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Students' Motivation to Learn Chemistry in Portugal

Lifelong Learning Programme

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Student's Motivation to Learn Chemistry in Portugal

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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. This work aims to report the current situation concerning student's motivation to learn chemistry in Portugal. The following points will be addressed: (1) A general overview of the national education system, (2) Chemistry in the Portuguese educational context, (3) Analysis of national/international reports/initiatives concerning motivation and/or performance in sciences/chemistry, (4) Analysis of the "Chemistry is All Around" project portal resources (papers, publications and ICT-based resources). Moreover, the composition of the Portuguese team in what concerns the involved scientific experts, schools, teachers and students is presented. As a last point the results of the first workshop are summarized. The findings presented in this report are based on both literature and analysis of the teachers and experts opinion, as expressed in the project portal.

1. INTRODUCTION TO THE NATIONAL SITUATION

1.1. GENERAL OVERVIEW OF THE PORTUGUESE EDUCATION SYSTEM [1-3]

The organization of the Portuguese Education System comprises: pre-primary education (ages 3 to 5), basic education (typical ages 6 to 15), secondary education (typical ages 15 to 18) and higher education. Basic education is organised according to three cycles (1st cycle (grades 1-4), 2nd cycle (grades 5-6) and 3th cycle (grades 7-9)). Presently, school is compulsory to 12th grade for any student enrolled in the 7th grade or below as of 2009/2010.

Secondary education can be oriented to higher education access or towards working life. In the first case it offers science-humanistic courses, such as science and technologies, social and economic sciences, languages, humanities and visual arts. In the second case, technological, specialised artistic and vocational courses are offered. Nevertheless the main professional vocation of these last described courses, the involved students have the opportunity to study further, namely via post-secondary technological specialization (CET) and higher education courses.

The Portuguese Education System also provides opportunities for non-traditional students (adults and youths from 15). The available courses provide a second opportunity to those individuals who left school early or are at risk of doing so, as well as those in the labour force who want to acquire further qualifications. Examples of the available opportunities are the Education and Training Courses (CEF courses) dedicated to young people over 15 at risk of leaving school or who have already left it before concluding the 9th grade, and Adult Education and Training Courses (EFA) targeted at individuals aged 18 or over who need to improve their qualifications.

Figure 1 schematises the Portuguese Education system organization.

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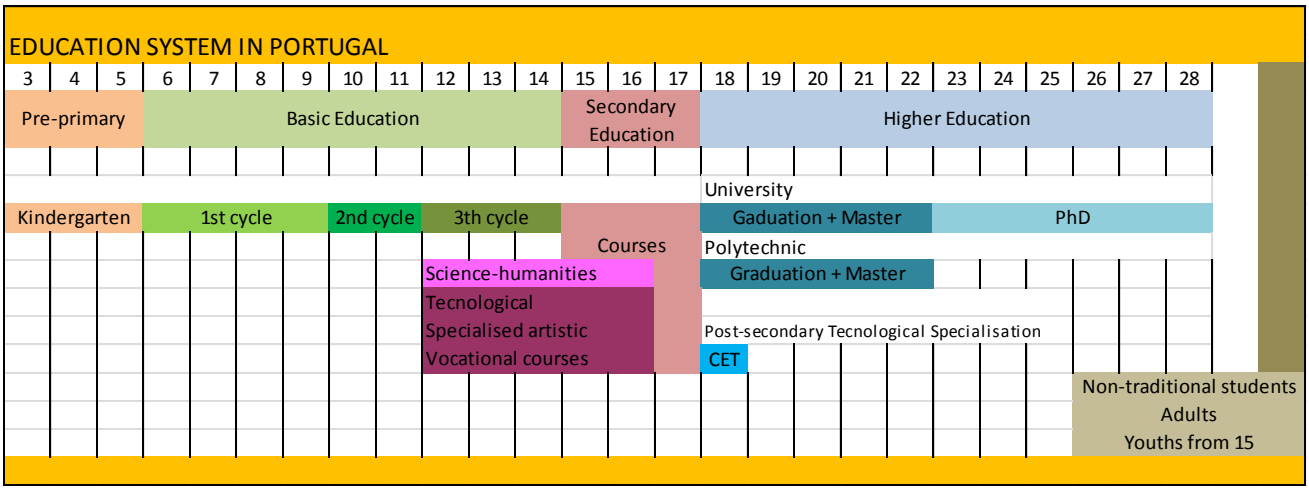

Figure 1. The Portuguese Education System
(Adapted from the source: GEPE (http://www.gepe.min-edu.pt) [1]).

1.2. CHEMISTRY WITHIN THE PORTUGUESE EDUCATION SYSTEM [4 - 7]

Apart from the pre-primary education, where some science activities and/or projects are accomplished, science teaching started to be introduced during the basic education with the courses of Environment Study (1th cycle) and Natural Sciences (2th cycle). Chemistry dedicated courses started with Physical-Chemistry Sciences in the 3th cycle, Physics and Chemistry A (10-11th grades) and Chemistry (12th grade) in the secondary level. Table 1 summarizes the structure of the Portuguese education system and the corresponding science/chemistry subjects weekly teaching hours.
Currently, chemistry integrates the study plan of the Science and Technologies area of the Sciences-humanities courses. During the 10th and 11th grades it is associated with physics in the Physics and Chemistry A course, where it covers 50% of the curricular program of this biennale course. At the end of the 11th grade, students have to attend a national exam, being Physics and Chemistry A one of the specific courses needed to access various science careers such as Medicine, Nursing, Veterinary Medicine, Pharmacy, Biochemistry, Biology, Clinical Analysis, as well as, some Engineering careers. In the 12th grade, Chemistry follows Physics and Chemistry A but with an elective character. Chemistry teaching in the Portuguese education system presently follows a context-based approach. Nevertheless, some recent movements state the need to refocusing chemistry curricula on structuring concepts (in opposition to the in context concepts).

The main curricular modifications performed during the last past years with impact on chemistry teaching, can be summarized as follows:

- Decreto-Lei Nº 286/89 (August 29th): According to this Decreto-Lei, students needed to attend a national exam in Chemistry at the end of the 12th grade being this course specific to access chemistry teaching careers. This national exam proceeded until 2006/2007 scholar year.
- Decreto-Lei Nº 74/2004 (March 26th): Physics-Chemistry A course was created in the 10th and 11th grade, substituting Chemistry of the 12th grade as the specific course needed to higher education access. Chemistry became then an elective course during 12th grade with a total weekly teaching time of 315 minutes (three weekly classes (90+90+135 minutes)).
- Decreto-Lei Nº 139/2012 (July 5th): Chemistry weekly teaching time was reduced to 180 minutes (two weekly classes of 90+90 minutes). It is a generalized opinion among teachers that the defined teaching time is insufficient to teach contents, particularly the experimental ones.

