Science, Technology, & Human Values
Volume XX Number X
Month XXXX xx-xx
© 2008 Sage Publications
10.1177/0162243907306707
http://sth.sagepub.com
hosted at
http://online.sagepub.com

Technological Innovation as Social Innovation

Science, Technology, and the Rise of STS Studies in Cuba

Jorge Núñez Jover
University of Havana
José A. López Cerezo
University of Oviedo

This article describes and analyzes the process of institutionalizing studies on science, technology, and society (STS) in Cuba, and the social and academic circumstances in which these studies are implemented there. The authors give a brief account of how science and technology have evolved in Cuba over the last four decades. The authors argue that the promotion of science and technological innovation in Cuba has purposely taken the form of social innovation. The authors offer our view of how the changes and demands on science, technology, and education can take advantage of the approaches and proposals of STS studies. The authors consider the traditions of thought that have influenced Cuban culture and construct a specific conceptual framework through which contemporary developments in STS are assimilated. Finally, on the basis of the above analysis, the authors describe experiences of the institutionalization of STS and their underlying objectives.

Keywords: *STS studies; science policy; R&D in Cuba; technological innovation*

Combining the viewpoints of an inside protagonist and a participating outsider, in this article, we will describe and analyze the main efforts made to achieve the institutional consolidation of science, technology, and society (STS) studies in Cuba, relating these to the particular reality of Cuban

Authors' Note: We would like to express our gratitude to three anonymous reviewers of *Science, Technology, & Human Values* for their contribution to the improvement of our final manuscript. We would also like to thank Paul Barnes for his valuable help with the English version, and research projects FICYT IB05-062 and MEC HUM2005-06760 for economic support.

society and the characteristic traditions of thought in this culture. It will be seen how a process of transfer and assimilation of international experience is taking place in the case of STS studies, although with the peculiarities related to the social and intellectual evolution of the country. First, some comments are necessary about how science, technology, and their policies have evolved in Cuba over the last four decades.

"Knowledge Policy" and Scientific and Technological Policy

The year 1959 was the starting point for a process of profound social changes in Cuba, the socialist objectives of which were officially declared in 1961. One of the characteristics of this social program, and one of its main directions, was the implementation of what we shall term a "knowledge policy." This policy has its basic starting point in the 1961 Literacy Campaign,[1] continuing with the nationalization of education, free access to education, and a far-reaching policy of book publishing and distribution. The new government undertook the development of further education; educational programs for peasants, particularly women; a large-scale scholarship program enabling students from any part of the country or social background to gain access to education, and other initiatives of this type.

When speaking of a "knowledge policy," we emphasize that this was a deliberate strategy, supported and promoted directly by the government and aimed at spreading as far as possible the benefits of knowledge. An essential component of this "knowledge policy" was precisely the country's scientific and technological policy (STP), the evolution of which is summarized in table 1 below.[2] The analysis of STP in Cuba will enable us to explore how diverse perceptions of the interrelationships between science, technology, and society have been expressed in their different stages, as well as the different social impacts registered in each of these stages. We will also identify the features of the current situation and in what way STS studies may possibly contribute to the success of the proposed policies.

Since 1959, STP in Cuba has gone through three main stages. The first stage can be labelled "controlled promotion of science" or "supply-oriented policy," that is, a policy striving to create an R&D sector, which had not previously existed in Cuba (García Capote 1996, 149). This entailed an extraordinary effort aimed at creating scientific institutions and training the researchers who were to work there. Along these lines, many of the main research centers that the country has today were created in the sixties,

Table 1
Scientific and Technological Policy in Cuba

Stages	Period	Objective
Controlled promotion of science	1960-1977	Creation of an R&D sector: research-oriented universities, research centers, and training of researchers
Centralized control model	1977-1989	Identification of priority problems and "introduction of results" into socioeconomic life
Science and technological innovation model	Nineties to today	Creation of a National System of Scientific and Technological Innovation, closely linked to transformations underway in firms and territories and aimed at the generation of new strategic opportunities

including the National Center for Scientific Research; the Polytechnic University; the Digital Research Center, which built the first Cuban computer in 1970; the National Botanical Gardens; the Cuban Academy of Sciences; and other institutions and work groups. From this time onward, a marked process of international exchange took off involving the participation of foreign scientists in Cuba and the training of Cuban specialists abroad.

Given the very limited background, it can be said that the advance in the controlled promotion of science in the sixties constituted an extraordinary leap in Cuban scientific development. This leap was possible, above all, as a result of political ideals and decisions. The new political power assumed that social development would depend on the capability and intelligence that the country was able to generate. In the early sixties, Fidel Castro defined the future of the country as a future of men of science, of thinkers, and not long after, Ernesto Che Guevara, upon becoming the head of the Ministry of Industry, defined a new technological strategy that would first focus on solving urgent problems related to economic production and would later be aimed at the generation of advanced technologies in the environmental and cultural conditions of the country[3] (García Capote 1992; Saenz and García Capote 1989).

It is not difficult to find a certain parallelism between the "stage of controlled promotion" of science in Cuba and the perceptions characterizing the scientific policies implemented from 1959 onward in industrialized countries (Núñez 1999b), inspired to a large extent by the classical report *Science, the Endless Frontier* (Bush 1945/1980). This is the report in which we can find the canonical statement of what has been called the linear model of innovation: more science produces more technology, which in turn

produces an increase in industrial capacity and eventually an increase in social welfare. The model's cornerstone was the adequate funding of research in basic science and engineering "to insure a reservoir of abstract knowledge that could be drawn freely by industry and the military in order to stimulate economic growth and enhance the nation's security" (Zachary 1997, 223). This is a highly simplified view of the science–technology–society relationship, but one that was extraordinarily powerful in the design of classical laissez-faire policies on science and technology all over the world (Fuller 1999, 117).

