CAPCIT
Parliamentary Advisory Council on Science and Technology

CAPCIT Bulletin #2 · October 2013

The scientific and technical education of children and youth in Catalonia

The quantity and quality of future highly skilled workers is key to our economic future. A suitable level of scientific and technical knowledge and effective measures to improve education in schools are both essential to the future of Catalonia (source: FCRI).

European context

There is a broad consensus in Europe about the need in the coming years for the population to have sufficient knowledge of science and technology topics to ensure social progress and the high levels of international competitiveness that each country requires. In the Europe 2020 strategy, the European Union has proposed to increase the human resources employed in teaching science, technology, engineering and maths (STEM) as part of the efforts to strengthen innovation and to ensure that there will be enough graduates in mathematics and engineering.[1]

It has been estimated that Europe will need at least one million more researchers over the next decade to achieve the objective of investing 3% of EU GDP in R&D in 2020.[2] On the understanding that education is key for achieving these goals, the Europe 2020 strategy recommends that Spain implement reforms of the national education system to correct the weaknesses of the current system and that it should set this objective.[3]

Need for science education for the new jobs: perception and reality

In view of the changes in the needs of labour markets, the jobs of the future are likely to require higher levels of education and a different combination of skills, competencies and qualifications.[4] Therefore, new education and training programmes should be aimed at ensuring that future generations have the necessary skills for the new professions.[5]

We know[6] that most Spaniards already associate *science and technology* with improved quality of life (88%) and economic development (87%), and that interest in science and technology has grown by 19% in the Spanish population since 2010 and by 40% among people aged 15 to 24 years.

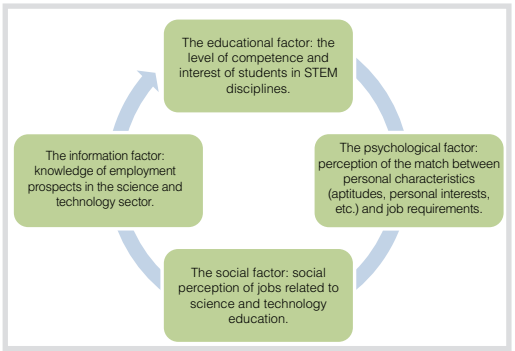
Nevertheless, only 28% of students in Catalonia enrolled in science and engineering courses in 2011, whereas 57% enrolled in humanities and social sciences; this trend is also observed in Spain and the European Union, but is not so clear.[7]

Therefore, for example, in 2011 people with higher education in science or technology fields employed in professions related to science and technology accounted for only 10.8% of the population of Catalonia, compared with 11.4% in Spain and 11.7% in the European Union (EU-27).[8]

Promoting scientific and technical vocations

If it is planned to increase the number of people who choose scientific and technical professions, we must consider the time when students choose their future and the motivations and circumstances that influence this choice.

We know that the process of choosing an academic future related to science and technology is influenced by self-perception and by family, education and society. We can identify four main factors involved in the choice of scientific and technical studies: [9,10]



Several studies show that between 10 and 14 years of age[11] each student builds a perception of what they are, what they are for themselves, what satisfies them, what interests them and what is in their best interests. And we must remember that school and education in general play a limited role in this process.[12]

Fundació Catalana per a la Recerca i la Innovació
FCRI

Authors: Roser Pintó and Cristina Simarro, Centre de Recerca per a l'Educació Científica i Matemàtica (CRECIM-UAB).
Dolors López and David Sastre, Gabinet d'Anàlisi i Prospectiva, Fundació Catalana per a la Recerca i la Innovació (FCRI).

For this reason, we must differentiate between an interest or leaning towards science or science classes and an interest in choosing science degrees or professions. This error has led to many wrong decisions.

Of the four factors, the first is closely related to the sciences taught at school and how they are taught.

Science and schools in Catalonia today

When do schools emphasize scientific and technical education?

The following table shows the importance of compulsory science education in the curriculum in Catalonia for all children aged 3 to 18 years. In the first three years of secondary education, i.e. among students aged 12 to 14 years, science subjects account for 21% of class hours. In the stages of primary and nursery education science has a far lower presence in the classroom. In the upper secondary stage (16 to 18 years), it depends on the track chosen.