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Table 1. Science/chemistry education within the Portuguese school system.

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

(*) Based on data supplied by Agrupamento de Escolas Abade de Baçal following Decreto-Lei Nº 139/2012 (July 5th) [7].

As a consequence of the aforementioned curricular modifications performed during the last six years period, chemistry has successively lost importance, both from students' and schools' point of view. 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. SETTING UP OF THE NETWORK [8]

For the setting up of the network the following strategies have been used to involve schools and experts:

- In the case of schools, many Physics and Chemistry teachers, mainly from the region of Bragança, visit IPB regularly, with their students, to participate in science events organized locally such as "Chemistry Olympics" (Sociedade Portuguesa de Química, 2006-2012), "Hands on Particle Physics Masterclasses" (International Particle Physics Outreach Group, 2010-2012) and "Verão Ciência no IPB" (Agência Ciência Viva, 2009-2012). During some of the events in 2012, most of the teachers were directly contacted by us and the objectives and activities of this project were presented. The role of teachers and schools was explained and a written dossier was delivered to each teacher, containing the description of the project and the corresponding forms to be filled in. Informative mailings and face-to-face meetings also took place to clarify questions and doubts. This recruiting strategy worked well as the schools already had cooperated with IPB for some years, resulting in the involvement of seven schools from our region, facilitating the maintenance and quality of communication.
- In case of experts, they were selected by their expertise in the areas of Chemistry Science, Science Education and/or Science Communication. They were all initially contacted by email and that has been, since then, the main form of communication. Again, the recruiting strategy was successful with the selection of five national experts belonging to different Higher Education Institutions.

In summary, there are 5 experts, 7 schools, 18 teachers and 470 students from Portugal, participating in the project. In sections 2.1 and 2.2, a more detailed description of the involved schools and experts, respectively, is provided.

2.1 SCHOOLS

Table 2 describes the involved seven schools, associated teachers and the corresponding grades taught. The number of students involved per school is also presented. As mentioned before the schools are located in the northeast region of Portugal, four of them in the city of Bragança (see Figure 2).

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Table 2. Characterization of the involved schools and teachers.

School	Students (age range)	Teachers	Years of experience	Grades
Agrupamento de Escolas Abade de Baçal	85 (6-18)	Arnaldo Fernandes	34	1-4
		Adilia Tavares da Silva	35	7-12
Escola Secundária de Valpaços	40 (13-18)	Silvino Rodrigues	12	7-12
		Lília Sofia Pires	10	
Agrupamento de Escolas Paulo Quintela	55 (7-11)	Maria Teresa Palas	33	1-4
		Abílio Ferreira Lousada	29	5-6
EBS de Miranda do Douro	90 (15-18)	Fernanda Martins	30	7-12
		Maria de Fátima Raposo	28	
Escola Básica e Secundária de Macedo de Cavaleiros	40 (12-18)	Lília Braz	16	7-12
		João Paulo Matos	12	
Escola Secundária Emídio Garcia	80 (12-18)	Luísa Maria Fernandes	16	7-12
		Célia Bento	14	
		Teresa Pinto	30	
		Mara Emanuela Dias	15	
Escola Secundária Miguel Torga	80 (16-18)	Olga Nunes	25	10-12
		Noélia Vilas-Boas	17	
		José Alberto Alves	19	
		Ana Cristina Falcão	19	

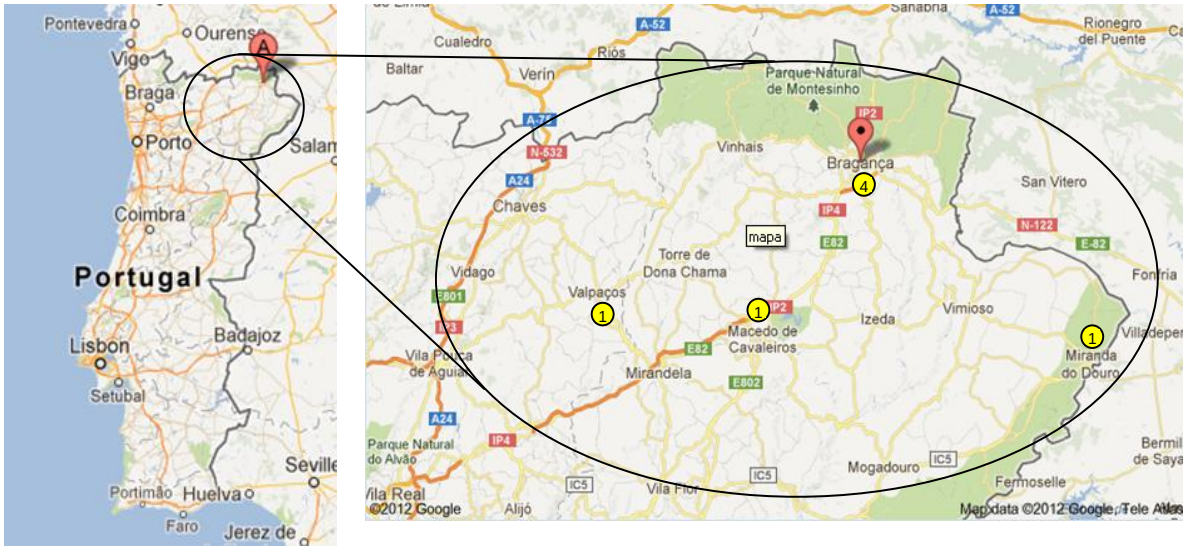

Figure 2. Geographical distribution of schools (yellow points: number of schools).

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2.2 EXPERTS

The name and Institution of each of the five Portuguese experts is presented in Table 3. They are all Professors at Higher Education Institutions, having different areas of expertise. Following, a short CV evidencing the relevance to the project is presented. More detailed information is available at the portal.

Table 3. List of Portuguese experts.

