Edmuse project

O1 Intellectual Output – Best practices analysis – Portugal

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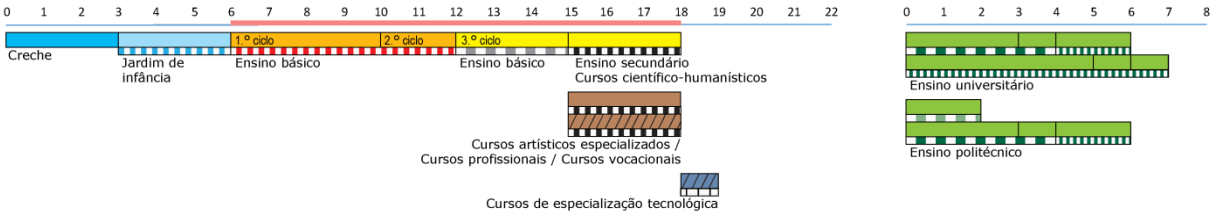
Contents

1) Description of Education System of Portugal and correspondence school levels of 8 to 12 age (Eurydice) and related school curriculum

The Portuguese educational system

The Portuguese educational system includes four levels of studies (Fig. 1): Pre-school, optional, for 3 to 6 years old children; Basic Education, which comprehends nine years of schooling, subdivided into three cycles (4 years - First Cycle + 2 years - Second Cycle + 3 years - Third Cycle), for 6 to 15 years old pupils, and Secondary Education, with three year grades; plus the Higher Education, usually from 17-18 year olders onwards (Fig. 1). From the academic year of 2009-10[1], compulsory lasts for twelve years, that is, until the end of Secondary Education.

Figure 1 – Cycles of studies in Portugal (Eurydice, 2016)



Curricular goals

Basic Education[2] aims to "Ensuring a common general background education to all Portuguese, which guarantees the discovery and development of their interests, skills, reasoning ability, memory and critical thinking as well as creativity, moral sense and aesthetic sensibility, in order to promote individual fulfillment in harmony with the values of social solidarity. "Overall, it is intended that compulsory schooling ensures a diversified formation, which allows the individuals' integration into society and the exercise of their active and responsible citizenship, both in national and in international contexts.

These goals support the curriculum that is defined at the national level by the Ministry of Education. According to the current laws, the curriculum integrates contents, aims and guiding principles that are converted into each subject syllabi and learning outcomes. Integrated into a broader trend of reduction of government control in countries with a more centralist tradition, dating back to the nineties (Leeuw-Roord, 2003), Portuguese schools may adapt the curricular general guidelines to the needs of their population[3]. Applying the fundamental principles of autonomy and flexibility, enshrined in law, during the last two decades, schools have had a margin to manage time allocated to each curricular component or subject; to create optional subjects, activities or educational offers - by creating vocational courses or other alternative educational pathways, from the Second Cycle onwards - among other curricular and administrative management options, in collaboration with local authorities.

Curricular structure

In order to better understand the educational context of the target population of the project in Portugal, it is relevant to present some features of the school curriculum for students from 8 to 12 years old.

The First Cycle

From 6 to 10 years old, students attend the First Cycle of studies (from 1st to 4th grade), at the pace of 25 hours[4] per week, from September to June. The curriculum unfolds into two main branches: 1) subject areas and 2) non-subject or transversal areas. The first one comprehends Portuguese, Mathematics, Environmental Studies

[1] Law nr. 85/2008, of August 27.
[2] Law nr. 49/2005 of August 30 (art.. 7).
[3] Decree-Law nr. 139/2012, of July 5 (defines the guiding principles of the organization and management of the curriculum of Basic and Secondary Education).
[4] Or 26 hours if parents opt for an extra class of Religious Education.

and Expressions (artistic, physical and motor). The second one includes Project area, Study guidance and Citizenship education. Still to mention the learning of English, that integrated the curriculum of the 3rd grade, in the current academic year, and will be extended next year to the 4th grade. Its learning was an optional extracurricular subject since 2010.

The options made in the School Cluster Coimbra Centro (AECC) can be seen in Figure 2.