The parallelism between this classical model and the "stage of controlled promotion" in Cuba lies in the idea that this stimulus to science would foster technological development and this would in turn nourish economic growth and welfare. This perception, prevailing internationally until the late sixties and early seventies, was later the subject of well-known criticism regarding, for example, its idealized causal linearity and excessive optimism concerning basic research and its undervaluing technological factors, and neglecting the role of demand. These criticisms and budget cutbacks in the seventies encouraged the evolution of science and technology policies in the industrialized countries. The former model, based on the assumed integrity and productivity of basic research, which left the regulation of science and technological innovation largely as a matter of internal corporate control, now began to be transformed into open intervention policies in which the civil, public authorities developed and applied a series of technical, administrative, and legal instruments for the channeling of scientific–technological development and the supervision of their effects on nature and society.[4]

In Cuba, the lack of a national scientific base accounts for the emphasis on the "controlled promotion of science." As early as the mid-seventies, evidence began to mount proving that the problem of the practical use of scientific results to meet the problems of manufacturing and services was a matter of greater complexity. This gave rise to changes in STP, the so-called "central control model" being implemented in the country (1977-1989) (García Capote 1996, 150-52). The aim of this model was to complete the supply-oriented effort with a deliberate strategy to use scientific–technical results; a strategy termed "introduction of results." This was intended to be achieved by means of a highly centralized model that, on the basis of the identification of "research problems," would focus research on matters of greater priority and on the use of results in the fields of manufacturing and services. Although emphasis was placed on the use of results, this stage relied on the same linear conception that perceives scientific research as an element triggering the relationship between science, technology, and production.

In addition to the problems concerning the overall view, we may also add a highly relevant practical circumstance. Together with the emphasis on basic science and the expectation that this should increase its contribution to development, an implicit technological policy was implemented that was characterized by the large-scale import of technologies, very frequently from the European socialist countries. These were moderately modern technologies, with low energy efficiency, that were environmentally nonfriendly (García Capote 1996, 146). The tendency to assimilate rather than improve traditional technologies or produce appropriate technologies, the lack of systematic technology assessment, and the frequent lack of interest in innovating shown by the manufacturing sector (García Capote 1996, 151) account for the fact that the new scientific development and human potential created did not produce the expected practical results. This situation justifies the critical perception that was formed on the subject throughout the eighties, a discussion that implied a broader debate on the practice of socialism in Cuba and in particular on the efficiency of the country's economy.[5]

Other factors may be added to this perception. The conception that the advance of socialism at a worldwide level would depend to a large extent on its ability to develop science and technology as social production forces was another important element. To this may be added the need to increase the country's ability to address the biological aggressions it was undergoing,[6] a priority heavily emphasized from the early eighties onward, and the effort to continue improving the Cuban health system with the creation of advanced technologies in this field. Consideration was also given to creating new products for export, making the most of the potentialities of the field of biotechnology in Cuba, a field that has been the object of exceptional efforts.

Although it does not provide the full picture, this panorama offers an account of the reasons the country introduced important changes in its STP from the mid-eighties onward. Among the most relevant changes we may highlight the relaunching of scientific research at university level, now with a more applied orientation; the definition of new priorities for scientific and technological development (biotechnology, pharmaceuticals, high-tech medical equipment, etc.); the creation of *Polos Científico-Productivos* (Centers for Science and Production); networks of integrated cooperation where scientific research, technology design, and the manufacturing and marketing of products all form part of a continuous process guided by specific strategies (see below); and the promotion of the *Foro de Ciencia y Técnica* (Science and Technology Forum), a uniquely Cuban experience aimed at increasing the participation of citizens in techno-scientific development and its applications (see below).

STP priorities during this period may be summarized in various main groups. The most interesting one for our purposes includes areas whose objectives are to achieve or maintain excellence or international competitiveness on the basis of new products or technologies. This particularly comprises new vaccines and new drugs, high-tech medical equipment, new vegetal varieties obtained through biotechnology, R&D related to genetically modified plants or animals, new diagnostic methods for plant diseases, and new software products and computer services in fields where the country has potential.[7]

The development of Cuban biotechnology is in itself an interesting social experiment, with a number of aspects that are worth summarizing (Lage 2000, 60). Important results have been generated here by the (policy-oriented) knowledge push, not by the market pull. The government played an active role by providing guidelines, resources, and supporting interinstitutional cooperation. Most of the science-production centers, the so-called *Polos*, develop activities covering the full cycle: scientific research, product design and development, and production and marketing, thus creating a strong connection between scientific rationality and economic rationality. Although the property is state-owned, these centers operate like firms with a high degree of autonomy within a framework of general strategic coordination.[8] The general rationale underlying this coordination is a systemic approach based on interdisciplinary and interinstitutional cooperation, aimed at integrating efforts, resources, actions, and services (Lage 2000, 61).

In the nineties, the national STP entered its third and current stage, characterized by the creation of a *Sistema Nacional de Ciencia e Innovación Tecnológica* (NSSTI, National System of Science and Technological Innovation), with features similar to the national innovation systems installed in other countries, though taking into consideration the significant differences in the country's internal and external conditions. The priorities that have been defined in the country since the mid-eighties and the need to obtain more practical responses from science and technology (particularly to the problem of the competitiveness of products and services) have meant the reform of STP in the form of the creation of an NSSTI (CITMA 1998a, 1998b). A certain social debate thus arose concerning the process of transforming the business system in which technological innovation takes a central role. In combination with this debate, as we have seen, the R&D sector was made responsible for the creation of new economic fields and new strategic opportunities.

It should be noted that the transition in Cuban STP from the second to the third stage overlaps in time with the so-called "special period" (*periodo*

especial) in which the Cuban economy experienced the combined effect of the collapse of the Soviet Union and the intensification of the U.S. blockade.[9] For decades, the relationship with the Soviet Union and other countries belonging to the Soviet Block helped provide Cuba with most of the technological equipment and other supplies necessary for its economic life and the majority of scientific exchanges and training programs, particularly at the postgraduate level. It is interesting to note that such a profound economic crisis did not lead to the stagnation of the scientific and technological sector, which turned instead toward the search for a greater contribution to Cuban economy. For example, in 1999, it was estimated that Cuba had spent about US$1,000 million on biotechnology over the previous fifteen years (Carr 1999).[10]

Cuban biotechnology, particularly, has generated more than five hundred patents, and the creation of highly novel products has even enabled the transfer of technology not only to countries belonging to the Southern Hemisphere (Malaysia, India, Brazil, and many others), but also to countries belonging to the Northern Hemisphere such as Canada, the United States, and Europe. Actually, bioscience is the field that has experienced the greatest development in Cuba. Important advances have been achieved in biopharmacological products, vaccines, or diagnostic procedures, which include immunoassay systems for perinatal diagnosis, reagents of certification of blood, AIDS diagnostic techniques, and many other applications. Under this light, it may be stated that science and technology are exerting a significant impact on human development in Cuba (CIEM/PNUD 2004).

