Cognitive and Emotional Dimensions Recorded when Implementing Specific Responsible Research and Innovation Aspects in Science Lessons

Elena Ancuța SANTI¹, Gabriel GORGHIU²

¹Teaching Assistant Ph.D., Valahia University Targoviste, Romania, santi.anca@yahoo.ro, +40726739911
²Prof. Ph.D., Valahia University Targoviste, ggorghiu@gmail.com, +40-742879508

Abstract: At the age when the mental processes involved in learning and the interest of students are at a high level of development, the school must find the opportunities and paths that are best suited for making their effective covering in practice. Teen-agers broaden their sphere of interest, explore the cognitive and practical skills, feel the need to engage in novel and valuable projects, and - in this respect - science lessons represent opportunities to manifest their abilities. The classical approach - in which there is little emphasis on making experiments, and the creation of contexts from which the student discovers, investigates, seeks solutions - does not correspond to the cognitive, affective and motivational profile of nowadays students. Students do not like a passive role, they want to be actively involved in the process of knowledge, to initiate demarches, to be leaders and to be free to practice their creativity and inventiveness.

Science disciplines should not be seen like abstracting of contents - far from the students’ knowledge interests - but should give them the opportunity to intervene directly in experiments, independently, stimulating in this way their desire to search and to seek answers. The student learns better by doing, not just by seeing or hearing. Responsible Research and Innovation - through its specific dimensions - is able to create proper frames for making students very interested in science, adapting the learning demarches by rethinking the lessons as opportunities to capitalize the cognitive and affective features of students’ personality in the learning process.

Keywords: cognitive; affective; Science; Responsible Research and Innovation; IRRESISTIBLE Project.

1. Introduction

It is essential to understand science nowadays. For many students, understanding science is strongly influenced by what they experience in class. They are able to initiate endeavors, to experiment and discover, expressing their interest to be active involvement in the development of scientific knowledge in various contexts. In general, science classes are seen by students as situations in which they can turn theoretic and - in many cases - abstract notions into practice. For learning science, the traditional approach of teaching lays emphasis on conveying a set of knowledge specific to the area - however, students must benefit of hands-on approaches to learning, in formal and non-formal educational environments, as important part of improving the pedagogy dedicated to science disciplines (Hayes & Kraemer, 2017).

However, science is taught with more focus on development of the students’ cognitive component (acquisition of notions, memorization, understanding, reasoning, problem solving, critical thinking) and less focus on development of the interest, the intrinsic motivation, attitudes, creativity, metacognition and personal desire to know. No matter what pedagogical strategy is introduced, and with all the efforts made by the science teachers, the interest of young generation for science recorded a severe decline (Rocard, Csermely, Jorde, Lenzen, Walberg-Henriksson, & Hemmo, 2007).

2. Conceptual Framework

Some teachers make huge efforts to inspire their students by introducing inventive teaching methods and use examples from real life to show them how science is present into everyday life; however, this method is not used by all teachers. If the students are able to see the relevance of science in relation to the real world, it can be said that a lesson is efficient.

As example, a study involving over 1,500 teenagers from different schools in the U.S.A., conducted by AmGen Foundation and Change the Equation showed that the teenagers are interested in science as a discipline, in its approached contents, but there were few students attracted by the science classes as taught by their teachers in classrooms. The study indicated that there are significant differences between science activities which teenagers find the most attractive and the way in which the science content is actually taught in class (Zubrzycki, 2016). Teenagers wanted to have practical experiments and to take trips in the real space, I order to find out more about how the world functions; however, most frequent science teaching
activities are performed as discussions, by reading the information included in the textbook. All those mentioned aspects are illustrated in table 1.

**Table 1.** A short comparison on how Biology is taught to youngers vs. how the youngers would like to learn Biology (Zubrzycki, 2016)

<table>
<thead>
<tr>
<th>Rank</th>
<th>Most used tools in the Biology classroom (used at least once in a week)</th>
<th>What would make Biology very interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Discussing concepts and related information in the classroom environment</td>
<td>Performing laboratory hands-on experiments</td>
</tr>
<tr>
<td>2.</td>
<td>Teaching/presenting concepts and related information straight from the recommended textbook</td>
<td>Organizing field-trips with the view to learn Biology concepts and related information in out-of-classroom environments</td>
</tr>
<tr>
<td>3.</td>
<td>Performing laboratory hands-on experiments</td>
<td>Designing projects which try to present and explain the importance of learning and understanding Biology for the real life</td>
</tr>
<tr>
<td>4.</td>
<td>Learning about how Biology is exploited by people, in the real life/world</td>
<td>Performing/Large using of simulations and/or virtual experiments in classroom activities</td>
</tr>
<tr>
<td>5.</td>
<td>Stating/formulating own hypotheses before performing experiments</td>
<td>Selecting specific topics with the view to be further exploited</td>
</tr>
</tbody>
</table>

