How to build an educational bridge

How can school pupils be introduced to materials science and nanotechnology? **Pierfrancesco Riccardi** and **Claudio Goletti** illustrate the advantages of extracurricular activities designed by researchers and teachers.

Working in outreach programmes run by our physics departments, we have learnt that pupils in secondary schools know very little about materials science and nanotechnology. There are various educational resources on these subjects for students and teachers (www.materialsworldmodules.org; www.pls.scienzamateriali.unimib.it) but because the topics are not included in Italian national curricula, they are usually covered only briefly within the context of more standard disciplines such as physics and chemistry.

A step forward has been the introduction of materials science — also encompassing nanotechnology — in secondary education as the subject of a specific programme within the 'Piano Nazionale Lauree Scientifiche' (PNLS), an initiative by the Italian ministry of education and research that aims to create connections between school and university. The programme entails the design of teaching projects centred around cutting-edge research co-designed by academics and teachers (P. Riccardi, *Science* **354,** 674; 2016). These projects have been highly appreciated by both students and teachers. Unfortunately, despite their success, we believe that these projects are still too sporadic and isolated.

The experience of the PNLS suggested an effective way to expose pupils to nanotechnology: an after-school programme launched by the Liceo Scientifico 'E. Fermi' in Cosenza in September 2016, in close collaboration with the Department of Physics of the University of Calabria. A group of 14-year-old pupils attended an extracurricular course focused on materials science. For its first year, this course of 'Physics and Materials Science Technologies' lasted for 40 hours, the same duration as the formal physics course. The aim is to eventually extend the course to the five years of secondary school in Italy. The initiative has now been extended to the Liceo 'G. Berto', in the town of Vibo Valentia and to the Liceo 'C. Darwin' in Rome, in collaboration with the bachelor's degree course in materials science of the University of Rome—Tor Vergata.

The contents are primarily based on laboratory activities and are developed in strict collaboration between university researchers and school teachers. The importance of physics and materials technologies from the historical, social and economic point of view is also addressed, so that students receive a complete 'Science Education for a Responsible Citizenship' (as recommended in the 2015 Report to the European Commission of the Expert Group on Science Education; http://go.nature.com/2yKpdak). After the first year, it has become clear that a strength of the initiative is its non-formal character. The great advantage of non-formal programmes is that they are freely chosen by the students and have an open curriculum that can respond to their and their teachers' interests. For this reason, the programme does not involve exams or assessments, as improving school performance is not a primary aim. Our first goal is to improve students' attitude towards nanoscience, and we expect that the students will learn the value of both scientific collaboration and competition from their social interactions in a participatory setting. The role of scientists in this environment is crucial, as they can bring up-to-date scientific topics into schools, transmitting to pupils the methodology and the mindsets of the scientific research process. Some of the activities are performed in the university laboratory (pictured). We believe that attending a university environment regularly during school time will make students more prepared when they have to move to higher education levels.

The programme coordinator, Rosa Tucci, and students from the Liceo 'E. Fermi', in the laboratory of the University of Calabria's physics department. Photo courtesy of Daniela Miano.

Secondary education is facing the challenge of an increasing amount of scientific knowledge in a research- and innovation-rich environment. Because emerging technologies cannot yet play an established part in formal school curricula, we have developed a bottom-up approach based on collaboration between schools and university departments operating in the same local context. The idea is simple, feasible and can be easily replicated and adapted, because flexibility in school programmes and schedules is currently being introduced in many educational systems worldwide. We hope that our initiative will serve as an inspiration for similar ones that could lead to a structural and long-term inclusion of nanoscience in secondary education. ❐

PIERFRANCESCO RICCARDI is at the Dipartimento di Fisica, Università della Calabria, Via P. Bucci, 87036 Rende (CS), Italy. CLAUDIO GOLETTI is at the Dipartimento di Fisica, Università di Roma 'Tor Vergata', Via della ricerca scientifica, 1-00040 Roma, Italy. e-mail: pierfrancesco.riccardi@fis.unical.it; goletti@roma2.infn.it