Name of the expert	Institution
Carla Morais	Faculty of Engineering University of Porto, Portugal
Maria de Fátima Paixão	Polytechnic Institute of Castelo Branco, Portugal
Maria João Seixas Melo	Faculty of Sciences and Technology/New University Lisbon, Portugal
Mónica S.N. Oliveira	University of Strathclyde, United Kingdom
Paulo Ribeiro Claro	University of Aveiro, Portugal

- Carla Morais holds a PhD in Education and Dissemination of Sciences. She is involved on the production and evaluation of multimedia pedagogical applications for science learning. She published in co-authorship, articles in magazines of chemistry teaching, pedagogical applications of ICT, particularly in Chemistry, and scholar textbooks of Physics and Chemistry. She is particularly involved in Teacher Training in the Faculty of Sciences, University of Porto.
- The main research interests of Maria de Fátima Paixão lie on Science Education, History and Philosophy of Science, STS Education, formal and non-formal education relationships. She is an expert for the Secondary Education Program of Science Technology and Society and scientific advisor to a guide book of the Ministry of Education for the National Program for Teachers Training in Experimental Sciences and, also, expert in the Program of the General Inspectorate of Education in the Assessment of Basic and Secondary Schools.
- The research area of Maria João Melo is Chemistry applied to the conservation of Cultural Heritage, and other areas of interest include Historic Dyes, Colour in Art and Nature, Medieval Illuminations and Polymers in Conservation. She is particularly committed in crossing the borders of "soft" and "hard" sciences, promoting a fruitful dialogue between these different cultures.
- Mónica S. N. Oliveira holds a Ph.D. in Chemical and Process Engineering and her main research activities are in the general area of fluid mechanics and transport phenomena. She has also been involved in several science communication activities, developing an experimental kit (including lab material, booklet and webpage) to be used in class (physics & chemistry) and in science clubs.
- Paulo Ribeiro Claro is author and co-author of ca. SCI 110 papers on the subject "Molecular and Supramolecular Structure". He is also interested in Public Awareness of Science activities, being the coordinator of the Portuguese Chemistry Olympiads since 2000. He is co-author of the chemistry demonstrations activity "Química por Tabela" for FÁBRICA Science Centre (2008, 2011), has regular participation in radio science programs ("Eureka!"/TSF and "ClicK!"/Antena 1), and is the coordinator of the media project "The Chemistry of Things" (TV, radio, newspapers and web, 2011-2012).

3. MAIN OBSTACLES TO STUDENTS' MOTIVATION TO LEARN CHEMISTRY

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. According to Martins et al. [9], three factors can be pointed out as the main obstacles to student's motivation to learn chemistry: (1) The negative image of chemistry in general society; (2) The type of curriculum, teaching strategies, didactic resources and lack of teacher's dynamic actions to incentivise the involvement of students into the discipline; (3) Teachers training, their conceptions and convictions.

In this context it is generally accepted that motivation to study chemistry can be increased by improving the image of chemistry in society and in school. This can be achieved through non-formal activities, such as the ones involving the participation of scientific researchers, highlighting the numerous positive and appealing aspects of several chemistry applications, i.e., approaching scientists to general society. Inside school, the type of curriculum and teaching strategies are essential factors. Some studies pointed out that teaching

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chemistry in context seems to motivate students in their classes. This approach is currently being followed in the Portuguese Education System.
Chemical laboratorial activities can also improve positive attitudes towards chemistry and promote cognitive growth. Studies indicate that inquiry-type experiments lead to a more positive attitude towards chemistry learning. In terms of laboratory learning methods, students generally show more enthusiasm if learning through collaborative and peer tutoring work.
The importance of a learning environment where students feel comfortable to communicate their points of view and exchange ideas with their peers and teacher should also be stressed as it contributes for their development and motivation affecting the way they learn and develop/acquire competences.
Next, the following studies/reports will be documented and the main conclusions stressed out:

- National reports/initiatives where motivation to study chemistry is addressed. Two reports will be in focus: (1) The white book of physics and chemistry – Students' opinions 2003; and (2) Motivation of Portuguese youth to study science and technology in higher education. 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 at national level and with this dimension were done and/or published.
- International reports/initiatives. Two reports will be in focus: (1) The main results and trends of the International Mathematics and Science Study published in 2011 (TIMSS 2011). This international study was conducted by the International Association for the Evaluation of Educational Achievement (IEA). TIMSS 2011 presents information on student's performance in science, including trends over the five assessments since 1995; and (2) The main results and trends of the International Student Assessment performed in 2009 (PISA 2009). PISA 2009 includes an evaluation at three levels: reading literacy, mathematics literacy and science literacy, with a priority focus on the first component.
- Chemistry is all Around Network initiatives concerning student´s motivation to learn chemistry, namely a summary of the reviewed national publications and comments analysis (posted by Portuguese teachers/experts and by non-national teachers/experts to the national documents).

3.1. NATIONAL REPORTS/INITIATIVES [10-12]

3.1.1. 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. The students sample included 7900 individuals, covering all the continental territory, evaluating the 9th, 11th and 12th 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 9th and 11th 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 taught 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 12th year were the fact that these courses were not specific for their career and a potentially low final classification might difficult higher education access;
- 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 exercises solving; 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, as well as 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.

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3.1.2. 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 the number of students following a career in science and technological 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 1st 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 (11th and 12th grades). Two important conclusions were selected and are summarized here:

- The importance of students' performance on Mathematics at secondary level, influence 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.

3.2. INTERNATIONAL REPORTS/INITIATIVES [13-16]

3.2.1. The International Mathematics and Science Study 2011(TIMSS 2011)

The TIMSS evaluates students from the 4th and 8th grades. In the present study Portugal participated only at the 4th grade level. The TIMSS science assessment is based on a comprehensive framework developed collaboratively with the participating countries that are organized around two dimensions: content and cognitive dimensions. For the 4th grade, content is evaluated considering the specific areas of Life Sciences, Physical Sciences and Earth Sciences. Cognitive dimension considers the following mental processes: knowing, applying and reasoning. The main conclusions are summarised in the following points:

- The overall results pointed out that Portugal raised the level of science achievement since 1995;
- No significant gender difference in science achievement was observed;
- 75% of the students achieve an intermediate benchmark level meaning that they know/understand pratical science facts, 35% raised the high level meaning they can apply knowdlege/understanding to explain everyday and abstract situations. 7% achieve the advanced level, i.e., they have shown scientific inquiry skills. They were able to select and justify an appropriate experimental method.
- Students with the highest science achievement typically attend schools that emphasize academic success, as indicated by rigorous curricular goals effective teachers, students that desire to do well, and parental support.

3.2.2. International Student Assessment 2009 (PISA 2009)

The acquisition of literacy is a lifelong process that takes place not just at school or through formal learning, but also through interactions with family, peers, colleagues and communities. PISA measures 15-year-old students' ability to complete tasks relating to real life, tapping a broad understanding of key concepts, rather than limiting the assessment to subject-specific knowledge. The results of the PISA 2009 assessment pointed out that the Science results of Portuguese 15-year-old were below the OECD average in 2009. Nevertheless, there was a significant improvement in the average scores between 2006 and 2009.

