

## Student's Motivation to Study Chemistry: some Insights into the Portuguese Case

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### Abstract

*Chemistry is universally assumed as one of the most difficult and demanding science subjects. It is recognized as involving difficult concepts, specialized terminology and mathematics. Moreover, some chemistry curricula are considered quite apart from students' interests, every-day life contexts and technological issues. Context-based chemical education has then emerged as a highly valuable strategy worldwide being presently also followed in the Portuguese educational system. Nevertheless this positive aspect, chemistry is nowadays facing several constraints in the Portuguese context, particularly in the 12<sup>th</sup> grade, namely by the reduction of the total teaching time, the fact of becoming an elective course, and the reduction of the teaching time devoted to experimental activities. With the present work we intend to give an overview of the Portuguese situation concerning student's motivation to study chemistry addressing the following points: (1) Chemistry in the Portuguese educational context, (2) Analysis of national reports/initiatives; and (3) Analysis of the Chemistry is all around Portuguese teachers' opinion. Concerning this last point, one important issue is the generalized acceptance that a motivated and well prepared teacher is the key for the success. The implementation and use of ICT-based resources in schools is seen as a powerful auxiliary tool to teach and learn science. Nevertheless, the chosen ICT-based resources must be centered on the student, motivating an autonomous thinking/learning process. Teaching resources could not be seen as a teacher substitute. It is generally accepted by the Portuguese involved teachers that students like and privilege the direct contact with the teacher.*

### 1. Chemistry in the Portuguese educational context

The school system in Portugal is organised in three sequential levels: pre-primary education (ages 3 to 5), basic education (typical ages 6 to 15) and secondary education (typical ages 15 to 18). Basic education is organised according to three cycles (1<sup>st</sup> cycle (grades 1-4), 2<sup>nd</sup> (grades 5-6) and 3<sup>th</sup> (grades 7-9)). School is compulsory to 12<sup>th</sup> grade for any student enrolled in the 7<sup>th</sup> grade or below as of 2009/2010 [1].

Apart from the pre-primary education, where some science activities/projects are introduced, chemistry related subjects start to be taught during the basic education (1<sup>st</sup> and 2<sup>nd</sup> cycles) as part of Environment Study and Natural Sciences courses. Chemistry education proceeds then with Physical-Chemistry Sciences in the third cycle and Physics and Chemistry A and Chemistry in the secondary level. Table 1 summarizes the structure of the Portuguese educational system and the corresponding relationship with chemical education.

Presently, chemistry integrates the specific formation component of the study plan of Scientific-Humanistic of Sciences and Technologies of the secondary level. During the 10<sup>th</sup> and 11<sup>th</sup> grades it is associated to physics in the Physics and Chemistry A course, where it covers 50% of the curricular program of this biennale course, subjected to a national examination at the end of the 11<sup>th</sup> year. This is a specific course to access various science careers such as Medicine, Nursing, Veterinary Medicine, Pharmacy, Biochemistry, Biology, Clinical Analysis and some Engineering careers. During the 12<sup>th</sup> grade, Chemistry course follows Physics and Chemistry A but with an elective character.

The main curricular modifications were performed with the Decreto-Lei N<sup>o</sup> 286/89 (August 29<sup>th</sup>). Accordingly, students were subjected to a national evaluation in Chemistry at the end of the 12<sup>th</sup> grade and Chemistry was a specific course to follow teaching careers. National exams have continued until 2006/2007 scholar year.



Later and accordingly to Decreto-Lei N° 74/2004 (March 26<sup>th</sup>) the chemistry curriculum has been reformulated and the Physics-Chemistry A course was created, substituting Chemistry as the specific course to university admission. Chemistry became then an elective course during 12<sup>th</sup> grade with a total weekly teaching time of 315 minutes (three weekly classes (90+90+135 minutes)). The last curricular organization was performed recently (Decreto-Lei N° 139/2012 (July 5<sup>th</sup>)) and Chemistry weekly teaching time was reduced to 180 minutes (two weekly classes of 90+90 minutes).

Table 1. Chemical education within the Portuguese school system.