Answering to the alarming decline of the teenagers’ interest in basic sciences and mathematics (Rocard et al., 2007), which is also confirmed by the results of the Romanian young students over the past few years (taking into account the international comparative assessment studies - TIMSS and PISA (Cârstoiu, Mihai, & Zus, 2013), a potential cause is directly linked to the way in which science subjects are taught in schools. In this respect, in a study related to teaching science in Europe, it is stated that educators recognized a real necessity for making changes in the methods used for didactic demarches (Gatt & Armeni, 2013). It is also mentioned that students must be offered with the possibility to explore and be engaged in science, becoming in this way, promoters of their own learning process. When teaching science, teachers should stimulate school-related interests and use a variety of learning experiments (Welz, Schlunk, Schulze, & Lührs, 2010).
3. Dimensions of Affectivity Involved in Science Teaching

The affective domain includes many psychical constructions: attitudes, values, beliefs, opinions, interests and motivation. Although those ones have been recognized as important to scientific learning, the research conducted in this area takes the cognitive dimensions into account in a great measure, explaining the misbalance by considering the archetypal image of the science itself, stipulating that thinking is separate from affectivity, relying more on the cognitive component (Alsop & Watts, 2003). Nevertheless, the contemporary educational research shows that the affective dimension does not play the role of a simple catalyst, being an important and a necessary condition for learning to happen (Perrier & Nsengiyumva, 2003). In this respect, attitude and motivation are the most important critical constructions of the affective domain, becoming vital for scientific education.

The cognitive-affective approach of the science lessons implies:

(a) teaching scientific concepts to students, who must be able to understand sufficiently in order to use the acquired knowledge in solving conceptual problems;

(b) developing attitudes, interests, values, social positive habits or life abilities by using the analogies with the learnt scientific concepts.

Whenever students understand the scientific concepts (from the cognitive point of view) and can introduce and apply the newly-acquired knowledge and skills in completing or solving problems and everyday life situations, they will be motivated to continue the process of learning.

4. Methodology

We are aware of the importance related to the affective dimension in learning, as a motivation and stimulation factor which vigorously supports the educative endeavor. This is the reason for initiating the exploratory study (Gemene, Unguru, & Sandu, 2018), in order to identify the cognitive and affective variables specific to Responsible Research and Innovation, aspects which may contribute to rethink the manner in which science lessons are approached in schools.

The target research group consisted of 96 students (from 13 to 19 years old) who visited two exhibitions organized in the frame of the IRRESISTIBLE FP7 Project, having the declared aim on projecting and implementing activities that encouraged the involvement of teaching staff, students and general public in processes specific to Responsible Research and Innovation (RRI), together with staff from universities, research institutes,
museums and other entities engaged in educating the young generation, by cooperating and capitalizing the expertise and the experience both in promoting formal learning activities and especially non-formal activities (www.irresistible-project.eu).

Both exhibitions - “The World of Nanomaterials and Solar Energy” hosted by the History Museum of Dambovita County (2015), and “The Sun & The <Nano> World” hosted by the Prahova Natural Science Museum (2016) - included exhibits designed by students and their teachers involved in the IRRESISTIBLE Project, with the help of its constituted Community of Learners (CoL), having as role to efficiently promoting the project activities and the proposed educational materials, but also to create a powerful impact on primary and secondary education (Anghel, Gorghiu, & Măntescu, 2016; Gorghiu, Măntescu, & Olteanu, 2016).

The CoL designed a Training Module consisted of 10 Units, all of them proposing the transfer of the knowledge related to “Nano” topics, substantiated by the introduction of IBSE Strategy (Inquiry-based Science Education) and 6E Model, with simultaneous approaches of RRI referring to the specified topics (Petrescu, Gorghiu, & Gorghiu, 2016; Gorghiu & Petrescu, 2016).

In the proposed research, a questionnaire with pre-established answers was administered to students. After collecting their answers, the data was processed using quantitative statistical methods.

5. Results and Analysis

The results and its interpretation try to offer an image on how students perceive and resonate to the learning model proposed by the Training Module designed in the frame of the IRRESISTIBLE project.