3.3. CHEMISTRY IS ALL AROUND NETWORK INITIATIVES [8]

Considering the thematic "Students' motivation to learn chemistry", 5 national publications have been reviewed and a paper presenting the state of the art and the future perspectives was written. These resources were commented by non-national teachers and experts. Table 4 presents the set of selected publications.

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Table 4. Selected publications and number comments received.

Title	Authors	Year	Language	Comments	Reference
Motivation of Portuguese youth to study science and technology in higher education	Leitão, L.M., Paixão, M.P., Tomás da Silva J.	2007	PT	0	[17]
Questioning patterns and teaching strategies in secondary education	Albergaria-Almeida, P.	2010	EN	1	[18]
Digital resources in lower secondary chemistry education: an experience with enthusiasm and constraints	Morais, C., Paiva, J.	2008	PT	0	[19]
Student generated recommendations for enhancing success in secondary science and mathematics	Conboy, J.E., Fonseca, J.M.B.	2009	EN	1	[20]
Student perceptions of the secondary science teachers' practices following curricular change	Carvalho, C., Freire, S., Conboy, J., Batista, M., Freire, A., Azevedo, M., Oliveira, O.	2011	EN	1	[21]

Some important conclusions resulted from the reviewed publications summarised as follows:

- The study of Leitão et al. [17] 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. One of the main conclusions of this study is the importance of Mathematics for the choice of courses in the areas of science and technology, including, of course, Chemistry related careers. Another important aspect is the role of a capable vocational orientation for a better match between school subjects and career objectives that students elaborate during their basic and secondary studies.
- Teacher's and student's role in classroom questioning was examined, as well as the relationship between the questioning patterns and the teaching strategies in the work of Albergaria-Almeida [18]. The study was conducted by three secondary school teachers dealing with three different disciplines (philosophy, Portuguese (native language) and chemistry). The treated subject (Questioning patterns and teaching strategies in secondary education) is of major importance and influences students' engagement at the class, which can promote motivation. It was put in evidence the distinct teaching strategies and patterns of questioning depending on the analysed class. Concerning this point, the chemistry teacher involved in the selected sample followed a fact-based questioning strategy. This is an interesting point of reflection since science and science enquiry are intimately related to an active questioning environment.
- Morais and Paiva [19] present a report on how our current information society is reflected in the type of education and motivation of students. The study relates the motivation of students to learn Chemistry with the use of diverse type of digital resources, especially designed for that purpose (6 videos, 6 games, 2 animations and 2 simulations), based on a small sample of twenty-one 7th grade Portuguese students (mean age of 12 years old). Very promising qualitative results were obtained, with the following main conclusions being drawn by the authors: (1) The students enjoyed the classes dedicated to the exploration of digital resources; (2)The use of digital resources seems to be an extra factor of motivation, also for the novelty factor; (3)The students are unanimous in recognizing the advantages of teaching resources and the use of scripts to exploit them and (4) Students recognize that they have learned more.

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- The work of Conboy and Fonseca [20] deals with the importance of listening students as a strategy to enhance success in secondary science and mathematics. Although the implementation of student recommendations may not be appropriated in all cases, their suggestions can be useful to identify critical areas, and could offer sound advice to teachers and educational leaders. In particular, students involved in this study pointed out that one approach to improve motivation consists of diversifying teaching methods, varying the routine of classroom activities. They also demand a greater student's input in defining and implementing practical, experimental and real-life activities. Also they feel that a positive classroom environment, which could be attained by teachers who enjoy teaching, who are patient and fair, and concerned with student understanding, is positive.
- In the work of Carvalho et al. [21] the authors tried to find an association between student perceptions and their motivation to study science. Some very interesting results were obtained, by studying three groups of low motivated students, from upper secondary school (a total of 59 students from 11th and 12th grades). According to the authors, significant associations were observed between intrinsic motivation and three dimensions of student perception: (1) Perception of the use of laboratory work; (2) Perception of science-technology-society and (3) Perceived student autonomy. An unexpected result was that no association was found between intrinsic motivation and the perception of teacher as facilitator.

The reviewed publications have received few comments from non-national teachers and experts. Moreover, the originally written in Portuguese received no comments. In general the comments express their accordance with the conclusions drawn in the presented studies. In some cases advices and recommendations were included. For example, the following recommendation was posted to the work of Conboy and Fonseca [20] "It would be interesting to know whether some the students' requests were indeed implemented and what effects these had on their results". To the work of Carvalho et al. [21] the following comment was posted "In my opinion, it is true that we, as teachers, need to move beyond the traditional teaching methods in a world that constantly changes". Nevertheless it was also pointed out that usually the published works fail to give "specific directions/practical advice/modes of action relevant to how this can be achieved in practice". Moreover "there is no reference to the difficulties that teachers may face during this process". To the work of Albergaria-Almeida [19], this final conclusion was posted "Although the study is performed on a small sample and it is not exclusively focused on chemistry, it proposes reflections that should be born in mind by chemistry teachers - at any school level - seeking for strategies to motivate their students".
In conclusion, although based in a small set of comments, the reviewed documents were found interesting by the portal users. We hope continuing receiving feedback from non-national teachers and experts in the next project year.
The paper presenting the state of the art and the future perspectives had more receptiveness being commented by 6 non-national portal users among the following countries: Belgium, Turkey, Bulgaria, Ireland and Greece. This work describes aspects related to the motivation of secondary school students to learn chemistry. The topics were discussed considering IPB experience in a polymer chemistry education project and its regular participation on a set of science communication activities. The lack of motivation is supported on three main factors: (1) the negative image of chemistry in society; (2) the type of curriculum and its contents, teaching strategies, didactic resources, and (3) teachers training. Concerning the context-based aproaches as a motivating element the following comment was made "A very important aspect of chemistry teaching in context is its potential to motivate students including for conceptual learning during and after academic studies. Contexts should be familiar and relevant for students (for girls and boys), not distract students from the related concepts; not be too complex or confused for students". Considering the negative image of chemistry in society, "discussion about actions that would invert the image of chemistry is needed". Moreover, developing "an attractive catchphrase of chemistry inspiration" is important. The promotion of non-formal activities was considered interesting and feasible, "but not adequate for addressing the existing problem" of lack of motivation. Other comments pointed out that the work does not "discuss the difficulties of chemistry teachers to keep update to the continuous progresses of the research but give good examples of application of different activities to promote chemistry among students and society".
Summarizing, the following major conclusions could be stressed out: (1) Context-based approaches are recognised as relevant to motivate students, (2) Chemistry image in society needed to be promoted focusing

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more positive aspects, (3) Non-formal activities are interesting approaches but could not per see solve the existing problem of the lack of motivation and (4) It is important to effectively support/help teachers to get updated. Additionally, the importance of laboratory instruction was emphasized as it improves students' motivation.
Considering the comments made by Portuguese teachers and experts to the non-national papers and publications, only 3 were made. The conclusions that could be taken from the preformed comments are in line with the previously stated, reason why no detailed analysis is presented.