Thus, the central importance of innovation in economic policy, the urgent need to implement mechanisms for technology assessment, and the consolidation of increasingly more solid and stable links between science and technology in the different sectors of society and territories make up a scenario in which the science–technology–society links are present with a greater intensity in the current STP. Since these interrelations are necessarily conceived under a certain paradigm, this also requires updating. This situation logically brings to the forefront the social interests and values underlying STP, thus raising the issue of the diversity and role assumed by the actors in the social setting. In the first stage of the aforementioned STP, basic research appears as the central protagonist of scientific–technological development, a conception that leads us to the second stage, with the addition of a high degree of centralization in the definition of research issues. In the current stage, the actors in the system of science and technological innovation are highly varied: R&D centers, universities, industries producing goods and services of various sizes and territorial scope, consultancy firms, technology managers, trade

unions, educational and financial bodies, among others. It is obvious that the perceptions of these diverse sectors will have an influence on the innovation system (NSSTI) that the country has been developing. From this perspective, it seems reasonable to suppose that STS studies can make an important contribution from a critical and interdisciplinary approach in the creation of a meeting place for different viewpoints and the provision of the conditions for social learning.

Ideology of Science, Ideology in Science

From the above, we should be able to appreciate that a perception has dominated since the earliest political discourse in the sixties that insists on the value of science and its direct connection with the problems of social development. As this perception comes from the highest levels of government in the country, this has triggered practical actions aimed at the development of education, the spread of scientific culture, and the consolidation of a national scientific and technological potential and infrastructure. It is therefore possible to observe in Cuban political thought a perception of the value and the social significance of science and technology, of their priority and central importance in the strategies of social development that we may sum up in the existence of an "ideology of science," upheld and promoted by the main political actors.

This ideology crystallized as part of the process of broader social changes in which the popular sectors were allowed access to education and science, nourishing the body of professionals, scientists, and lecturers that have filled university departments and founded the majority of research centers. If, as stated by D. S. Price (1963), 90 percent of the scientists who have existed worldwide are still alive, in Cuba almost all the scientists, engineers, technicians, professors, and teachers have qualified as such in the last twenty-five years, within the context of profound social changes in the country. It is not surprising that this developing scientific community has embodied the proposal of a science oriented toward the solution of the country's social problems. Here, we can find the complement for the "ideology of science" as projected from political power: "ideology in science," understood as the ethical–political perception of scientific work assumed by a good number of scientists, engineers, and lecturers; a perception that basically enables the work of all of these to be conceived as a social contribution.

The above values have matured, undergone tensions over decades, and formed a highly unusual ideological, political, and ethical context, incomprehensible from interpretations upheld by internalism and scientism that claim sharp separations between science and value, scientific aims, and political motivations. Clearly, Cuban scientists have not generally experienced similar dichotomies in their practical experiences.

In the nineties, the above-mentioned values were drafted into the "Code on Professional Ethics of Cuban Scientists."[11] This document sets down diverse ideals with respect to the behavior of scientists and proposes that specific sectorial and institutional codes be derived from it, according to the particularities of the scientific tasks undertaken. These ideals allude to concepts of a different nature, some of which are epistemological and ethical (truth, rigor, objectivity, honesty) and others sociological and political (patriotism, social commitment, social interests). While scientists are required to seek the truth and carry out honest, disinterested work to contribute to the advance of science, the main contribution expected from this work is social welfare, to which individual and corporate interests must be subordinated. The code thus proves to be a singular mix of requirements typical of the classical academic ethos (Merton 1942-1980) with political ideals and social values assumed as a priority—an interesting combination of epistemological, ethical, and political rationalities.

Integration, Collaboration, and Public Involvement

Among the distinguishing features of science and technology in Cuba, we may cite integration, collaboration, and public participation in these activities. These features are the result of the peculiar interrelations between science, politics, and the characteristic values of the Cuban context.

The national policy on science and technology is strongly and explicitly aimed at strengthening the links of all those involved in different ways and at different levels in technological change. For that reason, social movements, organizations, and institutional initiatives have developed that encourage the joint search for solutions to the different technical, economic, and social problems facing society. Among the former we find the *Brigadas Técnicas Juveniles* (BTJ, Youth Technology Brigades) with some 200,000 affiliated youths, the *Asociación Nacional de Innovadores y Racionalizadores* (ANIR, National Association for Innovation and Rationalization) with more than 100,000 members (CIEM/PNUD 2004, 59) and the *Sindicato de Trabajadores de la Ciencia* (STC, Scientists' Union). The first two are movements grouping

workers, technicians, engineers, and others linked to manufacturing activities who combine their efforts in the search for technical solutions; they are organized from a local factory or firm level up to a national level. The main difference between BTJ and ANIR is the age of their members, in that the members of the BTJ average under thirty. The STC, on the other hand, is an organization grouping Cuban scientists furthering the search for group solutions to their own problems and especially endeavoring to strengthen their social contributions. Alongside others, these organizations constitute technological links in the sense of the constructivist approach of Rip, Schot, and others: these are mechanisms for connecting the generation of variations in the R&D process and the selection environment, not only within the context of manufacturing activity, but rather of society in general (Rip, Misa, and Schot 1995).

Important institutional vehicles also exist fulfilling this function of technological links, designed to encourage cooperation and science–technology–society integration. One such institution is the previously mentioned *Polos Científicos Productivos* (Centers for Science and Production), which exist in practically all the provinces in the country. The efforts of research centers and the R&D laboratories of firms, universities, and other educational institutions are coordinated through these, with the active participation of the territorial administrations. The problems of the economic and social development of each region are discussed in the *Polos,* and an attempt is made to seek solutions based on the available scientific–technical capacity. The most well-known example at an international level, which has an increasingly greater impact on the development of the country, is the *Polo* situated to the west of the capital, whose efforts are mainly focused on the development of biotechnology, the pharmaceutical industry, and high-tech medical equipment. In this *Polo*, thirty-eight scientific institutions come together and collaborate, with approximately fifteen thousand workers including scientists, engineers, technicians, and others, more than half of which are women (CIEM/PNUD 2004, 169). A key factor of integration is the existence of a public body providing guidelines for national STP.[12]

One of the most interesting social experiences in the promotion of technical development in the country is the so-called *Movimiento del Forum* (Forum Movement). The roots of this movement go back to the early sixties with the strategy of technological development conceptualized by Che Guevara in his Ministry of Industry, consisting in generating technical solutions, for instance, to the lack of spare parts and machinery breakdowns. In fact, the BTJ and ANIR are movements that attempt to fulfill these needs.