The first analysis took into consideration the students’ feedback regarding the cognitive and affective dimensions, in relation to their experience recorded during the visit to the exhibition (figure 1). The Bloom-Anderson’s taxonomy of learning presents the relation between the cognitive and the affective domains in the process of building the learning objectives (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956; Anderson, Krathwohl, Airasian, Cruikshank, Mayer, Pintrich, Raths, & Wittrock, 2001). This is reflected in the objectives proposed by the exhibitions “The World of Nanomaterials and Solar Energy” and “The Sun & The <Nano> World”, as follows:
the items “I understood how nanotechnology is retrieved in real life” and “I understood the beneficial impact of renewable energy on the environment” target to understanding - the cognitive domain;

the item “I discovered new ideas and themes which help me in future activities” aims at finding out new knowledge which may be structured and organized towards elaboration of products, information, original knowledge, using both cognitive aspects - connected to the thinking mechanisms, creative thinking, curiosity -, and non-cognitive aspects - motivation, interest, positive emotions;

the items “I discovered interesting exhibits and projects, but also exciting subjects having great impact” and “The exhibition topic is interesting for me and for my generation, in general” indicate the interest in the activities proposed, with a personal significance, intrinsic to students.

The learning experiences, which aim to develop cognitive structures, should be in close connection with the affective factors, as they facilitate this process. Figure 1 shows that students highly value the learnt issues related to how nanotechnology may be introduced into practice, what is the beneficial impact of the renewable energies on the environment, how useful is a exhibition.

**Figure 1.** Students’ feedback regarding the cognitive and affective dimensions in relation to their experience recorded during the visit to the exhibition

Figure 2 illustrates the distribution of the students’ opinions on the importance of the acquired knowledge (gained during the visits of exhibitions) for their future activities related to science - it can be seen that...
approximately 75% of questioned students considered the experience to be useful for the future, whereas 8% thought it has no potential to be used in future activities.

**Figure 2.** Students’ considerations concerning the importance of the acquired knowledge for their future activities related to science

Figure 3 shows the importance considered by students (in terms of utility, practical and applicative character - all of them presented and discussed during the exhibitions with their teachers and invited experts) related to specific elements of nanotechnology on creating a healthier environment. It can be seen the extremely higher percentage of students who consider that the proposed practical applications may be transposed into concrete actions for the benefit of people and environment. Their assessment has a strong affective (beliefs, aspirations, ideals) and motivational charge.

**Figure 3.** Students’ rates concerning the importance of nanotechnology on creating a healthier environment
Figure 4 illustrates the students' opinions related to how the science lessons have to take place. To a very great extent, their option is to be given the opportunity to visit laboratories and locations where the implementation of new technologies (e.g., nanotechnology) are available - a choice probably influenced by the strong emotional impact produced during the visit of exhibitions. In this respect, the organization of activities in various educational contexts, in which they can understand and experiment, is strongly requested. In those settings, sharing their experiences through collaborative learning, is very welcome.

In addition, the students' answers indicate a series of specific elements to both cognitive and affective dimension, in relation to science lessons/activities. Understanding, acquisition of scientific concepts and notions, memorizing, reasoning, problem solving, critical thinking - all of them are compulsory processes which must be activated in modern science lessons/activities; however, without the affective components, the acquisition of knowledge continue to be mentally inactive, with lack of applicability. Creating concrete opportunities enable students to capitalize the theoretical aspects of science - this is an important requirement of a qualitative education, specific to the challenges faced by the actual period and to the modern students' cognitive interest.

**Figure 4.** Students' feedback related to how the science lessons / activities have to be organized and conducted.
6. Conclusions

Solving concrete problems in everyday life, regardless of their complexity level, involves the use of knowledge and skills which cannot be classified as part of one school subject or another. The skills which prove to be vital in solving such everyday situations are the ones which relate to skills of understanding and using notions and specific concepts, as well as the skills connected to the capacities of exploring/investigating reality and problem solving. The training process is fully exploited when learning experiences are created starting rather from students’ needs and expectations, than by exposing and assessing the information that the teacher believes to be assimilated by students. As students reflect more and more on their own experiences, they realize that their ideas have influence and complexity and they develop stronger abilities to integrate new information which generates positive learning emotions and feelings. Therefore, one of the most important roles of the teacher becomes to encourage the learning and reflection process and also to develop the interest, motivation and favorable attitudes for the study of science.

Acknowledgements:

This work has partially received funding through the Seventh Framework Programme Project entitled: “IRRESISTIBLE - Including Responsible Research and Innovation in Cutting Edge Science and Inquiry-based Science Education to Improve Teacher’s Ability of Bridging Learning Environments” - a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTIVITY 5.2.2 “Young people and science” - Topic SiS.2013.2.2.1-1: Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education - grant agreement no 612367.

The contribution of the authors to this paper is equal.

References


