science school curricula

The analysis made in this study has included a number of 56 school subjects curricula available on the site of The Ministry of Education, Research and Innovation (http://www.edu.ro/). Of these, 19 school curriculum subjects (marked with *) are not valid anymore (they were in use before 2003/2004 and 2004/2005 school years).

Table 5. The number of the school curriculum subjects analysed

	The Primary School	The First cycle of lower secondary school	The Lyceum lower cycle	The Lyceum uper cycle	Total
Knowledge of the environment	2	-	-	-	2
Sciences	2			6	8
Biology	-	4	2	5 (3*)	11
Physics	-	6 (3*)	2	9 (5*)	17
Chemistry	-	4 (2*)	2	12 (6*)	18
Total	4	14	6	32	56

The analysis of the school curricula has been made on two levels. The first level was the terminology level which aimed to identify the explicit references to the concept of „critical thinking":

a) the direct references which use the concept of „critical thinking";

b) the indirect references which use the term „critical" in relation to attitudes („critical spirit, critical reflection etc.) or in relation to the processes of thinking („critical analysis, „critical appreciation" etc.);

c) the components of the school curricula in which we can identify the concepts mentioned above.

The findings regarding the use of the concept "critic/critical" concerning the components of the science curriculum (syllabus) are presented in the following table:

Table 6. The typology of the explicit references to the components of the curriculum regarding the critical thinking:

The typology of the explicit references to the critical thinking	**The components of the school curricula**							
	School curriculum presentation	**Main objectives& Key Competences**	**Specific Objectives& Competencies**	**Abilities**	**Values & attitudes**	**Methodological specifiactions**	**Performance Indicators**	**Total**
The „critical thinking" concept	1	0	0	4	0	0	0	5
Attitudes: critical attitude, critical and self-critical spirit	-	9	0	1	6	3	0	19
The thinking processes: the critical analysis, the critical appreciation, the critical reflection and considerations, the critical interpretation	0	0	11	0	18	3	8	40
Total	1	9	11	5	24	6	8	64

As shown in the table above, the concept „critical thinking" is seldom mentioned (7.81%) being used in relation to the students' abilities. The majority of the references to the term „critical" targeted the thinking processes (62.50%) while the references regarding the „critical attitudes" represent 29.60%.

The distribution is shown in the following figure at the level of the components of the school curricula and at the level of the references to the term "critical":

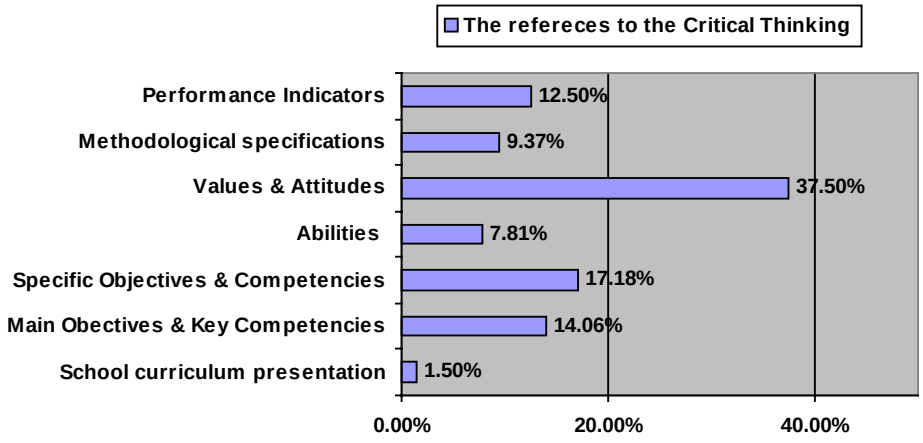

Figure 1. *The References to the „critical" Thinking, Attitudes and Operations in the science school curricula.*

The most direct and indirect references to the critical thinking in the curricula are formulated regarding the Values and Attitudes (37.50). Altogether, the references made on the objectives and performance indicators exceed those mentioned above which represent 43.74% of the total of 64 entries. In the presentation of the school curricula there are the fewest references to the critical thinking, attitudes and operations.

The second level of the analysis approached in the present study was aimed at detecting those benchmarks and competencies that may be assigned to the Critical Thinking Cognitive Skills (Facione, 1990, p. 6). The results are presented in the table below:

Table 7. The number of the reference objectives/specific competencies regarding the Critical Thinking Skills

Skills	Primary level	The Lower secondary Level (Gymnasium)	The Upper secondary Level (Lyceum)	Total
	4 Science curricula	14 Science curricula	38 Science curricula	
1. Interpretation	1	5	22	28
2. Analysis	0	2	16	18
3. Evaluation	0	3	10	13
4. Inference	2	3	17	22
5. Explanation	1	6	24	31
6. Self-Regulation		-	-	
Total	4	19	89	112

It can be observed from the analysis of the table above that almost 80% of the outcomes regarding the Critical Thinking Skills which can be identified in the school curricula can be found in the high-school programs.