From the early eighties onward, the creative search for technical solutions was expressed via the Forum Movement. This is a process that ranges from factories, firms, workshops, and other primary manufacturing units up to a national meeting level, promoting debate with respect to proposed solutions and stimulating those presenting the most valuable initiatives. From 1982 to 2006, fifteen processes of this type were undertaken. Among the changes to be observed, we may cite the different demands that this movement has had to face. When it began, the basic aim was the replacement of machinery and technology from Western countries whose flow to the island had been interrupted, attempting to solve this problem with replacements from the European socialist countries. Following the fall of European socialism, greater creativity has been needed to overcome technological shortcomings. The movement has opened its frontiers by incorporating research centers, thus converting it into the current *Forum de Ciencia y Técnica* (Science and Technology Forum).[13] This is now the meeting place for a wide cross-section of society: from workers, peasants, technicians, and students to scientists and engineers linked to the most advanced research and technological innovation in Cuba. The forum has become an increasingly significant channel, encouraging public participation in the process of technological innovation by opening the stage of genesis of variation to a broad variety of social actors, thus making it a highly interesting participatory experience.[14]

The major difficulty with the forum consists of the barriers for generalizing innovations beyond the specific contexts in which they arise. Still, this conception broadens the range of actors participating in these practices, not limiting them to the scientists and engineers of the R&D sector, but rather including a vast segment of the population, in principle all those who can be involved in the production, dissemination, and application of knowledge. In this way, the social basis for the innovation process is enhanced. To this we may add that in Cuba, 7 percent of the population are university graduates and one in every seven workers is a university student.

Given the above initiatives and experiences, and taking the existing limitations into account, we may state that an unusual and interesting model for the social regulation of scientific–technological development has been assayed in Cuba. This is a model that makes use of a wide range of control strategies, specifically promoted by the aforementioned institutional organizations (BTJ, ANIR, STC, and Polos) acting as technological links between the generation of techno-scientific variation by the R&D community on one hand and the context of innovation diffusion and its social appropriation on the other. As suggested by constructive technology assessment (Rip, Misa, and Schot 1995), these links adapt the variation process by taking into account

the stimuli and requirements of the selection environment. This is also a socialization experience acting on the very source of the genesis of variation, not only because of the particular commitment of the R&D community in the social orientation of their specialized work (what we have termed "ideology in science"), but also because of the experience of the Forum Movement as a mechanism for opening the innovation process to a broader cross-section of society. This model also includes a socialization experience in which the government plays an important role, creating or activating the technological links that transfer the requirements of the selection environment to decisions on resource allocation in R&D. As several authors have pointed out, this role is necessary for the modulation of the selection environment to lead us in the desired direction (e.g., Schot 1992).

Thus, the model of public participation assayed in Cuba is not a reactive one, that is, a model based on product scrutiny by social actors whose actions can be perceived as an external interference by government authorities. The social actors are involved in the innovation process from the very definition of the problems that this innovation has to solve. It is not a model giving rise to diverging interests between the agents of variation generation on one hand through their investment and regulation policies (in Cuba, the public administration), and a diversity of social actors receiving this innovation on the other. In the face of great difficulties and even though it still has a long way to go, an active participation model has been attempted in Cuba, with some type of "constructive" management in the political horizon.

The Institutionalization of STS

When defining the basic traditions that articulate the field of STS studies, two such traditions are usually recognized: the tradition of European origin and one of an American origin (González García, López Cerezo, and Luján 1996). These have also been termed "high church" and "low church" (Fuller 1992a, 1992b), respectively, as they are focused on the academic study of the social antecedents of scientific–technological change, or rather on the understanding of the ethical, political, and educational problems related to the results of this change. These studies respond to both an academic and social reaction that took place in the sixties and early seventies, respectively, closer to each of the mentioned traditions. The academic reaction is linked to the rise of the new sociology of scientific knowledge, from which a wide range of programs later derived as a critical response to the inherited conception of science—an essentialistic and triumphalistic view of science that

undervalued the social determinants of scientific and technological development. In turn, the social reaction underlying STS studies has its origins in the negative public reception and academic critique of military uses of science and technology, as well as the environmental and health hazards produced by technological development. These factors account for the process of consolidation and institutionalization of STS studies that has been taking place since the sixties and seventies, mainly in Western Europe and the United States (González García, López Cerezo, and Luján 1996; López Cerezo 1998).

When explaining the institutionalization process of STS studies in Cuba, other considerations must also be taken into account. Since the sixties, the most influential tradition in Cuba in the field of social sciences has been Marxism. This has been taught and researched in Cuba for over four decades, and its influence reaches broad sectors of society. In particular, it is taught at university level as part of the training of scientists, engineers, and other professionals.

Despite the varied perceptions that can be found regarding scientific and technological development in different Marxist sources, it is clear that this is a proposal which, from its origins and in the voice of its most brilliant promoters, has insisted on the interrelations among science, technology, social structure, and actors. Within the seminal ideas of Marx, scientific development was included as part of the reproduction process of capital and directly linked to the industrialization process, as was the well-known proposal by B. Hessen or the ideas of J. D. Bernal, among other perhaps less well-known conceptions.[15] Marxism has inclined toward an understanding of science and technology as dimensions of the society as a whole, inexplicable outside the economic and political variables and social interests of various types. In Cuba, it is these Marxist roots that have passed on their spirit to the current institutionalization process of STS studies.

In the seventies and especially in the eighties, many courses and publications on science (much more than on technology) emerged in Cuba. The points of interest were mainly philosophical debates on the development of sciences (with less emphasis on logical subjects than on value-based or political issues), studies on the scientific–technical revolution and its social consequences, as well as subjects of history of science and scientific policy.[16] With the passing of the eighties, the idea took form that it was necessary to overcome the disciplinary frontiers of these studies (history, philosophy, sociology, and others) and advance in favor of an interdisciplinary conception.