First Cycle - Curricular Subjects and Areas		Weekly Schedule 1st, 2nd and 4th Grades	Weekly Schedule 3rd Grade
Compulsory Subjects	Portuguese	8	8
	Mathematics	8	8
	Environmental Studies	3	3
	Artistic and Physical Expressions	3	3
	Study Support	2	2
	Citizenship Education (complementary offer)	1	1
Optional subject	Religious and Moral Education	(1)	(1)
Ativities of Curricular "Enrichment"		5	3
English		-	2
Total (= hours)		25 (26)	27 (28)

Figure 2 – First Cycle curricular options in AECC.

There is a focus on the study of Portuguese and Mathematics, considered as core or instrumental subjects. Each one allocates, officially, 7 hours per week. However, teachers might have been using more time, considering the pressure to present good results in the national exams, at the end of the forth year[5]. It is worth to add that the scores obtained in the examination rankings are relevant components in the external evaluation of schools. Therefore, it is likely that the remaining areas of study have been affected by this situation, as frequently noted by some teachers, namely those of Visual Arts,that comment on the gradually reduced manual dexterity of their students.

It is in the frame of the study of the Environmental Studies' area (Estudo do Meio) that children ought to establish contact with other physical and social realities, closer or distant in time and space. By other words, *it is an area for which contribute concepts and methods from various scientific disciplines, such as history, geography, the natural sciences, ethnography, among others, seeking to contribute to the progressive understanding of the interrelationships between Nature and Society*, as stated in the main guidelines of the syllabus[6] and suggested by the six topics proposed, as follows:

1 - The Self Discovery
2 - Discovering the Others and Institutions
3 - Discovering the Natural Environment
4 - Discovering the Inter-Relationship between Spaces
5 - Discovering Materials and Objects
6 - Discovering the Inter-Relationship between Nature And Society

The curriculum guidelines prescribe that the non-subject areas should be explored in an interdisciplinary mode and include specific tasks using ICT, that must be incorporated in each class plan.

[5] Since 2004, Portuguese and Mathematic exams were implemented in the final years of each cycle of Basic Education, beyond the existing ones relative to various subjects of the Secondary Education. The exams in the final years of 1st and 2nd Cycles have been extinguished after the changes in Parliament, that followed the October elections.

[6] The Environmental Studies Syllabus was issued in 2004 by the Department for Basic Education of the Ministry of Education.

The Second Cycle

Students between 10 and 12 years, average, attend this stage of schooling, which corresponds to the 5th and 6th grades.

The curriculum unfolds into four areas - Languages and Social Studies, Mathematics and Science, Artistic/ Technological Education and Physical Education - plus a complementary discipline, chosen by the School Cluster, and study guidance-support/(Apoio ao Estudo) when the pedagogical team recommends extra school aid.

As it can be observed in Fig. 3, the specialization of teaching starts rather soon in Portugal and the trend to assign a higher valuation to mother language and Mathematics, followed during the First Cycle, proceeds. The weekly timetable of the other school subjects is equivalent, with a slight advantage to English and Physical Education.

Second Cycle - Curricular Subjects and Areas			Weekly Schedule (50 min.)		Observations
			5th Grade	6th Grade	
Citizenship Education (a)	**Compulsory Subjects**	Portuguese	5	5	(a) Transversal area. (b) Complementary offer of the Cluster. (c) Compulsory for the students recommended by each class council, after parents' agreement.
		English	3	3	
		History and Geography of Portugal	2	3	
		Mathematics	5	5	
		Natural Sciences	3	2	
		Visual Education	2	2	
		Tecnological Education	2	2	
		Musical education	2	2	
		Physical Education	3	3	
		Citizenship Education (b)	1	1	
	Optional Subject	Religious and Moral Education	(45 min)	(45 min)	
	Study support c)		4	4	
Total			32 (33)	32 (33)	

Figure 3 – Second Cycle curricular options in AECC.

