The Impact of the "Third Mission" of Universities and Research Institutions on Physics Education in Secondary Schools

Pierfrancesco Riccardi
Dipartimento di Fisica, Università della Calabria and INFN Gruppo Collegato di Cosenza, Italy,
https://orcid.org/0000-0002-9966-7379

Giuseppe Prete
Dipartimento di Fisica, Università della Calabria, Italy

Federica Chiappetta
Dipartimento di Fisica, Università della Calabria, Italy

Claudio Meringolo
Dipartimento di Fisica, Università della Calabria, Italy

Abstract: Because of the increasing importance of the so called "third mission", the number of activities toward the public, conducted at various scales by individual scientists, research institutions and universities, is steadily increasing. Educational programs developed by universities and research institutions for secondary schools have also been promoted. This contribution examines the opportunities and challenges that the interaction with research environments is having on physics education in secondary schools, starting from the interactions that the Physics department of University of Calabria has established with schools through extracurricular programs and citizen science projects, often combined with work-based learning programs, recently introduced in Italian schools by the recent reform of secondary education.

Keywords: Physics Education, Science Education, Public Outreach, Public Engagement

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Introduction

Historically, scientific communities did not consider public communication their own responsibility, valuing research productivity overall, so that participation in other types of activities was even discouraged and

disapproved of. The so-called “Sagan Effect” was named to indicate the loss of respect and reputation experienced by scientists involved in public communication, after the denial to Carl Sagan of membership at the National Academy of Science in 1992 [1-4]. This was accompanied by a widespread negative opinion of the public, who were considered to be lacking knowledge. Based on this knowledge-deficit model [5], early forms of communication with the public were thus didactic, in a one-way flow, assuming that a mere knowledge transfer process would increase public support for science. Only a few scientists were involved, generally the senior and prominent ones, who usually took part in one-time-only events, such as a public talk, newspaper interview, or guest appearance on a TV program. What has changed in almost three decades?

In these last years, the so-called “third mission” is becoming increasingly important in the activities of research institutions and universities [1-9]. Scientific and academic institutions today provide support, funds and staff that can help researchers in their communication with the public and the number of activities carried out at various scales by individual scientists, research institutes and universities is steadily increasing.

These interactions between schools and universities have been established through a variety of activities, most of which constitute short experiences like seminars, guest speakers and other one-day events. More recently, the interaction has been brought to a higher level by specific policy interventions. For example, in Italy schools can include after-school programs, up to 15% of normal school hours, which favors the development of extracurricular programs. An interesting intervention is related to work-place experiences, which have become compulsory in the last three years of the secondary education cycle in Italy. They are integrated with school learning, aiming to combine (formal) school education with real-life non-formal learning experiences [6-8], through the collaboration of schools with organizations, such as enterprises or universities. The integration of these informal activities into the school curriculum allows for a more sustained interaction between school and university and provide opportunities for structural and long-term connection between the world of scientific and academic research and schools. This structural connection also fosters a broader involvement of researchers and provides opportunities of active learning for students and of professional growth for their teachers. In this paper we will try to examine some of the opportunities and challenges that the interaction with research environments is having on physics education in secondary schools.

Examples of Interaction between Schools and Universities

In recent years, educational and outreach activities towards schools have been developed through informal teaching programs integrated with school programs and schedules. In our departments we have developed programs in collaboration with schools and non-formal education operators, such as the planetariums of the town of Cosenza [6-9]. Extracurricular programs can provide a wide variety of activities and generally operate during the hours immediately following the school day, but also include activities on weekends or during the summer. They have the great advantage of being freely chosen and can have open curricula, which can align with the learner's interests in a participatory and collaborative context [9]. These programs provide the opportunity to connect scientific research, education and science communication. Some activities are carried out

in university laboratories (fig.1). We think that regularly attending a university environment during the school period can help students to cope with the transition to the next levels of education.

As above mentioned, the mechanism of integration of the informal activities is favored by flexibility in schedule of formal schools and by specific policy interventions. This makes possible a long-term and structural collaboration between schools, university departments and non-formal education operators, in the development of extracurricular programs, with the aim of creating innovations and introducing new topics, such as the Course of “Physics and Materials Science Technologies" which is currently being developed in some schools in Italy [9], to introducing topics in nanotechnology and materials science. This program is mainly based on laboratory activities, developed in close collaboration between university researchers and teachers. This is a non-formal initiative, which is freely chosen by students and has an open curriculum, able to better respond to the interests of students and teachers. The goal is to increase students' attitude towards nanoscience in an interactive and stimulating learning environment. In this environment, researchers from university bring current scientific issues into the school alongside with their experience with the practice of the scientific method.

Figure 1. School Pupils at the Didactic Lab of the Physics Department of University of Calabria during on Extracurricular Activity

Another important innovation of these last years has been citizen science [10-12]. Citizen science projects entail the participation of non-experts in real scientific research projects alongside professional researchers, underlining the inclusion of the public in the process of producing scientific knowledge. There are many citizen science projects often organized and coordinated nationally and internationally in many fields of research, ranging from astrophysics to marine biology and to environmental monitoring [11]. These projects entail different levels of participant involvement [11], ranging from the basic level of volunteering, with minimal cognitive involvement, to a high degree of engagement and peer-to-peer interaction between participants and professional researchers. While the literature on citizen science focuses mainly on the involvement of adult

volunteers, a growing number of studies highlight how participation in real research activities through involvement in citizen science projects has interesting educational benefits for school pupils [12]. Educational citizen science projects constitute a particular category of the more general definition of citizen science. Citizen science in schools is seen as a way to expose pupils to all stages of scientific inquiry, not only to simple laboratory work or data collection, but also as a way to consolidate knowledge of scientific methodologies by of students and teachers, as well as obviously improving the level of students in scientific disciplines.