In the second half of the eighties, some studies began to be prepared that combined the above perspectives (Núñez 1989, 1999a), degree theses were

defended, and courses were given along these lines in an attempt to relate these perspectives to one another. Likewise, during the eighties, another notable influence came from Latin American thought in science and technology (Vacarezza 1998).[17] The debate concerning social development and its relation to matters such as scientific backlog, technological dependence, appropriate technologies, public policies in science and technology in developing countries, or the particularities of the institutionalization process of peripheral scientific communities aroused greater academic interest because of their direct link to the Cuban situation problem. New traditions, authors, and problems found their place on research agendas and the academic syllabi of science studies, giving rise to a set of problems for which debate was not possible other than from a social, interdisciplinary, and critical perspective. These studies were also considered to have important potential in the field of education, as well as in scientific and technological policies.

In the early nineties, these advances prepared the ground for the emergence of the discipline *Problemas Sociales de la Ciencia y la Tecnología* (PSCT, Social Problems of Science and Technology) in the social sciences cycle of most university degrees in Cuba. It was thus considered that higher education, especially in the case of scientists and engineers, was to be enriched with the study of the social problems of scientific and technological development, providing it with a universal dimension as well as a Latin American and Cuban perspective. It should be noted that the incorporation of this discipline was possible because Cuban higher education assumes that scientific–technological and humanities studies should go hand in hand. Eventually, PSCT arose as a discipline in most university syllabi on the basis of this general approach.

About the same time, the National Committee for Science Degrees[18] replaced the philosophy exam that PhD candidates usually had to take and that basically included philosophical Marxist contents by a PSCT exam. The same decision was taken for promotions in lecturing and research positions. Assessment consists of the preparation and public debate of a text in which the lecturer or researcher discusses some ethical, political, or social problem related to his or her professional experience. Every year, hundreds of contributions of this kind are produced that strengthen the presence of STS approaches in academic institutions and broaden the studies of available cases that help activate the scientific and technological dynamics of the country. With these dispositions, this discipline was opened to an audience that included a good part of the academic sphere. The first text was published in 1994 (Núñez and Pimentel 1994).

In the nineties, amidst the economic crisis, academic exchange between Cuba and Spain grew considerably. It was, therefore, not unusual for these contacts to spread to the field of STS. Within the new institutional possibilities, personal contacts enabled the advances in collaboration in STS,[19] while also taking into account the ground gained by the subject of PSCT and the PSCT exam. In particular, this support has been fundamental in advancing a postgraduate program aimed at preparing people who can now develop education and research in STS in a more professional way. The STS Master's Program, inaugurated in 1997, already has fifty graduates, and currently twenty students are studying for this degree at the University of Havana, twenty-five students at the University of Cienfuegos, and twenty at the University of Computing Sciences. Five master's students have already defended their doctoral theses. Although they normally have a background in social sciences or philosophy, some come from the fields of science and engineering. People from almost all the provinces in the country are represented in the master's degree.[20]

The activities related to the program, and in particular the master's and PhD theses, are enabling the development of research in the field of STS. The research agenda is varied and includes matters such as the impact of scientific and technological development, innovation, technology transfer, research study groups, scientific and technological education, public perception, and citizen participation, among others. Together with the master's program, the institutionalization of STS studies rests on the existence of a Science, Technology, Society, and Innovation (STS&I) Chair, which constitutes a national network that came into being connected to a professorship network of the same name created by the Organization of Ibero-American States.[21] The STS&I Chair, inaugurated in 2001, is integrated into several networks with European and Latin American universities and focuses on the study of interrelations between university and society.

STS in Context: Looking Ahead

A classical lesson of STS studies is the understanding of the scientific and technological phenomenon as a complex process that cannot be properly understood outside of a social context, that is, without the constellation of the social circumstances that make sense of it.[22] From this perspective, science in its widest sense presents itself as a network of individuals, institutions, and practices depending on contexts with their own cultural, economic, and social determinants (Chambers 1993; Núñez, Montalvo, and Pérez 2007).

It is from this perspective that the consolidation process of STS as an academic field must be understood. For this reason, when describing its institutionalization process in Cuba, we have referred to the particular social institutional and ideological background, its own context on the island. As a cultural artifact, the transfer of STS has peculiar features depending on each reception context (Luján, López Cerezo, and Muñoz 1994). The further development of these studies will likewise require special attention to be given in the future to the society in which it is produced.

This refers, for instance, to the increasingly fruitful relation that STS should establish with the educational changes and the system of science and technological innovation that is currently being developed in Cuba. Although STS has gained ground at the level of higher education and postgraduate studies, the same does not occur for the lower levels of Cuban education in which STS is lacking as a discipline or approach. Similarly, the actual teaching of scientific and technical disciplines in universities is far from incorporating social or historical approaches. Thus, the educational presence of STS in higher education, although practically ubiquitous through the PSCT courses, in general takes the form of a curricular addendum in most degrees (López Cerezo 1994).

Besides, setting an STP in motion implies the mobilization of diverse actors with different interests, diverse ways of understanding, and different degrees of coming to terms with their involvement in the new scenario. There may be opposition from academic groups, who may try to locate their sources of legitimation from analogous international groups instead of locating them from their supposed role within the new system—typical behavior in peripheral scientific communities (Anda and Iglesias 1983). There may be opposition from firms, faithful to an import mentality and who perhaps undervalue possible scientific contributions of strategic value. Or there may be resistance from the educational system, the science and technology managers, or other actors.

STS may contribute—and formal and informal education becomes crucial here again—to communication between actors on the basis of a certain number of shared values and more or less overlapping perceptions of science and technology and their links to social development. The most relevant task for STS studies from the viewpoint of a nondeveloped country is possibly that of stimulating reflection and social debate on the complex interrelations between techno-scientific development and social development. As we see it, social debate and criticism, and the promotion of democratic participation through science and technology constitute a condition for the goal of achieving a stronger connection between technological innovation and social innovation, and thus for the advancement of the country's development.