2) National recommendations and guidelines for preparation and implementation of curricular materials

As mentioned earlier, the legislative framework currently in force is based on the principles of autonomy and flexibility. This means that schools and teachers should plan the educational work in the light of each particular social and class group contexts. Therefore, based on the syllabus and the learning outcomes, teachers are free to select contents, aims, methods and assessment tools, taking into account students varied starting points and learning rhythms, their interests and needs and the local environment features.
The existent official guidelines assume a constructivist matrix since 2001 (Abrantes et al, DEB), although the learning outcomes issued in 2013 have implied a regression in some subjects, as it was placed a higher emphasis on content matters.
Regarding the First Cycle, the Environmental Studies program encourages teachers to develop diversified and meaningful learning experiences to ensure direct contact with the environment. Students should conduct research tasks, using various kinds of sources, and establish real experiences in school and community, in order to progressively apprehend and integrate the meaning of the concepts.
Some of the 32 learning outcomes for this discipline, published in 2010, prescribed the use of cultural heritage and ICT in particular, as the following ones demonstrate:
The student structure, communicates and debates knowledge about the natural and social environment, using ICT as a resource;
The student identifies the existence of different peoples and cultures, describing their customs and traditions and respecting them (Example: ethnic minorities that may exist in the area or neighborhood, or who knows in other ways - media, travel, cinema, reading);
The student communicates and participates at their level of knowledge in digital spaces of debate and dissemination on issues related to natural and social environment (examples: build or participate in blogs and webquests and edit podcast).

However, the implementation of these guidelines was not compulsory and the Ministry of Education and Science, from the government in office from 2011-2015, has not issued any curricular learning outcomes neither to the Environmental Studies nor to Expressions, which is, in itself, very meaningful.
This factor, as evidence of political lack of investment in these areas constitute an important constraint to the development of teaching and learning of knowledge of experimental and social sciences as well as of artistic and cultural domains that can jeopardize the onset of interests and fundamental skills indispensible for the comprehension of today's world and the practice of citizenship and, consequently, the realization of key goals set out for basic education. In addition, it is worth to refer as well that initial and in-service teacher training scarcely offer specialized and school context courses, especially for Social Sciences, and the computer resources available in the First Cycle schools of the AECC (and of other schools and clusters) are not enough to ensure its systematic use by students.
By contrast, on a regular basis, First Cycle AECC teachers organize laboratories in their classrooms to explore natural-science related topics, based on the learning experiences resulting from the attendance of an in-service training course that was partly run in school context and equipped schools with some specific materials. This training was implemented in partnership with the Ministry of Education and a local higher school for education.
Summing up, during the last decade the teaching process in the First Cycle has been focusing more and more in learning of the Portuguese and Mathematics, especially due to exam pressure, which led to the reduction of investment in the other subject areas, in matters of training, time allocated and material resources. For instance, the study visits to museums and other cultural sites have been reduced. Currently, each class group visits a cultural place once a year.

Regarding the Second Cycle, and particularly the learning of Natural and Social Sciences (History and Geography of Portugal), both curricular learning outcomes - issued in 2013 and based in the syllabus dating back to 1991 - are aligned with the Decree-Law nr. 139/2012, of July 5 (curricular revision). They propose learning outcomes for each grade in the various dimensions of the disciplinary knowledge.

Recognizing the management role of teachers, it is proposed that they implement a learning by doing approach. The curricular guidelines relative to Natural Sciences specifically mention the appreciation of experimental tasks of various kinds, being it paper and pencil ones or relative to the use of laboratory equipment. There are no explicit references to the use of museum resources. However, it is explicit the mention to the use of ICT resources and the recommendation of some websites.

In turn, the History and Geography of Portugal 2013 curricular reference document also prescribes the use of diversified learning strategies and materials (sources with various statutes and languages) and emphasizes the mobilization of ICT resources: it should be given relevance to multimedia tools and support materials in order to take advantage of the current technological equipping of schools and carry out activities capable to accomplish more effectively learning purposes (Ribeiro et al, 2013, p. 2) .

In fact, using partnerships with other institutions, such as the Museum of Science of the University, the Exploratory or the Junior Science Center of Cantanhede, among others, Natural Science teachers organize field visits to diversified science sites or to museums and other heritage places, in the case of History and Geography of Portugal teachers. But it is not usual that museums "visit", with the ICT mediation, the classrooms, particularly in the so called "exact" and/or experimental subjects. In addition, the exam factor has acted in this cycle of studies in the same way as in the previous one, provoking an increase of distance between curricular norms and school practices.

It should be noted, however, some innovative experiences of science learning using ICT that have been developed at the AECC, in partnership with other institutions, national and international, as was the case of Socientize, in the academic year of 2013-2014.