Science and technology education received by young Catalans

Age	Preschool education 3 to 6 years	Primary education 6 to 12 years	ESO (lower secondary education) 12 to 16 years	Batxillerat (upper secondary education) 16 to 18 years
Subject / Knowledge	Exploration of the physical environment Experimentation	Knowledge of the natural, social and cultural environment (NCSE) Mathematics	1st to 3rd year: compulsory subjects on natural science, technology and mathematics 4th year: elective science subjects Mathematics	1st year: science for the contemporary world + subjects of the track chosen 2nd year: variable (depending on track)
Curriculum load / class hours	Not known	12% (NCSE) 12.6% (mathematics)	1st to 3rd year: 21% of class hours 4th year: Variable science and technology (depending on electives) + 10% maths.	1st year: between 6.6% (STEM) and 60% (depending on track) 2nd year: between 0% and 53%

(Source: authors based on data from the Ministry of Education of Catalonia.[13,14,15])

These conditions will change with the entry into force of the Spanish Law for the Improvement of Educational Quality (LOMCE), which in the current draft divides knowledge of the natural, social and cultural environment in primary education into two subjects, one of which is specific: natural sciences. In secondary education, it will divide the current interdisciplinary curriculum of natural sciences into separate subjects, biology, geology, physics and chemistry, as they were many years ago. Technology will be an optional subject in some years and will depend on the offering of each school.

The scientific education of young people is influenced not only by school but also by the media and by the mainly private initiatives that they choose in their leisure time. Many varied and sporadic events are also organized throughout Catalonia. The informal education activities are usually aimed at promoting positive attitudes to science rather than teaching specific knowledge or skills.

What results are obtained?

The Evaluation Council of the Education System of the Generalitat of Catalonia annually evaluates the basic language and mathematical skills that students should have reached by the end of primary education (sixth year) and compulsory secondary education (fourth year) but does not assess the level of science.[16]

At the state level, in 2009 the Ministry of Education conducted a general diagnostic assessment of students in the fourth year of primary education. In the results Catalonia was just above average in Spain in mathematical skills and below average in knowledge and interaction with the physical world.[17]

Moreover, in the last edition of the Programme for International Student Assessment (PISA) in 2009,[18] 15-year-old Catalan students earned an average score of 497 points in scientific literacy, slightly lower than the OECD average (501) and the US average (502), but higher than the Spanish average (488).

Therefore, although the results of both primary and secondary education are not completely negative, they are far from satisfactory.[19]

How were the teachers trained?

As is shown in the ENCIENDE Report,[20] most of the current science teachers graduated before the implementation of the European Higher Education Area (EHEA), which means that primary school teachers are highly specialized in educational psychology content to the detriment of science content and science teaching, and secondary school teachers are highly specialized in science to the detriment of teaching and educational psychology content. While the situation of secondary school teachers will change in the coming years with the new master's degrees, the same cannot be said of primary school teachers. Their scientific training will continue to be very limited.

In addition, the continual changes in the organization of the education system have made many teachers resistant to new ideas. They have experienced disappointment and disorientation as a result of the efforts required by fleeting innovations that they now see as impositions rather than identifying with them.

Some measures for better science education of our youth

When proposing measures to overcome the current problems and challenges of educating our youth in science and technology, we must take into account the working environments that allow or prevent teachers from working with dignity, their role in the classroom, and the training they need.

Recommendations on the working environment

1. Teachers should be considered as professionals who have specific knowledge of the content to be taught and how to teach it, and who know how to make their work more productive and better adapted to the specific environment of the school. That is, we must abandon the old concept of teachers as practitioners of a skill that they learn over the years.

2. Training and retraining of teachers should be based on the scientific, pedagogical, psychological and sociological knowledge that is available to present-day society.

3. Solid connections should be established between researchers in science education and the educational authorities so that research results are applied in schools. On the occasions when this has happened, it has been very beneficial.

4. Teachers should receive support from the authorities to allow them to successfully carry out their work and introduce innovations. It is crucial to train, retain and reinforce the science teachers with the best teaching skills and competencies.[21]

5. Classrooms should have suitable facilities for the educational level taught and teachers should be offered the necessary equipment and resources, in addition to working conditions that are suited to them individually.