Thus, we understand that the STS approach is relevant in Cuba for at least the following reasons:

1. It recovers the political dimension in science and technology decision taking.
2. It insists on the need to throw light on means and ends in policies, facilitating the reorientation of these toward human and sustainable development.
3. It highlights the illusion of unique solutions, emphasizing the need to formulate one's own policies while being aware of the experiences of others (Arocena 1993).
4. It creates an interdisciplinary field in which the economy plays an important, but not an exclusive role. Social sciences, cultural studies, or ethics, to mention only a few disciplines, are also important.

The conceptual framework normally underlying the understanding of the interrelations between science, technology, innovation, and society, and thus nurturing mainstream STS in Cuba, receives influences from the main international STS traditions (the aforementioned high and low churches). However, though recognizing the need to keep an attentive eye on American and European authors, and simultaneouly trying to maintain international standards of academic rigor, the "STS project" in Cuba does not aim at being a mere local replication of foreign experiences. Two main sources of influence are shaping the Cuban approach to STS: Marxism on one hand, and on the other, Latin-American thought on science, technology, and social development over the last four decades (Oteiza and Vessuri 1993; Dagnino and Thomas 1999; Vacarezza 1998). This explains why the practical horizon of improving social conditions and contributing to social development is seen in Cuba as an essential task for STS studies.

These remarks are aimed at stressing the political and educational, that is, practical, meaning of STS studies in Cuba. This, of course, requires the development of appropriate theoretical approaches as well as adequate methodological tools, for which international experiences provide an indispensable resource. Studying science and technology as social processes while defending the ideals of academic rigor and domestic significance is thus seen as a task that contributes to a more far-reaching objective, namely that of contributing to enhancing the role that science and technology are already playing in social development.

In parallel to this, the success of an academic initiative, seen as a process taking place in a certain local context (Chambers 1993), depends on the ability to guarantee an appropriate interrelation between elements such as the actual academic activity, with its institutions, syllabi, work groups, and

publications, among other elements, as well as the international communication network that might be established, and its relations with the social mechanisms and cultural strategies linked to this academic activity. In relation to these elements, a number of tendencies that appeared in Cuba in the late nineties may be cited:

1. Most currently existing departments, work groups, and syllabi are advancing toward the creation of a national STS program consisting of a network of individuals and institutions aimed at developing different work agendas, normally oriented toward diverse educational channels, both formal and informal, and the strengthening of innovation strategies, especially from the perspective of the university system.
2. STS audiences are gradually broadened. Some of the groups that gain access to STS education, most often through postgraduate studies, are scientists and engineers linked to the R&D sector; a variety of innovation agents; university professors of science, technology, and medicine; diverse professionals, science journalists and recipients of scientific communication; and secondary school teachers.
3. Academic exchange has been consolidated, especially with Latin America and Spain. Various initiatives are under way to intensify the international links of the Cuban STS program. Examples already exist in the exchange of professors and bibliographic material that will undoubtedly be enhanced in the future.

All this exchange and its expressions through postgraduate education and research will enable the consolidation of the process of assimilation (and adaptation) of the international trends in the field of STS studies. A current goal is to stimulate the updating process of these developments in so far as they are cultural products whose importance varies from one context to another. Laboratory studies, risk management studies, issues in technology assessment, studies on scientific controversies, scholarships on science and gender, or ethical conflicts in science and technology, to mention just a few examples, provide extraordinary material for understanding the particularities and role of scientific and technological development in contemporary society. Of special interest is the updating of Cuba compared with the international experience in STS education at a nonuniversity level.

Each society and culture, however, has its own conflicts and tasks to solve. STS studies in Cuba should preferably pay attention to these problems, strengthening the process of endogenization of STS studies, using the international tradition for this purpose at the same time as trying to contribute to it. As one of the island's poets once said, "being Cuban is the best way to be universal."

Notes

1. The country had an illiteracy rate of 23.1 percent in 1958, and of 3.9 percent in 1961.

2. On the subject of STP in Cuba, see Castro and Codorniú (1988), Saenz and García Capote (1993), Simeón (1991, 1996, 1997), and García Capote (1996).

3. This strategy is stated in the first editorial of the journal *Nueva Industria Tecnológica,* founded by Che Guevara in 1962. Examples of these political decisions can be found in the development of the industry of sugar cane by-products and the development of agricultural machinery. An important technological innovation, the harvester for cut cane, decreased the demand for labor and brought about a transformation in the organization of the labor force. The technical–scientific and institutional paths that began to open in the sixties continued in the following decades.

4. The late sixties and early seventies saw the creation of the Environmental Protection Agency (EPA) and the Office of Technology Assessment (OTA), both in the United States, pioneering initiatives of the new political management model. Another important area of innovation in these new public policies on science and technology concerns their increasing focus on economic competitiveness (González García, López Cerezo, and Luján 1996).

5. The reciprocal alienation between science and production is a well-known characteristic of Latin American development. Although the Cuban economic and social model is different from the other the Latin American countries, it conserves some features that have likewise not fostered the meeting of science and production. Among these, we cite the high dependence on imported technology, the scant capacity for innovation in the business system, and the slow creation of legal, fiscal, economic, or other mechanisms that foster synergy between science and production.

6. The evidence supporting the conclusion of a biological aggression against Cuba has been piling up from many episodes over the last decades. Contrary to logic, and unrelated to natural transmission patterns, for forty years now a variety of pests, viruses, and diseases have been appearing on the island, attacking animals, plants, and human beings by surprise. African pig fever (*fiebre porcina africana*), tobacco blue mould (*moho azul del tabaco*), bleeding influenza (*dengue hemorrágico*), bleeding conjunctivitis (*conjuntivitis hemorrágica*), among others, are diseases whose existence in the country is attributed by specialists to intentional actions. Because of these and other aggressions, in 1999, Cuba filed a legal suit against the U.S. government (Mendoza et al. 1999). The important point here is that such a perception was one of the causes for emphasizing biological research in Cuba, particularly from the eighties onward.

7. Other groups define STP priorities at this stage: A second group includes areas linked to more traditional production sectors, such as sugar and its by-products, human and animal foodstuffs, energy diversification, technology building, and others areas crucial for the country. A third group focuses on biodiversity, soils, inland and marine waters, and atmospheric pollution, and a number of research programs focus on the study of Cuban society via several dimensions (economic, political, cultural, etc.) and the interaction of society and the environment. A fourth and final group includes areas of R&D that focus more on basic research and fundamentals, such as physics, chemistry, mathematics, electronics, computer sciences, or new materials.