3) Experiences or recommendations about the use of cultural heritage, especially if issued from scientific museums, and about the use of ICTs by science teachers

According to the Eurydice report (2011), in Portugal there is no overall strategy, at the educational system level, for the teaching of science.

In the scope of this report (Eurydice, 2011) steering documents of European countries recommendations for the use of specific science teaching and learning activities were analyzed. According to this document, in Portugal, for science teaching and learning, there is no explicit recommendation to use specific ICT applications at ISCED1 level. However, discussions and argumentations were very frequently recommended in steering documents at both primary and lower secondary level, as well as explanations, namely making scientific observations, recognizing issues that are possible to investigate scientifically (p. 70).

Several initiatives have been launched by schools and other institutions to improve science teaching and learning and promote students interest for science. Among these initiatives, there was the creation of science alive centers promoting science education outside school involving a wide range of activities, as disseminating innovative learning materials, non-formal science learning activities for students and for professional development.

> "In Portugal the agency Ciência Viva (science alive) was created in 1996 as a unit of the Ministry of Science and Technology; its role is to promote scientific and technological education in Portuguese society, particularly among younger pupils from preprimary upwards but including the whole school population (ISCED 1, 2, and 3). The agency collaborates with 11 different partners such as state bodies… The agency runs a programme which supports the use of experimental science teaching methods and the promotion of science in schools. Under this programme an annual national competition of science education projects is organized and science inquiry and laboratory activities are provided during the holidays. The agency also coordinates and manages the national network of regional centres Ciência Viva" (Eurydice, 2011, 40-41).

There are two Science Alive Centres associated with the University of Coimbra: Science Centre Rómulo de Carvalho http://nautilus.fis.uc.pt/rc/ and Science Centre Infante D. Henrique http://www.exploratorio.pt/

Among the ongoing initiatives, there was also the implementation of programmes and projects aiming to encourage school partnerships in the field of science, namely with Higher Education institutions or museums developing educational activities to motivate students for learning science.
At a national level, an example is the project *Motivation of Young People for Science-Champimovel*, a project developed by the Champalimaud Foundation with the Ministry of Education aiming to promote biomedical research in Portugal and interest in for biomedical research (Eurydice, 2011).
At the University of Coimbra there are some examples of developing activities targeted at schools, coming from different faculties and departments, namely:

- the project *Sun for all* (Coimbra's Astronomical Observatory), http://www.mat.uc.pt/sun4all/index.php/en/;
- the project *Inquire* (Coimbra Botanic Garden) http://www.inquirebotany.org/;
- *Elevate* (Faculty of Science and Technology) https://sites.google.com/site/elevategrundtvig/;
- *Clohe* (Faculty of Science and Technology) http://www.clohe-movingtoys.eu/www/Home_EN/Home.htm,
- *Portal of Virtual Chemistry Labs* http://labvirtual.eq.uc.pt/siteJoomla/index.php?option=com_frontpage&Itemid=1;
- *Mocho a* web portal with didactic resouces for science teaching http://www.mocho.pt/
- Also, the *Science Museum* of the University of Coimbra http://www.museudaciencia.pt/index.php?module=content&option=museum "an interactive science museum that aims to provide visitors of all ages an entertaining environment in which to discover science" has also been involved in educational activities of different types, namely study visits, workshops for students, teachers, or international projects as Socientize http://www.socientize.eu/. It

must be stressed that the Museum presents the University's collections of scientific objects and instruments, the oldest and most important in Portugal. Most of the items are dated from the Pombaline Reform of the University, which took place in the last quarter of the 18th century establishing the basis for modern teaching and scientific research in Portugal.

At a national level, project Heritage (Património) was also launched, http://www.dge.mec.pt/patrimonio-cultural, in the scope of a Protocol of Collaboration between General Directorate of Education (Direção-Geral da Educação, DGE) General Directorate of Cultural Heritage (Direção-Geral do Património Cultural, DGPC) (november 2013) This Protocol of Collaboration aims to promote Education for Cultural Heritage by conducting a series of joint initiatives, namely the School contest "My school take charges of a musuem, a palace, a monument…", the Kit Intangible Heritage Collection and the dissemination to the educational community of information on National Treasures of Museums da DGPC.