4. ANALYSIS OF TEACHING RESOURCES [8]

In this section a summary of the innovative resources and materials to teach chemistry, identified at national level, are provided. The complete information is available at the project portal. Tables 5 and Table 6 list the 20 teaching resources (TRs) selected by IPB. They are divided in 2 groups according to the language they were originally developed. Table 5 presents 11 Portuguese resources and 1 developed in Brazil. The remaining TRs were developed in USA and are presented in Table 6.
From the first group, only two TRs, highlighted in Table 5, are partially translated in English (TR2 and TR6). Here, TR2 "The Chemistry of Things" clearly stands out, with 5 comments. The remaining TRs had no comments. A possible explanation could be the difficulties with the translator tool available at the portal that made Portuguese resources less attractive as a first choice.
Starting with TR2 ("The chemistry of things"), this is a media project that shows the relevance of Chemistry in every day's life, including some recent scientific findings. According to the comments of non-national teachers and/or experts, though it is not an innovative didactical approach, it can introduce students to new topics in a very motivating way. It can be used as an introductory element adapted by the teacher to their course topics. Each video episode lasts 2-3 minutes, with a scientifically rigorous and appealing script and attractive animations that are presented by a young person, seen as a peer by students. The possibility of including subtitles in several languages is an important asset and according to the comments, it could allow their use in other countries.
The other resources from Table 5 had no comments. However, the main features will be described:

- TR1: This is a very interesting resource that introduces students to the chemistry of color, historical use of pigments and its manufacture while dealing with Medieval Illumination. The step-by-step "Towards color discovery in Medieval Illumination" is organized in three main areas: Introduction, Notebooks and Annexes. The notebooks can be used independently to implement activities in classroom, during study visits or in a workshop.
- TR3: "Acessa Física" integrates a set of educational resources (audiovisual, audio, software and experimental protocols) devoted to teach Physics to intermediate level students. This is a very interesting site where physics contents are explored rigorously from a scientific point of view using an appealing, intuitive and user-friendly interface. Nevertheless the site is presented as physics devoted one it includes several materials that can be used in chemistry classes. This is a valuable tool for physics-chemistry teachers. Face to the presented quality, attractiveness and pedagogical approach, we believe that this site could be used as a model for other science teaching resources.
- TR4: Ciência@Bragança presents a set of interesting resources that can be used to support teaching activities or serve as a motivation tool. Additionally, Ciência@Bragança site includes a virtual consulting office where questions can be addressed in order to be answered by scientific experts. The site is devoted to promote science to general public but it can be also considered as a valuable teaching resource tool.
- TR5: This resource was developed for students of the 9th grade (~14 years old) that are studying the periodic table and is composed by several games related to elements and their properties. It is a playful activity that can be used to consolidate and memorize theoretical concepts about elements, after an introduction made by the teacher. This interactive resource can be used by teachers in the classroom, as a motivating activity, and by students in their individual study, at home.
- TR6: This portal presents several molecular simulations that can be used in Chemistry and Physics teaching. The activities presented in this website can be used in the context of a classroom, as a complement to the theoretical concepts presented by the teacher.

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- TR7: This user-friendly resource can be used at an introductory course of Chemistry as it illustrates basic concepts related to the formation of molecules and ionic substances. It is constituted by two programs: 1. Molecular chemistry; 2. Ionic substances. Both programs can be used by the teacher in the classroom or by the student to practice at home.
- TR8: Skoool is an innovative website of e-learning, developed to work in several devices and technological platforms: PC, PDA and mobile. It enables online and offline work modes. Skoool technology can be used by teachers to support classes or used as a self-learning tool by students. The website provides guides for both teachers and parents.
- TR9: The resource is very well organized in terms of simulation and theoretical contents related to concentration, in order to be used by different education levels, from lower secondary school to university level. Part of this resource is interactive, as students can simulate the preparation of a solution by selecting both the amount of an electrolyte and the volume of water and, then, to obtain the value of correspondent concentration.
- TR10: According to the authors, this collection of experiments aims to introduce a practical component in the study of physical properties, so that students can "feel" their physical meaning and understand their relevance in the materials behaviour. Starting from very simple materials, it proposes short and appealing experiments to explore several properties such as density, viscosity and surface tension. The interpretation of experiments can be adapted, with more or less deepness, to the study level of students.
- TR11 and TR12: Another interesting teacher resource is provided by webquests in which most or all the information that learners work with comes from the web (http://webquest.org/index.php). It has an inquiry-oriented lesson format with the following structure: Introduction; Tasks; Process; Resources; Evaluation; Conclusion. This type of methodological activity is designed by teachers. The investigation is made by students, using informatics tools to consult online information. All the research elements/tasks are organized so that students are focused on the project. Two examples are provided by TR 11 and 12. These web resources could be easily translated and adjusted to other countries, using local examples.

The remaining eight TRs developed in the USA, therefore originally in English, were object of the majority of comments, a total of 11.

Table 5. Selection of teaching resources originally developed in Portuguese.

Title of teaching resource	Name of author(s)
1. À descoberta da Cor na Iluminura Medieval - step by step (Towards colour discovery in Medieval Illumination - step by step)	Departamento de Conservação e Restauro Faculdade de Ciências e Tecnologia Universidade Nova de Lisboa
2. A Química das coisas (The Chemistry of Things)	Paulo Ribeiro Claro (Universidade de Aveiro), Science Office and Duvideo Filmes.
3. Acessa Física	IEASC - Instituto de Estudos Avançados (USP) DICE - Centro de Divulgação Científica e Cultural (USP)
4. Ciência@Bragança	Centro Ciência Viva de Bragança Instituto Politécnico de Bragança
5. Jogos em Química (Games in Chemistry)	Isabel Ramos, Flora Ferreira, Paula Gomes, Vitor Gil e João Paiva
6. Molecularium - Simulações em Química Física (Physical Chemistry Simulations)	João Paiva, Victor M.S. Gil, Carlos Fiolhais, Pedro Vieira Alberto, Delfina Almeida, Jorge Gonçalves, Manuel Salgueiro, Susana Fonseca, Ilídio Martins
7. Química molecular e Substâncias Iónicas (Molecular Chemistry and Ionic substances)	Ricardo Sousa Rodrigues
8. Skoool.pt	Intel, Castelo Branco Municipality, University of Coimbra, Polytechnic Institute of Castelo Branco.