For example, RadioLab is a project of the National Institute of Nuclear Physics (INFN) on environmental monitoring of natural radioactivity (https://web.infn.it/RadioLAB/). The project involves the combination of a real research activity, strictly connected to the themes of the physics curriculum at school, with important problems of social relevance. In Italy, extra-curricular educational programs, participation in citizen science projects can also become part of the (formal) school curriculum as a work-place experience [6-8].

These activities and programs allow and support opportunities for more sustained and deeper interactions than most of the current ones between research scientists and the public, especially in schools. These interactions can be further strengthened by institutional collaborations of universities and research institutions with science communication centers and schools. For example, the inclusion of PhD students from the local universities into the staff of a museum can favor involvement of young researchers (see fig.2) [8], simultaneously providing them with the opportunity for the specific training needed to improve communication abilities, which is still largely inadequate within the current graduate programs in higher education. Young researchers practice outreach less than senior scientists [1], but there is evidence [8,13] that these programs are much more successful when young graduate students and postdocs are actively involved. Participation also enhances the education of scientists and helps them to develop skills and capacities useful for both academic and non-academic careers.

Figure 2. A Ph.D. Students and (one of the author, G. Prete) of the Physics Department Performing an Activity with Students at the Planetarium of Cosenza [ref]

Opportunities and Challenges for Science Education in Schools

The approach we followed in developing these extracurricular activities integrated into the formal curriculum is based on peer-to-peer interaction of researchers, teachers and students. The university researcher is asked to put his / her experience in the practice of research and experimental method at the service of students, stimulating their personal initiative and encouraging them in their attempts. The approach favors the uptake of active learning techniques [14,15], putting the students at the center of a stimulating learning environment, that engage them in a creative activity aimed at building knowledge based on learning by doing. In this environment, schoolteachers have the peculiar role of placing the activity in the curricular didactic and pedagogical context. This has an impact on the ordinary activity of teachers in the classroom, which must be connected and oriented with the contents and practices of the extracurricular program. This represents an important redefinition of the work of teachers, called to integrate their teaching with real life experiences in which knowledge is built through inductive processes in active learning contexts, where the focus is on the interaction between the participants. In this sense, what is important in this learning environment are the dynamics of social interactions among all the participants. The assessment of the activity is also performed by observing, stimulating and evaluating the propositional and relational capacity of students, their degree of autonomy, awareness and responsibility, as well as their mental elasticity and creativity [6].

Obviously, there are difficulties to overcome. The participation of school pupils in real research activities is a demanding challenge. The participation of school pupils in educational projects of Citizen science needs to be carefully calibrated and focused, so that the level of activity results appropriate to the age and knowledge of the pupils, to avoid feelings of frustration and inadequacy towards science.

The interaction between schoolteachers and university researchers also requires a change of mentality on the part of both and some resistance is to be expected. Teachers are called to move from transmissive teaching methods to collaborative contexts that stimulate social and peer-to-peer interactions not only between students, but also between the other actors involved, including the teachers themselves and other figures such as operators' museums and professional researchers. Moreover, active learning methodologies are struggling to establish themselves in schools and universities [15].

Although scientists are committed and enthusiastic working toward high purposes and community building, it seems that their practices and attitudes toward public communication have not changed in these last 30 years. There is still a persistent negative perception of the public and of the media [16]. There is an active resistance to sharing power and control in the process of knowledge generation and diffusion [17], and scientists try to maintain control over the knowledge they provide, so they tend to act individually and through one-way communication [1]. Public communication activities are generally designed and performed individually by researchers, mostly senior, even in the institutions that provide support and have communication staff that are used by scientists only rarely and to obtain media attention. Moreover, likely because of their seniority, involved scientists mostly communicate through traditional means but are still largely absent from the internet and from

social media [1,16], being cautious about the capability of the media in dealing with scientific issues [16]. As a result, outreach programs with schools, seminars, public talks and debates, science cafés, fairs or festivals, march for sciences, etc., though appreciated by the public, are generally short-term experiences that often remain occasional and isolated events, which do not succeed in closing the gaps between scientific research and science education and communication.

Conclusions

In the last two decades, the interactions between secondary schools and university have taken a structural character. These interactions are developing through the integration of a whole range of extracurricular activities into the usual curricular activities, allowing and supporting opportunities for more sustained and deeper interactions than most traditional outreach programs, which often result in events of just one day. These activities integrate formal and informal education, resulting in a significant interaction of students and teachers with university environments. This type of integration, through activities co-designed with the active participation of teachers, brings together topics of current scientific relevance and social relevance with an approach intended to expose students and teachers to the practice of the scientific method, while remaining strictly connected to the school curriculum. In this way, current research topics, which are usually not dealt with, can be transferred to schools. Furthermore, through the integration of citizen science projects and other extracurricular programs, the approach can improve the uptake of active learning techniques, which are still poorly applied. In this sense, these activities can be useful for teachers to move from transmissive teaching models to active learning ones based on the interaction between all the participants. Finally, the activities are advantageous for the researchers involved, especially younger ones, who can improve their communication skills and acquire teaching and pedagogical skills.

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