Summing up, despite various initiatives, projects and activities around education for science and cultural heritage, there are still no systematic actions that cross these various topics and develop educational resources through the use of ICT.

4) Experiences and materials for making cross-disciplinary didactic units

As referred in 3) there are projects aiming at developing educational materials and experiences for science teaching that bring together knowledge and resources from science researchers and organizations.

Science Alive Centres and Web Portals present educational resources that can be used by teachers to develop their classes, namely:

- Class plans (e.g. http://nautilus.fis.uc.pt/rc/?cat=39);
- Videos (e.g. http://nautilus.fis.uc.pt/bl/conteudos/23/index.html);
- Simulations (e.g. http://www.mocho.pt/Ciencias/Fisica/simulacoes/);
- The Science Museum also has a collection of digitals objects, as images, scientific instruments, models that are on open source and can then be used for educational purposes.http://museudaciencia.inwebonline.net/

The project *Sun for all* (Coimbra's astronomical observatory) http://www.mat.uc.pt/sun4all/index.php/en/ "funded by Ciência Viva (2005 117/ 18) aims to promote science in general and astronomy in particular, among students. The project rests on the asset of over 30000 Sun images (spectroheliograms) that are kept in the Astronomical Observatory of the University of Coimbra, as a result of a work of over 80 years of daily solar observations that started in 1926. Presently there are about 15000 digitized images that are available to the general public due to another project, also funded by "Ciência Viva", which was developed from 2002 to 2004. The solar observations collection has an enormous scientific value. Thus, this project aims to make this collection available in a digital way via WWW to Portuguese and foreign students, as well as a set of activities that enables them to use these images, in order to introduce them to the scientific method, having the Sun and its atmosphere as the background (see in "SUPPORTING MATERIAL")". http://www.mat.uc.pt/sun4all/index.php/en/supporting-material
The project aims students to explore the Sun, in its several wavebands, and understand a variety of phenomena related to our star and its influence in our planet. Students can measure spots and prominences, count the number of spots in order to determine the solar activity, make movies presenting the solar rotation and study the contribution of the Sun to climate change.
The Sun for all guidebook is an example of material that can be used in several subject areas. It can be integrated in math classes, physics lessons, biology, geology, arts, etc

The project *Inquiry* http://www.inquirebotany.or aims to develop educational resources that enable the implementation of inquiry based science education projects for students from 10 to 14 years old. Along with all partners of the European consortium, the Botanical Garden of the University of Coimbra (JBUC) developed manuals, educational resources and a teacher training course on the IBSE method (Inquiry based science education) promoted in outer space to the classroom, such as the botanical gardens, which titled "Inquire Project: training in biodiversity and sustainability". These resources can be used in various fields such as biology, geography, geology.

The European CLOHE educational project http://www.clohe-movingtoys.eu/www/Home_EN/Home.htm is an innovative project that is using mechanical moving toys (Automata) as a learning tool for primary students to build transversal key competences. Mechanical moving toys (Automata) offer educational ways to explore arts and game based activities around the construction and understanding of Automata. Mechanical moving toys (Automata) are also a great way to introduce engineering, arts, sculpture, mechanics and science, by combining play and technology. CLOHE aims to motivate primary children to use multidimensional, cognitive resources to achieve learning outcomes. The resources the project produced included everything that allow a teacher to make automata with their students. An online virtual museum was created were students were able to show their results to their peers.

In the Project ELEVAtE (*E-Learning & Science Education for Adults: a Virtual Approach to Experimenting*) learning was approached through virtual media and utilized the technology used in everyday life of the students. The main objective was to produce examples of videos of science practical activities to be used in e-learning activities. The project also produced a set of guidelines and resources (Toolbox) that allow teachers and students to plan and to develop this kind of activities for different themes. Although the target group of the project were adult learners and their teachers, the approach developed can be transferrable to earlier ages.

Socientize, acronym for "*Society as e-Infrastructure through technology, innovation and creativity*" developed several web-based applications to support scientific projects in the areas of molecular and cell biology and drug discovery (Cell Spotting2), linguistics and semantics (Mind Paths3), energy saving and sustainability(SavingEnergy@Home4) and astronomy (Sun4All5). In order to promote the engagement of society, Socientize developed many dissemination activities to specific target groups, such as students and teachers in school communities, citizens 50+ through universities for seniors and 50+ web platforms, patients associations, and other risk-of-exclusion groups such as prison inmates.

