

# Introduction to Research in the Secondary School.

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**Abstract.** In Catalonia, research projects in secondary schools have formed part of the curriculum for a number of years. Here we describe the activities of the University of Barcelona and the Barcelona Science Park aimed at helping secondary school students to develop a research project and their teachers to supervise the project. The relationships formed between students, their secondary school teachers and university teacher/researcher mentors appear to have a lasting positive effect. The research projects make a positive contribution to learning science and stimulate scientific vocation.

## 1. Introduction

### *Background of Spain.*

It is widely accepted that Europe's future must be built on a knowledge-based society. Thus, the future of Spain, a member state, depends on the knowledge produced here. The secondary school is an excellent setting in which to foster this knowledge.

Spain is formed by 17 Autonomous Communities. It has a national policy on education [1]; however, each region develops its own independent education system. Secondary school comprises two years in which students from 16-18 years old choose subjects to prepare their application to university [2]. Maths, Computer Science, Physics, Earth Sciences, Chemistry, Technology and Biology are the subjects required to enrol on a university degree in Sciences, while History, Literature, Latin, Greek, Economics, The History of Art and Geography are necessary to start a degree in languages or social science.

Of the 17 Communities, only Catalonia includes a research project [3-5] in the final year of secondary school (17-18 years). This project is compulsory for all students at this level and accounts for the 10 % of the final grade.

## 2. Research projects for secondary school students

In Catalonia, research projects in secondary schools have formed part of the curriculum since 1992.

### 2.1 General description of the research project on science.

One of the most difficult tasks for students is to decide on a topic for the research project. They must first identify their interests and their desired career; establish the time they wish to spend on the project and whether they enjoy working in a laboratory. Once these points have been addressed, a science teacher (tutor for the research project) can guide the student in his/her choice of topic.

After checking the resources available for the project, students can then start. During this activity and assisted by their tutors, students review the topic by reading bibliographic references, focus on the objectives, and then select the materials and methods of the project. Once completed, the final project is written up and defended in front of a panel of teachers. This panel evaluates the report, the oral presentation and the answers given in response to questions asked by the panel.

Examples of topics from biology, chemistry and physics (to mention a few areas) covered in research projects.			
Test of anti-bacterial substances	Obtaining soap	Superconductors	Virtual genes
Lipid identification	Synthesis of aspirin	Magnetic levitation	Diabetes
Growing plants in the presence of CO <sub>2</sub>	Planck's constant	Energy from Hydrogen	Young people's nutrition

Towards the end of the school year, the projects of a number of talented students are published for dissemination.

### 2.2 Tutoring research projects.

In the context of science, many secondary school teachers (especially older ones) do not have enough research experience and may therefore generate only bibliographic proposals. Furthermore, many schools do not have enough laboratory material or equipment. These situations decrease student expectations about a research project, and also decrease their interest in science.

Remarkably, an increasing number of secondary school science teachers take the initiative to request collaboration and help from university researchers. This initiative arises because a number of students (generally talented ones) wish to address hot topics in scientific fields with which the teacher is not familiar or topics not covered in standard school curricula. In this context, several teachers and researchers from departments of the University of Barcelona (UB) and the Barcelona Science Park (*Parc Científic de Barcelona*, PCB) have helped secondary school students and their teachers to build up the confidence they need to interact with research departments and to perform simple research projects with modest experiments in their classes. Universities and research centres can play a crucial role in familiarising secondary school teachers with novel scientific knowledge [6,7].

Motivated students who wish to address complex fields and show great enthusiasm for research are referred by their secondary school teachers to researchers at the UB or PCB.

Moreover, a university teacher or researcher may offer to become a second tutor for a research project. Researchers can help talented students by putting forward new ideas and stimulating new approaches. They can also provide access to technological research equipment that is not available in secondary school laboratories mainly because it is expensive or dangerous.

Furthermore, a booklet covering a set of relevant biochemistry research projects was edited by the UB and distributed among secondary schools in Catalonia [8]. The aim of the UB [9] and the PCB [10] is to introduce talented students to science by helping them with their projects. Supervised by a university teacher and guided by a PhD student, secondary school students have first-hand experience of the techniques related to biochemistry, biology, chemistry and physics. Given the age proximity between students and researchers (PhD student), laboratory work is greatly facilitated in an easy-going atmosphere.