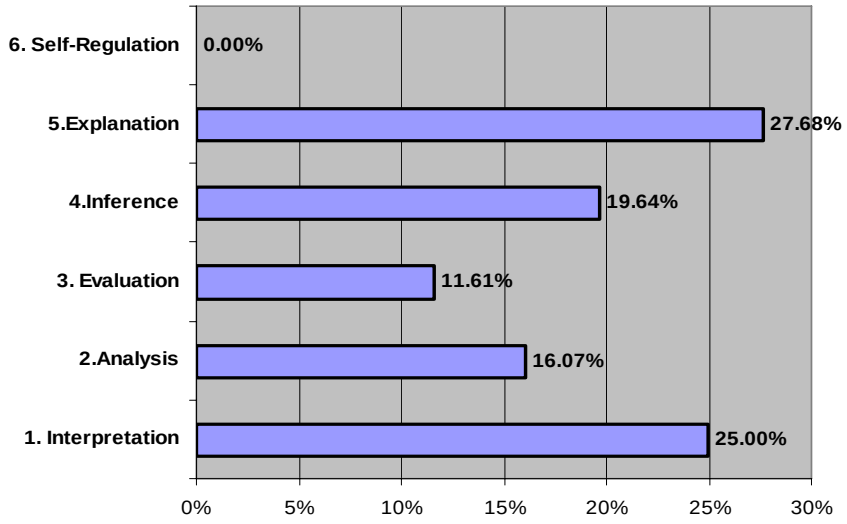

Figure 2. *The References to the „critical" Thinking, Attitudes and Operations in the Science school curricula*

The histogram presented above shows that two thirds of all the competencies mentioned in the school curricula, which belong to the critical thinking domain, refer to the formulation of explanations, interpretation and making inferences. None of the school curricula reviewed in this analysis explicitly mentions among its outcomes competencies such as self-regulation.

4. Discussion

The investigations conducted on the content of the Romanian science school curricula in order to identify the references of the critical thinking skills named by Facione "critical skills" led to the following relatively surprising results:

- the terminological entries (critical thinking, critical analysis, criticism etc.) are poor. They are based in roughly equal percentages on the attitudes (37.5%) and goals (31.50%);
- the competencies of the list of the critical skills proposed by Facione are on the average 2 benchmarks/specific skills per curriculum. In reality, the critical thinking skills are disproportionately represented in the science curricula of the primary and secondary education. For instance:
    - one in eleven competencies belongs to the critical thinking in the science school curricula of the primary education.
    - one in ten competencies refers to the critical thinking in the Biology school curricula of the fifth grade;
    - two in fifteen competencies belong to the critical thinking of the Physics school curricula of the seventh grade;
    - two in eleven competencies belong to the critical thinking in the Chemistry school curricula of the tenth grade etc.
- •the ratio between the number of the critical skills specified in the school programs of one educational cycle and the appropriate number of curricula doesn't record spectacular growth in the transition from one educational cycle to another. Thus, the ratio is 1 in the case of the primary education, 1.36 in the case of the lower secondary education and 2.34 in the case of the upper secondary education.

5. Conclusions and implications

We have presented in this study the way in which critical thinking is illustrated in the Romanian science curricula. In this respect we analysed the Romanian science curricula at two levels. At the first level of analysis we identified the explicit references to the concept of „critical thinking" while at the second level we identified the references to the „critical thinking skills". We have shown in this study that critical thinking is not a real concern for the authors of the Romanian science curricula since the terminological entries (critical thinking, critical analysis, criticism etc.) are poor and the critical thinking skills are disproportionately represented in the curricula of the primary and secondary science education.

What kind of "thinker" does the Romanian education prepare through the study of natural sciences? In which stage of the development of critical thinking (Paul & Elder, 2001) are the Romanian students? Are Romanian students able to solve problems that fall outside of discipline specific areas? Do Romanian students consider themselves active contributors to the learning process? Certainly, the responses to these kinds of questions can't be formulated only on the base of the results presented in this study. There is a need for more detailed investigations which should present the outcomes of the studied content in order to establish the way in which every school discipline can contribute to the development of the critical thinking of the students. In addition, there is a need for investigations regarding the critical thinking skills of the students and of the ways in which these skills can be improved.

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