In the Framework of the international *Project Dark Skies Rangers* students were invited to produce a mockup of a dark skies friendly street. Teachers were trained on the use of ICT tools to demonstrate the impact of light pollution in our sky and students invited to make a light audit in the school street in order to evaluate the energetic impact of bad illuminated streets. The Dark Skies Rangers project can also involve a variety of subjects depending on the reach the teacher wants to give to the project.

5) Experiences of innovative practices in science teaching and in evaluating the impact for learning improvement

There are not yet systematic data for Portuguese educational system about the impact of different science teaching approaches and methods. However the General Inspectorate is carrying on a monitoring activity called Curriculum Management: Experimental Science Teaching (Gestão do Currículo: Ensino Experimental das Ciências aiming to monitor the development of experimental science teaching in the classroom, promote the improvement of educational practices and to contribute to effective science curriculum management with positive impact on the results of students. A report presenting data gathered in 2015 is foreseen to be available in 2016.
It must also be stressed that results of international studies on scientific literacy of Portuguese 15 years old students, namely PISA; show that it is below the European average. However, the results have been reversed and an explanatory hypothesis for such changes can be related to the different initiatives and science teaching projects that have been implemented.

Two of the projects referred above have already published evaluation results of the activities and resources developed and its impact on teacher professional development and students' motivation and learning. A synthesis of the results obtained in Inquire Project http://www.uc.pt/jardimbotanico/projetos/inquire/ refers that "concretizada uma ampla reflexão e avaliação sobre as duas edições deste Curso de formação INQUIRE em Coimbra, as evidências indicam múltiplas vantagens na utilização da metodologia IBSE na produção e implementação dos 36 projetos educativos, sustentáveis e reprodutíveis, com a apresentação de temas curriculares relevantes e bem refletidos nos portefólios dos formandos e do Curso, e demonstrando uma franca melhoria na competência, conhecimentos, participação, interesse e motivação dos formandos e dos seus alunos (7,8)".

Results from the implementation of the Socientize project have just been published http://jcom.sissa.it/sites/default/files/documents/JCOM_1501_2016_A02.pdf . The results presented for a citizen science project in the area of cell and molecular biology — Cell Spotting — implemented with hundreds of students in high schools in Portugal and Spain as part of regular Biology class *"suggest that citizen science projects, acting as alternative teaching approaches, can increase especially the interest of the low performance students to science topics. Other important aspects to take into consideration for the implementation of citizen science projects in schools are the development of easy-to-use and self-guided applications (if applicable), and the preparation of rich and attractive support activities and educational materials so that continuous participation and engagement can be triggered outside the classroom. Support infrastructures and regular contact with the researchers involved in the project to clarify doubts and report on the progress of the project and results accomplished with the collaboration of schools was also considered of the utmost importance to motivate both teachers and students."*

6) Possible issues and concerns

The use of ICT in classroom is a challenge issue in Portugal. There are not enough computers and the use of student's own smart phones and tablets is in general not allowed. Another problem is the time constrain and the need to focus on a dense curriculum and an exam driven system. Teachers from middle school and secondary level have severe time limitation to explore alternative teaching methodologies.
Teacher training on ICT tools and its use in class to implement innovation and active methodologies must also deserve particular attention, as teachers often do not feel enough confident to use ICT tolls in their classes. This is in line with the results of an European survey presented by Silvia Costa at the Conference *Education in the Digital Era* *http://www.openeducationeuropa.eu/en/news/video-recordings-and-materials-education-digital-era-conference-now-online:* 70% of the teachers consider important to use digital tools and resources in their classes but only 20% of the students are taught by digitally confident teachers. https://www.youtube.com/watch?v=_m6RZbwkjNI

7) Do you know any concrete museum experience of museums using/share its heritage, also online, to help teacher to teach science? If yes, please describe and provide references.

As it was already referred in sections 4 and 5, there are web portals and projects that developed educational resources to be implemented in schools and that aim to establish articulated relationships with schools.

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