6. It is advisable to promote actions to ensure that families are involved in the education of their children and that they support the school in working towards this goal.

7. The assessment of science education should be revised, because what is assessed has a strong influence on what is considered important to teach and learn. Scientific literacy should be ranked as high in assessment as language and mathematics.

Recommendations for teaching

From the point of view of science education, the school has a dual function: a) to promote the scientific literacy of the whole population so that citizens can be sufficiently informed to be able to make rational decisions, and b) to promote the highest scientific and technological competence of the gifted so that they can become highly skilled workers for the level of competitiveness that society requires. Though good teachers know how to do their work, we would like to stress five essential features:

8. In formal terms, the time spent teaching science in schools should help students to build a solid knowledge rather than to memorize a string of unconnected facts. The conceptual models should provide a firm grounding for interpreting everyday phenomena.

9. A good scientific and technical education should encourage students to play an active role in the interaction and discussion with their peers and teachers in class and in experimental work. It should also encourage reflection on the learning process.

10. In addition to scientific and technical literacy, young people should acquire highly valuable skills such as inventing, seeking original answers and designing new solutions to problems, issues, situations, etc. One of the milestones for meeting the demands of Europe in R&D would be to train young people to have a taste for knowledge and critical thinking aimed at analysing reality.

11. The teaching of science should be in tune with the reality of our society: contextualized and linked to the competencies that are currently demanded. At present the use of information and communications technology (ICT) and the ability for lifelong learning are the priority skills that must be fostered.

12. In educational guidance, it must be remembered that children and young people take an interest in and enjoy the knowledge that they understand and learn, but they do not understand and learn it because they enjoy it. Remember the motto: «Science is exciting because it is meaningful but science is not meaningful because it is exciting.»

Recommendations for teacher training

13. All proposed improvements must focus on supporting teachers. A clear example of the importance and influence that good training and support for teachers can have on improving educational systems is the case of Finland.[22] The key for achieving this lies in teacher training and fostering the prestige of the profession.

14. The initial training of primary teachers must enable them to successfully deal with the science subjects in the primary school curriculum. In Catalonia this requires an increase in the time devoted to knowledge of science content and how to teach it during their initial training.

15. In secondary education the new master's degrees in teacher training are alleviating the lack of training in science education, but the training should be longer or graduates should be tutored during the first few years of work. Support communities for teachers in their first few years of work should also be created and maintained.

Source: FCRI

Fostering interest in and improving the perception of science

We should also bear in mind the role that non-formal education can have in making scientific and technical careers attractive. Incorporating elements of informal education that are more fun can be a good incentive to boost interest in STEM and awaken an early interest in scientific and technical careers: exhibitions, activities in museums, fairs, science festivals awards for students' projects or exhibitions, games, science clubs, etc. These can be organized as part of recreational activities or within the framework of European projects designed to introduce and evaluate innovative proposals for children and young people from kindergarten to university.[23]

Moreover, if resources of various organization are made available to all citizens in coordination, the general perception of science will improve and families will be keener for their children to pursue STEM careers. For all non-formal educational activities, the objectives, instruments and scope must be defined and the effectiveness and efficiency must be assessed. It should be clear that showing an interest in science does not necessarily involve a good academic performance in science subjects.[24]

Contacts of schools with companies and research centres are also very valuable in making STEM careers more attractive. Collaboration with companies and technology centres increases students' knowledge of their activities, helping them to envisage their future and to understand how the scientific knowledge acquired in the classroom can be applied in the workplace. Such collaboration contributes to the corporate social responsibility of companies, technology centres and research centres and allows them to promote their activities and identify future talent.

Despite some success stories, these initiatives are often isolated and do not have sustainable structures that guarantee quality (through expert advice) and viability (by establishing legal frameworks for collaboration with research centres and policies systematizing promotion of STEM by companies).

This type of collaboration needs a stable framework with institutional support. For example, the Danish Science Municipalities involve companies and schools and have the support of several Danish city councils. Creating and extending structures with these goals would help provide our citizens with infrastructure to increase interest in science and improve its perception.[25]

Notes

1 European Commission (2010). Europe 2020. *A strategy for smart, sustainable and inclusive growth.*

2 Innovation Union. Key initiatives (http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=key).

3 Europe 2020 in Spain (http://ec.europa.eu/europe2020/europe-2020-in-your-country/espana/country-specific-recommendations/index_en.htm).