8. Still, relevant differences, such as the governmental coordination role or the global aim of providing a social service, must be appreciated between this type of entity and full-blown firms proper of capitalist countries.

9. Between 1989 and 1993, the import capacity of the Cuban economy decreased over 75 percent, falling from US$8,139 to $1,700 million. The GNP was reduced by 34.8 percent

and approximately 80 percent of existing industrial plants came to a standstill. It was only in 1994 that a modest 0.7 percent growth in GNP was achieved, thus stopping the economic slump and starting a slow and gradual though sustained process of economic recovery (Bell Lara 1999, 37-38).

10. In 2003, Cuba devoted 0.65 percent of its GDI to R&D. From the institutional perspective, the country has 215 Science and Technology Units. The total number of researchers is 5,378 (51.9 percent women), which represents an index of 1.27 effective researchers in R&D per thousand economically active persons (CIEM/PNUD 2004). In general, these indexes show that Cuba occupies a relatively favorable position within the Latin American context (RICYT 2006).

11. CITMA, working paper, no date.

12. This is the Ministry of Science, Technology and the Enviroment (the so-called "CITMA").

13. These changes can be seen in the different names adopted. Whereas the first forum (February 1982) was named *Forum de Fabricación y Restauración de Piezas de Repuesto* (Forum for the Production and Restoration of Spare Parts), the sixth forum (1991) was originally called *Forum de Piezas de Repuesto, Equipos y Tecnologías de Avanzada* (Forum for Spare Parts, Equipment and Advanced Technologies), to be later renamed, since 1993, *Forum de Ciencia y Técnica* (Science and Technology Forum).

14. The following figures illustrate the functioning of the forum: whereas in 1982 there were 818 studies providing 818 solutions to diverse technical problems (spare parts, equipment, technology, technical design, R&D, among others), in 2002 these figures rose to 940,828 studies providing 2,056,228 solutions and 1,484,363 authors, of which 29 percent were women (CIEM/PNUD 2004, 25). People with very different levels of education participate in the forum, ranging uniformly in recent editions from university graduates to people with primary education (CIEM/PNUD 2004, 24).

15. See Hessen (1931/1985) and Bernal (1954).

16. The views of various authors are partially reflected in the 1985 *Filosofía y ciencia*. Havana: Ciencias Sociales.

17. Oscar Varsavsky, Amilcar Herrera, or Jorge Sábato were some of the socially committed thinkers linked to this influence. See also note 22.

18. The institution guiding PhD policy in Cuba.

19. Of course, it is only thanks to the institutional and financial support provided by a number of Cuban and Spanish universities and funding bodies that these personal contacts have managed to create stable links of academic cooperation. An intergovernmental organization promoting science and education in Latin American countries plus Spain and Portugal, the Organization of Ibero-American States (OEI), has also supported STS international cooperation with Cuba since 1999.

20. Its disciplinary structure reflects the interest in encouraging multidisciplinary collaboration and combining theoretical and practical aspects. The master's program includes, among others, the following subjects: Epistemology and Philosophy of Science, History of Science and Technology, Economy and Technological Change, Management of Science and Technology, Sociology of Science and Technology; Science, Technology and Development; Education and Development; Legal Regulation of Science, Technology and the Environment; Thought and Action in Latin America.

21. See note 19.

22. STS studies in Latin America offer a substantial amount of empirical evidence on the close relationship between the orientation and organization of science and technology in these countries on one hand, and their economic, social, cultural, and political situation on the other.

Underdevelopment and international dependence, in particular, are two major factors that are usually taken into account (Cardoso and Falletto 1978). Some studies providing specific examples or general reflections on this subject are Varsavsky (1969), Sábato and Botana (1970), Herrera (1975), Sábato and Mackenzie (1982), Fajnzylber (1983), Vessuri and Díaz (1983), Albornoz (1997), Sutz (1997), Nieto (2000), and Arocena and Sutz (2003), among others.

References

Albornoz, M. 1997. La política científica y tecnológica en América Latina frente al desafío del pensamiento único. *Redes* IV/10, October. Buenos Aires: Universidad Nacional de Quilmes.

Anda, E., and R. Iglesias. 1983. La actividad científica en los países dependientes. *Revista Mexicana de la Física* 30 (1).

Arocena, R. 1993. *Ciencia, tecnología y sociedad. Cambio tecnológico y desarrollo*. Buenos Aires: Centro Editor de América Latina.

Arocena, R., and J. Sutz. 2003. *Subdesarrollo e innovación*. Madrid: Cambridge University Press.

Bell Lara, J. 1999. *Cambios mundiales y perspectivas de la revolución Cubana*. Havana: Editorial de Ciencias Sociales.

Bernal, J. D. 1954. *La ciencia en su historia*, vols. 1 and 2. Mexico: Dirección General de Publicaciones, UNAM.

Bush, V. 1945/1980. *Science, the endless frontier*. New York: National Science Foundation.

Cardoso, F. H., and E. Falletto. 1978. *Dependencia y desarrollo en América Latina. Ensayo de interpretación sociológica.* Mexico: Siglo XXI.

Carr, K. 1999. Cuban biotechnology treads a lonely path. *Nature* 398 A (April supplement): 22-23.

Castro Díaz-Balart, F., and D. Codorniú. 1988. Cuba: En el camino de una ciencia acorde con nuestra realidad. *Cuba Socialista* 34 (July-August).

Chambers, D. W. 1993. Locality and science: Myths of center and periphery. In *Mundialización de la ciencia y cultura nacional*, 605-18. Madrid: Planeta.

CIEM/PNUD. 2004. *Investigación sobre Ciencia, Tecnología y Desarrollo Humano en Cuba 2003*. Havana: ENPSES.

CITMA. 1998a. *Ley de la ciencia y la tecnología de la República de Cuba* (bill project), (May) Havana.

———. 1998b *La ciencia y la innovación tecnológica en Cuba. Bases para su proyección estratégica*. Havana: Editorial Academia.

Dagnino, R., and H. Thomas. 1999. La política científica y tecnológica en América Latina: Nuevos escenarios y el papel de la comunidad de investigación. *Redes* VI/13 (May).

Fajnzylber, F. 1983. *La industrialización trunca de América Latina*. Mexico: Nueva Imagen.