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9. Soluções aquosas de elétrolitos fortes (Aqueous solutions of strong electrolytes)	Carla Morais, João Paiva, Maria das Dores Silva, Carolina Alves, Ilídio Martins
10. Tudo Flui (Everything flows)	Mónica Oliveira (project coordinator)
11. WebQuest: Investigando as chuvas ácidas (Investigating the acid rain)	Maria do Rosário Beleza
12. WebQuests: 1. 2010 Viagem no espaço! (2010 Travel in space!) 2. A Química no rasto do crime! (Chemistry in the track of crime!) 3. Sensibilizando para a energia limpa! Raising awareness for clean energy!)	Carla Morais e João C. Paiva

Table 6. Selection of teaching resources from USA.

Title of teaching resource	Name of authors	Number of comments
13. Chemistry Experiment Simulations and Conceptual Computer Animations	Tom Greenbowe (Iowa State University)	4
14. ChemVLab+ project	Jodi Davenport	---
15. Cool Science	Howard Hughes Medical Institute	1
16. Free Online Stoichiometry Course	David Yaron, Rea Freeland; Colin Ashe; Michael Karabinos; Kirk Zhang; Keith S Williams; Nathan Dobson	---
17. Rader's CHEM4KIDS	Adrew Rader Studios	1
18. The Macrogalleria	Department of Polymer Science - University of Southern Mississippi	1
19. The Web-based Inquiry Science Environment (WISE), 4th Generation	The Technology Enhanced Learning in Science Community (TELS)	1
20. Virtual Chemistry Experiments	David N. Blauch (Davidson College)	3

- TR13: The website presents a collection of Chemistry Experiment Simulations and Conceptual Computer Animations, appropriate for university and upper secondary school students. They can be used to illustrate and support several concepts, given in the classroom. Many of the simulations reproduce laboratory experiments and have an associated tutorial. The webpage provides a script on how to use the software and proposes a set of experiments and related questions to students. According to the comments of teachers/experts, this TR helps to explain complex abstract concepts at a microscopic level, resulting in better understanding of concepts and, hopefully, to an increase of student's motivation.
- TR14: This resource contains the simulation of four experimental activities covering topics such as concentration, unit conversion, molar mass, balancing reactions, and stoichiometry use. The more innovative features include the Virtual Lab activities with embedded assessments that are aligned with core high school chemistry content and inquiry standards. Students are able to achieve the purpose by themselves since as they solve the questions they are not allowed to continue if the answer is not correct and in that case, doubts are clarified.
- TR15: Cool Science is a general science site that includes chemistry related topics. It is organized in five topics: Ask a Scientist, Curious kids, BioInteractive, For Educators, Becoming a Scientist. Additionally, a link to the educational project Science Education Alliance (SEA) developed by the Howard Hughes Medical Institute is presented. Although this is a general science site with emphasis on biomedical research, several topics with interest for chemistry teachers can be found. This site puts in evidence the interdisciplinary of some research topics and highlights the importance of approaching scientists to school teachers and students. This aspect is clearly visible in the topics "Ask a Scientist"

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and “Becoming a Scientist”. Cool Science is a site of high scientific level and offers innumerous useful teaching resources possibilities. This TR had one comment from a primary school teacher that suggested that this site would be more appropriate for secondary school students.

- TR16: This course can be taken by secondary school students as an additional resource to practice stoichiometry and by university students that would like to review this thematic. The learning script is very well organized, with an attractive design. It is very appealing as the chemistry topics are integrated in a real world scenario where problems need to be solved. One of the biggest points of strength is the variety of activities: videos, worked problems and experiments in a virtual lab.
- TR17: Chem4Kids presents basic chemistry information in an illustrated textbook-like format with attractive graphics. Some of the pages are interconnected by links redirecting the user to other pages (whenever a concept needs to be introduced). This constitutes an interesting strategy, where each user can follow its own learning plan. At the end of each subject, a quiz is presented aiming at “check for understanding”. Concepts are clearly explained and in context with real everyday life facts, which is quite motivating for students. Being more adequate suited to middle, intermediate and high school students. It can be used to review subjects, to support assignments and act as a supplement to traditional textbooks. This TR had one comment suggesting that this resource “could be very useful for chemistry students outside the classroom”, classifying it as “a very good instructive tool to supplement work being covered in class”.
- TR18: The Macrogalleria is a “cyberwonderland of polymer fun”. It could be a valuable tool for teachers who want to follow an everyday life chemistry approach, as well as to teach technological aspects, which are key issues in actual chemistry curricula. It presents two versions (The Macrogalleria and Kids’ Macrogalleria) making it easily adaptable for students of all levels and general society.The site is well organized following a structure of interconnected levels (topics) where each user can design/follow its own network. This TR had one comment stating that “it may be used for self-learning”; “it highlights the close relationships between polymers and everyday life and is likely to promote the students’ interest towards chemistry” and “This site can be exploited by science teachers as a teaching support, in spite of the low interactive character and although it does not propose any innovative didactical approach”.
- TR19: The Web-based Inquiry Science Environment is an online platform that includes at least 23 projects in the areas of General Science, Earth Science, Life Science, Physical Science, Biology, Chemistry and Physics. All of the projects are very well characterized in terms of the scientific topics covered; duration of the activity; software needed and study level of students. They also provide Teaching Tips & Content Standards. The WISE platform is an extremely valuable source of inquiry-based digital resources. The projects have been specially developed to be used in classroom context which facilitates their introduction in the curriculum. The projects use an enormous variety of online interactive tools which make them quite appealing. This TR had one comment stating that the site was not very easy to use and its application in the context of a classroom would not be very straightforward.
- TR20: Virtual Chemistry Experiments include a set of interactive web-based chemistry tutorials where several experiments and apparatus are simulated. Its interactive features allow the user to control a few parameters. According to the author “The guiding concept is to involve the read in making observations and acquiring data, and then using this information to draw conclusions and infer chemical principles.” They present high pedagogic value but, unfortunately, their use is restricted to English speaking students and teachers. Nevertheless, the author provides documentation for the chemistry applets, so that teachers can adapt and write their own web pages. Another point of strength is the fact that files can be downloaded and installed on local computers. This TR had three comments: the first comment mentions that though the resource is very interesting, it would need to be adapted to be used in the classroom; the second comment suggests that these virtual tools can be used as a support to experimental activities or as a replacement when no laboratorial conditions exist; finally, the third comment also suggests that these simulations can be very useful in the area of molecular and physical chemistry but, again, should complement but not replace lab experiments.