Levels	Grades	Age	Chemistry related courses	Typical Weekly time (*)
Basic education	1 <sup>st</sup> cycle 1 <sup>st</sup> -4 <sup>th</sup>	6-10	Environment Study	5 hours
	2 <sup>nd</sup> cycle 5 <sup>th</sup> -6 <sup>th</sup>	10-12	Natural Sciences	(45+90) minutes Two weekly lessons
	3 <sup>rd</sup> cycle 7 <sup>th</sup> -9 <sup>th</sup>	12-15	Physical-Chemistry Sciences	(45+90) minutes Two weekly lessons
Secondary education	Secondary 10 <sup>th</sup> -12 <sup>th</sup>	15-18	Physics and Chemistry A (10 <sup>th</sup> -11 <sup>th</sup> )	(90+90+135) minutes Three weekly lessons
			Chemistry (12 <sup>th</sup> - elective)	(90+90) minutes Two weekly lessons

(\*) Based on data supplied by Agrupamento de Escolas Abade de Baçal following Decreto-Lei N° 139/2012 (July 5<sup>th</sup>).

As a consequence of the aforementioned curricular modifications that have occurred during the last six years period, chemistry has successively lost importance, both from students' and schools' points of view.

Summarizing, a positive aspect is the context-based approach followed by the chemistry curricula. Some evidence exists that it motivates students enhancing more positive attitudes towards science. The most negative aspect is the elective character of Chemistry course during the 12<sup>o</sup> scholar year. In this context more effective measures towards student's motivation to study chemistry are needed and urge to be implemented. Students' motivation to follow chemistry careers is highly dependent on how students perceive chemistry importance during basic and secondary education.

## 2. Analysis of national reports/initiatives

In this section national reports/initiatives where motivation to study chemistry is addressed are documented and the main conclusions stressed out. Two reports will be in focus: (1) The white book of physics and chemistry – Students' opinions 2003 [2,3] and (2) Motivation of Portuguese youth to study science and technology in higher education [4]. The first one was performed by a group of teachers from different educational levels (basic, secondary and higher education) and was sponsored by the Portuguese Societies of Physics and Chemistry. The second one was published by the National Council of Education. To the best of our knowledge no recent studies with this dimension were done and/or published.

### 2.1. The white book of physics and chemistry – Students' opinions 2003

In 2005, a comparative and broad study was published concerning the opinions of both students and teachers about several important aspects of Physics and Chemistry Education [2,3]. The students sample included 7900 individuals, covering all the continental territory, evaluating the 9<sup>th</sup>, 11<sup>th</sup> and 12<sup>th</sup> grades, in the year of 2003. Several important aspects were discussed by the authors and some are highlighted here:

- The motivation to study Chemistry was not very high (49%) for 9<sup>th</sup> and 11<sup>th</sup> grade students increasing slightly for University students (53%). The main reasons pointed for the lack of motivation to study Physics and Chemistry were: the difficulty of the subjects, the characteristics of manuals, the dependence of these sciences towards Mathematics and the difficulties to apply knowledge in problem solving. In the case of university students, the main reasons for not attending Physics or Chemistry at the 12<sup>th</sup> year were the fact that these disciplines were not specific for their career and a potentially low final classification might difficult university access [3];

- In general, students consider teaching strategies centred in the teacher more effective for their learning process. The more adequate ones include the revision of concepts prior to evaluation tests and solving exercises; the teacher explanation accompanied by experimental demonstrations, home study and the execution of experiments in small groups of students. Some gender differences were also mentioned. While boys value more the activities that involve the use of a computer and the participation in experimental activities, girls prefer teaching strategies centred in the teacher, followed by individual study at home, and experimental demonstrations performed by the teacher. However, there is a low frequency of experimental activities organized by teachers when compared to the expectations of a high percentage of students that enjoy them.

## 2.2. Motivation of Portuguese youth to study science and technology in higher education

Another recent report [4] highlights the Professional and Educational Orientation role as strategic for promoting an increase in the number of students following a career in the science and technology areas. The decreasing number of students pursuing a career in science and technological areas and the low scientific literacy of students were some of the factors that motivated this work. This report provides information on the motivations (interests, expectations, valences and perceived support nets), from the individual and contextual point of views, that are associated or condition the choices of scientific and technological careers.