In general, the university/researcher tutor provides “brainstorming” sessions. Generally, these sessions stimulate a series of questions that students wish to pose and which improve the quality of the project. Students and tutors build a one-to-one relationship (extra time outside the class) which fosters the acquisition of knowledge, and provides experience of laboratory techniques. Increasing students’ self-confidence could facilitate the development of their research projects. Each student has a just claim that his or her research project is singular, and has needs that deserve special attention from secondary school teachers and university teachers/researchers.

### 3. Feedback.

#### 3.1 Student feedback.

Having finishing the research projects and presenting them for evaluation, students were asked to complete a questionnaire. An analysis of the answers are shown in the following table.

<b>Student feedback about the research project developed out of the school</b>		
	<b>YES</b>	<b>NO/I am not sure</b>
My relationship with the researcher tutor was excellent	100 %	0 %
The atmosphere in the lab encouraged learning.	95 %	5 %
Learning in the lab was exciting.	95 %	5 %
I feel that I learned the topics covered in the lab in depth.	82 %	18 %
I feel confident about giving a public presentation of my research work.	30 %	70 %
I am interested in additional time in the lab during my science degree.	70 %	30 %

Students most greatly appreciated the opportunity to work in a laboratory and expressed that they would repeat the experience. Almost all the students considered the research project as a valuable experience. They also valued personal interaction with

the researcher (university teacher or PhD student); however, most did not feel comfortable presenting their work in public because they were unaccustomed to making presentations. In addition, 7 out of 10 expressed an interest in spending extra time working in the lab during their science degree.

### 3.2 Secondary school science teachers' feedback.

In the same way a questionnaire was utilized to get an evaluation about the research project developed out of school. Responses from secondary school science teachers are in the next table..

<b>Secondary school science teacher feedback about their students and research projects developed out of the school.</b>		
	<b>YES</b>	<b>NO</b>
My relationship with the university teacher or researcher was excellent.	100 %	0 %
Were the students you referred to researchers the most talented in your class?	90 %	10 %
One of the most important things was to use scientific equipment.	50 %	50 %
My students have gained lab experience.	95 %	5 %

The answers reflected in this table indicate that most of the secondary school science teachers were more interested in increasing their students' laboratory knowledge than increasing student access to using university equipment.

### 3.3 University/researcher tutor feedback.

At the end of the school year, university and researcher tutors of all research projects were asked to fill in a questionnaire about their opinions and tasks. The following table shows their answers.

<b>University/researcher tutor feedback about the research project.</b>		
	<b>YES</b>	<b>NO</b>
My relationship with the student was excellent.	100 %	0 %
My relationship with the secondary school teacher was excellent.	100 %	0 %
I contributed to the design of new strategies to address the issues posed in the research project.	80 %	20 %
Were you able to cover all your initial objectives?	90 %	10 %
Did your students find it relatively easy to perform their research work?	70 %	30 %
My talented student enjoyed working in the lab.	90 %	10 %

The university/researcher tutors gave positive feedback on the research projects performed and their relationships with students and secondary school teachers alike was excellent. Furthermore, these tutors considered that 7 out of 10 students had been able to develop their projects with relative ease and this was attributed to their motivation and effort.

#### 4. Global results.

After collecting the opinions of students, secondary school science teachers and university teachers/researchers, we evaluated the global results, final grades of the projects, university entrance exam success/failure and enrolment on a university science degree. In Spain, students make four choices of degree in order of preference. Access to a degree is awarded on the basis of the final grade attained in the university entrance exam. We compared the results obtained from students who developed their research projects out of school, in the UB and PCB, with those obtained from the remaining students.

Global Results		
	Research Project in the University	Research Project in general
Grade of the research project (10 maximum)	9.2	7.8
Pass the university entrance exam (%)	100 %	86 %
Enrolment on first university science degree option	96 %	70 %

The results show that the research project grade was 1.4 points higher for students who had developed their project with the support of university/researchers than that obtained by the remaining students. All of the students whose projects were supervised by university teachers/researchers passed the university entrance exam. Finally, only 4% of these students were unable to enrol on the science degree of their first choice. In contrast, of the students who did not develop their projects in the UB or PCB, 30% were not able to enrol on the first degree option.

On the basis of our results, we conclude that:

The interactions between the students and their mentors, and the relationships formed, appear to have a positive effect.

The research projects done by secondary school students and developed in the UB and the PCB make a positive contribution to learning science and stimulate scientific vocation.

#### 5. References.

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