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A total of 27 comments were posted by our national team of teachers and experts that have selected 20 non-national teaching resources, as listed in Table 7. Following, a selected fraction of the comments is presented. The complete version is available at the Portal.

- TRA: The two comments praise the variety of activities proposed here, useful both for teachers and students, to be used in the classroom or for individual work at home. It is described as a resource capable to motivate students and enhance their scientific curiosity. One of the teachers also reinforces that the use of digital resources should serve only as a complement to experimental work and to traditional exposure of concepts.
- TRB: The teacher considered this resource particularly useful for 12th grade students. Additionally, visualization of 3D structures that are difficult to build using traditional models of molecules, is highlighted. The only drawback pointed out, was an apparent bug found when using the software.
- TRC: The expert positively evaluates this site, suggesting that students can learn faster the scientific concepts under study (infrared and Raman spectra interpretation). Also, it is mentioned that "*the simplicity of the site makes it effective…*". Only one drawback was described as apparently it was not possible to enlarge the spectra image.
- TRD: The teacher thinks that this is an user-friendly site for lower and upper secondary school students, with very diverse type of well-structured resources, stating that it can be a highly motivating and innovative approach in chemistry teaching.
- TRE: The expert appreciates the idea to present monthly-based information about a specific molecule and the related contents are considered appealing and interesting. For lower secondary school students, it should require teacher guidance. It is also suggested some planning in the organization of the information in the long term to maintain its utility.
- TRF: The teacher characterizes this resource very positively suggesting its use in the classroom as a complementary activity to the theoretical concepts and as a factor of motivation for students, allowing them to learn in an easier way.
- TRG: The teacher suggests that the contents of this resource cannot be directly applied in the classroom, as they are not clearly related to the school curricula. However, they can be helpful and motivating for students.

Table 7. Non-national teaching resources commented by our teachers and experts.

Title of teaching resource	Name of authors	Number of comments
A. 100cia química (chemistry science)	José António Pascual	2
B. 3DMolSym (Molecular Symmetry)	Nickolas D. Charistos, Scientific supervisors: Michael P. Sigalas, Constantinos A. Tsipis	1
C. 3DNormalModes (Normal Modes)	Nickolas D. Charistos, Scientific supervisors: Michael P. Sigalas, Constantinos A. Tsipis	1
D. An Introduction to Chemistry	Mark Bishop	1
E. Chemical Compound of the Month	Valavanidis Athanasios, Efstathiou Constantinos (Eds.)	1
F. Chemical reaction	A. Willm	1
G. Chemistry at Home	Salta,K.; Gekos, M.; Koulougliotis, D.; Petsimeri, I.	1
H. Chemistry for Juniors - Sci-spy	National Centre for Technology in Education	1
I. ChemLab	Model Science	1

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J. Discover Primary Science Activities	Various	1
K. FisQuiWeb	Luis Ignacio García González	1
L. juniorLAB	Nickolas D. Charistos, Scientific supervisor: Michael P. Sigalas	1
M. Learn Chemistry	Royal Society of Chemistry	1
N. PARSEL (Popularity and Relevance of Science Education for Science Literacy)	Consortium of 9 partners from 8 European Countries (University of Ioannina, University of Lisbon, ICASE London, Free University of Berlin, IPN Kiel, University of Tartu, Weizmann Institute Rehovot, Lund University, University of Southern Denmark Odense)	1
O. PhET	Kathy Dessau, Linda Wellman, Noah Finkelstein, Chris Malley, Noah Podolefsky, Mindy Gratny, Jonathan Olson, Julia Chamberlain, Danny Rehn, Sam Reid Oliver Nix, Ariel Paul, Kelly Lancaster, Emily Moore, Kathy Perkins, Trish Loeblein, Michael Dubson, Robert Parson, John Blanco	7
P. RSC – Advancing the Chemical Sciences	Royal Society of Chemistry	1
Q. Tavola Periodica degli Elementi	Riccardo Pettinari, Ivan Timokhin, Corrado Di Nicola, Claudio Pettinari, Fabio Marchetti	1
R. The Periodic Table of Videos	University of Nottingham	1
S. Virtual experiment: viscosity explorer	SEED (Schlumberger Excellence in Educational development, Inc.)	1
T. World of Chemistry	Roald Hoffman *et al.*	1

- TRH: This comment was made by a primary school teacher that mentions that this “is one of the few resources that are primarily oriented to the school population of the basic education”. The main points of strength pointed out are the documentation provided for teachers; the short and motivating videos that mostly start from real situations of people’s everyday life. Therefore, the teacher concludes that “this is an innovative resource that can be more easily understood by students”.
- TRI: This resource is considered by the teacher as very useful as the execution of virtual experiments may replace lab experiments helping to surpass economical and/or time restrictions. Also, the teacher refers that “This software potentially increases student’s interest towards chemistry, since they usually enjoy ICT-based resources”. Also he considers that it can improve student’s learning, however, laboratorial practice is essential.
- TRJ: The expert mentions the “large spectrum of science activity sheets, providing helpful instructions for science activities”. Additionally, she believes “this website, given the quality and diversity of the resources it provided, can increase students' interest toward chemistry, in particular, and sciences in general” and that “this kind of resources can help the students to understand better and faster because the values and content are usually presented mainly through playful aspects distributing scientific information along fictional narratives and simple activities, which may contribute to arise curiosity and prepare the brains of younger for processing more complex knowledge”.
- TRK: The teacher made a comment to this resource based on her experience using a specific simulation/interactive experiment available at the website, related to the study of Snell's law. She recognizes the importance of this type of digital resources as there are schools that do not have the

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laboratory equipment to perform such experiments. She also refers that it can be easily adapted to be used in the classroom.