Two questionnaires were conducted at national level, one to 1000 students from the 1<sup>st</sup> year of science and engineering courses of several Universities and Polytechnics and, another, to 600 students enrolled in the last two years of the secondary school (11<sup>th</sup> and 12<sup>th</sup> years). Again, some of the most important conclusions are summarized here:

- The importance of students' performance on Mathematics at secondary level, not only for the choice of science and technology careers, but also for the degree of satisfaction felt during their attendance;
- The fundamental importance of the instrumentality given to Mathematics for the accomplishment of future life objectives in the election of S&T careers;
- The authors of the study also emphasize the role of a consistent and continued vocational orientation for a better alignment of school courses with the career objectives that are defined by students along their basic and secondary studies.

## 3. Analysis of the Chemistry is all around Portuguese teachers' opinion

The comments of 12 Portuguese teachers working in several schools from the Bragança district, integrating the Chemistry is All Around Network, were gathered regarding the thematic of student's motivation to study Chemistry and, also, the use of ICT based teaching resources. The group includes 2 teachers from the 1st cycle, 1 from the 2nd cycle and 9 from the 3rd cycle and secondary school levels. The main conclusions/comments can be summarized as follows:

- It was generally consensual that chemistry is a difficult subject;
- In addition, the motivation to study chemistry in the Portuguese context decreased. In particular for the 12<sup>th</sup> grade, the recent curricular reformulations resulted in: (1) Chemistry started to be an elective subject, (2) Too much long programs, which are considered difficult to be carried out and finalized by the teachers, and (3) Reduction of the laboratorial activities teaching time, which are undoubtedly recognized as a key motivation element;
- Motivation to study chemistry can be improved by implementing laboratorial activities and by using everyday life examples. Moreover it was recognized as crucial to motivate students to have a motivated teacher. The use of ICT-based resources was also considered important;
- It was consensual that Portuguese schools are generally well equipped as a result of the strong investment carried out by the Ministry of Education according to the Portuguese Technological Plan for Education [5]. Nevertheless, even the facilities exist, including laboratorial equipment; some teachers reported a lack of background knowledge to take full advantage of it.
- Teaching resources could not be seen as a teacher substitute. It is generally accepted by the Portuguese involved teachers that students like and privilege the direct contact with the teacher. Having this in mind, long movies or other non-interactive resources should be avoided. Short non-

interactive resources are only recommended to be used as an introductory motivation element or to introduce a specific subject.

- In a general way, and if using web resources, teachers prefer the ones suitable to be used in an offline basis avoiding dependence on the web connection. The chosen resources must also be centered on the student, motivating an autonomous and active thinking/learning process. Moreover, they seek for validated resources, at least they feel more comfortable to choose resources belonging to well recognized institutions. In that view the “Chemistry is all around network” project was welcomed.
- When questioned about the utilization of ICT based-resources, teachers pointed out that, among the possible types, they generally prefer simulations. Ideally these simulations must be accompanied by an orientated guide with final checkout questions, which could be prepared by the teacher having in view the desired outcome learning objectives. Ideally, simulations should be followed by experimental practice at the laboratory.
- Phet (<http://phet.colorado.edu/it/simulations/category/chemistry>) was mentioned as one of the most popular digital resources being widely used by Portuguese teachers of lower and upper secondary school.
- In the case of primary school teachers, a lack of background preparation to teach experimental sciences was pointed out, as well as to use digital resources. Even if experimental activities are recommended at these school levels, most of the times they are carried out with the help of other school level teachers. As so, experimental science teaching training for teachers of these early school levels are recommended and welcome.

## 5. Conclusions

From the analysis of the Chemistry is all around Portuguese teachers’ opinion, the main aspects are summarized:

- The motivation to study chemistry in the Portuguese context decreased as a result of the last years curricular reformulations (particularly in the 12<sup>th</sup> grade, where chemistry is an elective course, with insufficient time to teach contents, particularly the experimental ones);
- It was recognized as crucial to motivate students to have a motivated teacher.
- The use of ICT-based resources was also considered important. Long movies or other non-interactive resources should be avoided in classes. Short non-interactive resources are only recommended to be used as an introductory motivation element or to introduce a specific subject. The selected resources should be student centered, motivating an autonomous and active thinking/learning process; they should be scientifically validated resources; in the case of digital simulations they should have a guide with final checkout questions, having in view the desired outcome learning objectives. Finally, when possible, simulations should be complemented with experimental work.

## References

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