4 European Commission (2009). *New Skills for New Jobs.*

5 Vassiliou, A. (2012). *Creativity and Education in Europe. Debate on 21st century education: creativity and innovation in primary and secondary STEM education.*

6 Encuesta de percepción social de la ciencia 2012, FECYT, octubre 2012.

7 IDESCAT, 2013.

8 Eurostat, 2011.

9 CRECIM (2011). *Observatory Methodology.* Deliverable 2.1 Project InGenious.

10 DeWitt, J.; Osborne, J.; Archer, L.; Dillon, J.; Willis, B. & Wong. B. (2013). «Young Children's Aspirations in Science: The unequivocal, the uncertain and the unthinkable». *International Journal of Science Education*, 35:6, 1037-1063.

11 Osborne, J. *et al.* (2008*). Science Education in Europe: Critical Reflections*, Nuffield Foundation, London, p. 8.

12 Archer, L.; Osborne, J.; Dewitt, i ASPIRES Advisory Committee. *Ten Science facts & Fictions. The Case for Early Education* about STEM Careers ASPIRES Project · King's College London (http://www.kcl.ac.uk/sspp/departments/education/research/aspires/index.aspx).

13 Decree 142/2007 of 26 June, regulating teaching in primary education. *Diari Oficial de la Generalitat de Catalunya* (DOGC, Official Journal of the Generalitat of Catalonia) no. 4915 - 29/06/2007.

14 Decree 143/2007 of 26 June, regulating teaching in compulsory secondary education. D*iari Oficial de la Generalitat de Catalunya* (DOGC, Official Journal of the Generalitat of Catalonia) no. 4915 - 29/06/2007.

15 Decree 142/2008 of 15 July, regulating teaching in upper secondary education. *Diari Oficial de la Generalitat de Catalunya* (DOGC, Official Journal of the Generalitat of Catalonia) no. 5183 - 29/07/2008.

16 Departament d'Ensenyament (2013). Sistema d'Indicadors d'Ensenyament de Catalunya. Informe 16. Any 2013.

17 Ministerio de Educación (2010). *Evaluación general de diagnóstico 2009. Educación Primaria. Cuarto curso. Informe de resultados.*

18 The OECD's PISA programme assesses every three years the school performance of 15 year-olds in different countries in reading, mathematics and science.

19 Informes d'avaluació 18. Informe PISA 2009, Catalunya. Ministry of Education, Generalitat of Catalonia, 2011.

20 COSCE (2011). Informe ENCIENDE. Enseñanza de las Ciencias en la Didáctica Escolar para edades tempranas en España.

21 *Pla per a la reducció del fracàs escolar a Catalunya 2012-2018.* Departament d'Ensenyament, 2012.

22 Stanford Center for Opportunity Policy in Education (2010). *The Secret to Finland's Success: Educating Teachers.*

23 http://www.kiics.eu/en/, http://www.kidsinnscience.eu/, http://www.stemnet.org.uk/ambassadors/, http://www.creative-little-scientists.eu/node/57.

24 Osborne, J.; Simon, S. & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications, *International Journal of Science Education*, 25:9, 1049-1079.

25 Danish Science Communication (2011). *Science Municipalities - education for growth. Experiences and recommendations from the Science Municipality project 2008-2011.*

PARLAMENT DE CATALUNYA

The Parliamentary Advisory Council on Science and Technology (CAPCIT) is a parliamentary body created in 2008 with the objective of co-ordinating the information and advice on science and technology that members and bodies of Parliament require. CAPCIT is a combined body made up of members of Parliament appointed to the Council and representatives of the leading scientific and technical institutions of Catalonia: the Catalan Studies Institute (IEC), the Catalan Foundation for Research and Innovation (FCRI), the Catalan Scientific Communication Council (C4) and the Catalan Association of Public Universities (ACUP). For further information: http://www.parlament.cat/capcit.

Electronic edition DL: B.11006-2014