- TRL: The teacher states that "This resource proves to be interesting as a motivational tool for studying the chemical nature of substances". He also mentions that it is more adequate for students from 7th to 9th grades, and highlighted the high interactivity, the possibility of being used individually at home, as a complement to the experimental activity in the classroom. Finally, he mentions that "At a graphical level, this resource is very well designed, very intuitive, even managing to work around any language issue".
- TRM: This site is classified as excellent by the expert that mentions the wide variety of resources of high quality, appellative design and adequately organized. According to the expert, "A few resources may promote innovative didactical approaches if effectively integrated in a teaching plan". "The main limitation of this site seems to arise exactly from its dimension: with more than one thousand resources, navigation through it will turn to be a big challenge for beginners".
- TRN: According to the expert, "PARSEL modules, developed under this project are a set of teaching strategies for science approach through social and ethical problems that show a high potential and usefulness for teaching and learning science". In terms of proposing an innovative didactical approach, the expert agrees by referring that "PARSEL modules are extremely facing for contextualized prospects and engaging in real situations and allow teachers to implement approaches based in IBSE". "The IBSE promotes learning through creativity, scientific problem solving and decision-making procedures socio-scientific". Note: IBSE stands for Inquiry-Based Science Education.
- TRO: This resource clearly stands out having 7 positive comments from Portuguese teachers. Many of them already have used some of the simulations presented at the PhET website in their classrooms, for example, to study: Energy conservation, Radioactivity, Blackbody spectrum, Acid-base solutions and States of matter.
- TRP: According to the expert, "A site full of information and where you can always find something interesting to bring to the classroom, or share with students. I especially liked the periodic table and the videos about the elements, produced by the University of Nottingham, although it is necessary to note that hosts presented themselves with a somehow old-fashioned archetype for a young student or a curious person...".
- TRQ: The teacher evaluates this site very positively: "The structure and organization of the Periodic Table of Elements available in this website constitutes a very important pedagogical tool, privileging a simplified and fast access to several chemical concepts. The teacher can propose to students, exploration tasks based on the existing portal contents. From the analysis and treatment of the collected data, students are able to acquire competences to relate element position with its physical and chemical properties. The presented experimental activities based on a video/film platform assume a huge importance since they can surpass the inexistence of equipment and laboratorial conditions in several schools. Moreover, they contribute to enhance motivation and learn outcomes, helping to understand elements chemical/physical transformations. From this starting point the teacher can lead students to establish relationships between microscopic and macroscopic properties." She makes a final suggestion "In my opinion it would be interesting to upgrade the site in order to include subjects such as variation in ionization energy and electron affinity, which are subjects of recognized difficulty for students".
- TRR: The expert acknowledges "The technical quality of the videos is high, since they result from collaboration between scientists and professional journalists". Another huge advantage of this site is also pointed out "In most cases, the experiments cannot be replicated in a classroom environment (because they involve expensive chemicals, present safety problems, or require highly specialised equipment), and thus the videos have great potential for use in a teaching context, since they have the correct blend of scientific information and visual appeal". The expert concludes "Overall, this teaching resource is very appealing, having the potential to increase student's interest toward chemistry and their ability to better understand the underlying concepts".
- TRS: The expert starts by mentioning that "The virtual experiment is probably of limited use in the classroom (unless time and basic resources are an issue), but its simplicity and visual appeal mean that it can be used as a learning resource by people of all ages, for example in the home environment.

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Furthermore, it can serve as a basis to develop an in-class experiment". She also suggests the use of a more general link (http://www.planetseed.com/science/lab/) as it contains a large amount of additional valuable information for other experiments: "In each experiment, a detailed protocol with illustrations is provided, both in html and as a downloadable pdf file (the latter can be directly used as a handout in class), as well as teacher's notes, providing further in-depth information, safety concerns, expected results, etc. Very interestingly the site, as well as the downloadable files, is translated in several languages, including Portuguese and Spanish, which may be of added value to school teachers. The experiments are simple, well-conceived and tested, and focus on materials and properties of relevance in day-to-day life".

- TRT: According to the expert, "A site where science is still shown with videos of 90 minutes... Too long for our frenetic times, without HD, but with very good ideas and a vision of chemistry that reminds us that being a chemist is one of the most beautiful professions one can imagine".

5. WORKSHOP

The first Workshop on the topic "student's motivation" took place at the Polytechnic Institute of Bragança, in Portugal on September 20th, 2012. A total of 17 persons have participated in the workshop:

- 2 teachers from the 1st cycle;
- 1 teacher from the 2nd cycle;
- 9 teachers from the 3rd cycle and secondary school;
- 1 expert via virtual communication;
- 4 members of the IPB team.

5.1 CONTENTS OF THE FIRST WORKSHOP

The agenda of the meeting was as follows:

- Presentation of a teaching resource and practical activities. The expert Carla Morais organized a virtual multimedia presentation available at http://www.emultimedia.com.pt/carla/workshop/.
- Presentation of teachers' and experts' comments about the papers on student's motivation uploaded by Partners on the Project Portal.
- Presentation of teachers' and experts' comments about the teaching resources uploaded by Partners on the Project Portal.
- Discussion on the national availability of ICT resources to teach chemistry and science at different levels and on the difficulty to select suitable teaching resources.
- Description of the future activities.

5.2 MAIN RESULTS OF THE WORKSHOPS

From the analysis of the Chemistry is all around Portuguese teachers' opinion, the main aspects are summarized here, from the minutes of the meeting:

- The motivation to study chemistry in the Portuguese context decreased as a result of the last years curricular reformulations (particularly in the 12th grade, where chemistry is nowadays 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. 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 centred, motivating an autonomous and active thinking/learning process; they should be scientifically validated resources; in the case of digital

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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 by laboratory work.

6. CONCLUSIONS

Student's motivation to learn chemistry in Portugal was presented based on both literature and analysis of the teachers and experts opinion expressed in the project portal. From the preformed analysis it is consensual that, chemistry has successively lost importance, both from students' and schools' point of view.

During this first year, the project Portal was created and users recruited, being the Portuguese team composed by 5 experts, 7 schools and 18 teachers. Considering the thematic "Students' motivation to learn chemistry", 5 national publications have been reviewed and a paper presenting the state of the art and the future perspectives was written. 20 ICT-based resources have been collected and reviewed. 1 workshop was organized by the Portuguese partner. The uploaded resources have been commented by the portal users.

Summarizing, the following major conclusions could be stressed out from the analysed comments: (1) Context-based approaches are recognised as relevant to motivate students, (2) Chemistry image in society needed to be promoted focusing more positive aspects, (3) Non-formal activities are interesting approaches but could not *per see* solve the existing problem of the lack of motivation and (4) It is important to effectively support/help teachers to get updated. Additionally, the importance of laboratory instruction was emphasized as it improves students' motivation.

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