Fuller, S. 1992a. STS as a social movement: On the purpose of graduate programs. *Science, Technology and Society* 91:1-5.

———. 1992b. Give STS a place on which to stand, and it will move the university—And society. *Science, Technology and Society* 92/93:4-6.

———. 1999. *The governance of science: Ideology and the future of the open society*. Buckingham: Open University Press.

García Capote, E. 1992. Algunas ideas principales de Fidel Castro sobre la investigación científica. *Revista Cubana de Ciencias Sociales*, Supplement.

———. 1996. Surgimiento y evolución de la Política de Ciencia y Tecnología en Cuba (1959-1995). In *Seminario Taller Iberoamericano de Actualización en Gestión Tecnológica*

(Ibero-American Workshop on Currrent Technological Management), ed. E. García Capote and R. Faloh, 144-72. Havana: GECYT.

González García, M., J. A. López Cerezo, and J. L. Luján. 1996. *Ciencia, tecnología y sociedad: una introducción al estudio social de la ciencia y la tecnología.* Madrid: Tecnos.

Herrera, A. 1975. Las determinantes sociales de la política científica en América Latina. Política científica explícita y política científica implícita. In *El pensamiento latinoamericano en la problemática ciencia—tecnología—desarrollo—independencia,* ed. Jorge Sábato, 98-112. Buenos Aires: Paidos.

Hessen, B. 1931/1985. *Las raíces socioeconómicas de la mecánica de Newton*. Havana: Academia de Ciencias de Cuba.

Lage, A. 2000. Las biotecnologías y la nueva economía: Crear y valorizar los bienes intangibles. Vol. 17, 1 of *Biotecnología Aplicada 2000*. Havana.

López Cerezo, J. A. 1994. STS education in practice: The case of Spain. *Bulletin of Science, Technology and Society* 14 (3): 158-66.

———. 1998. Ciencia, tecnología y sociedad: El estado de la cuestión en Europa y Estados Unidos. *Revista Iberoamericana de Educación* 18:41-68.

Luján, J. L., J. A. López Cerezo, and E. Muñoz. 1994. STS studies in Spain: A case study in STS transfer. *Technoscience* 7 (2): 14-16.

Mendoza, J., L. Pérez, M. Iserne, and I. Pérez. 1999. *Demanda del pueblo de Cuba al gobierno de Estados Unidos por daños humanos*. Havana: Editora Política.

Merton, R. K. 1942/1980. Los imperativos institucionales de la ciencia. In: *Estudios sobre sociología de la ciencia*, ed. B. Barnes, 64-78. Madrid: Alianza.

Nieto Olarte, M. 2000. *Remedios para el Imperio: Historia natural y la apropiación del nuevo mundo*. Bogota: Instituto Colombiano de Antropología e Historia.

Núñez, J. 1989. *Interpretación teórica de la ciencia*. Havana: Ciencias Sociales.

———. 1999a. *La ciencia y la tecnología como procesos sociales. Lo que la educación científica no debería olvidar*. Havana: Félix Varela.

———. 1999b. Tratando de conectar las dos culturas. *Epistemología y educación*, University of Havana.

Núñez, J., L. Montalvo, and I. Pérez. 2007. Universidad y desarrollo social basado en el conocimiento: nuevas estrategias desde lo local. In *Innovaciones creativas y desarrollo humano,* ed. A. Gallina, J. Núñez, V. Capecchi, and L. Montalvo, 165-82. Montevideo: Trilce.

Núñez, J., and M. Pimentel, eds. 1994. *Problemas sociales de la ciencia y la tecnología*. Havana: Félix Varela.

Oteiza, E., and H. Vessuri. 1993. *Estudios sociales de la ciencia y la tecnología en América Latina*. Buenos Aires: Centro Editor de América Latina.

Price, D. J. S. 1963. *Little science, big science*. New York: Columbia University Press.

RICYT. 2006. *Indicadores de Ciencia y Tecnología Iberoamericanos/Interamericanos*. Buenos Aires: RICYT.

Rip, A., T. Misa, and J. Schot, eds. 1995. *Managing technology in society*, London: Pinter.

Sábato, J., and N. Botana. 1968. La ciencia y la tecnología en el desarrollo futuro de América Latina. Revista de la Integración 1 (3): 15-36.

Sábato, J., and M. Mackenzie. 1982. *La producción de tecnología: Autónoma o transnacional*. Mexico: Nueva Imagen.

Saenz, T., and E. García Capote. 1989. Ernesto che Guevara y el desarrollo científico-técnico en Cuba. *Cuba Socialista, Segunda época* 41 (September-October).

———. 1993. El desarrollo de la ciencia y la tecnología en Cuba: algunas cuestiones actuales. *Interciencia* 18/6 (November-December): 289-94.

Schot, J. 1992. Evaluación constructiva de tecnologías y dinámica de tecnologías: El caso de las tecnologías limpias. In *Ciencia, tecnología y sociedad: Lecturas seleccionadas,* ed. M. González García, J. A. López Cerezo, and J. L. Luján, 205-23. Barcelona: Ariel.

Simeón, R. E. 1991. Science and technology: Their roles in the development in Cuba. In *Worldwide science and technology advice to the highest levels of governments*, edited by W. Golden, 114-52. New York: Pergamon.

———. 1996. Estrategia de la ciencia y la tecnología en Cuba. In *Seminario Taller Iberoamericano de Actualización en Gestión Tecnológica* (Ibero-American Workshop on Current Technological Management), ed. E. García Capote and R. Faloh, 1-14. Havana: GECYT.

———. 1997. La Ciencia y la tecnología en Cuba. In *Seminario Iberoamericano sobre Tendencias Modernas en Gerencia de la Ciencia y la Innovación Tecnológica* (Ibero-American Seminar on Modern Trends in Science Management and Technological Innovation), ed. R. Faloh, Fernández de Alaiza, and E. García Capote, 1-12. Havana: GECYT.

Sutz, J., ed. 1997. *Innovación y desarrollo en América Latina*. Caracas: Nueva Sociedad.

Vacarezza, L. 1998. Ciencia, tecnología y sociedad: El estado de la cuestión en América Latina. *Revista Iberoamericana de Educación* 18: 13-40.

Varsavsky, O. 1969. *Ciencia, política y cientificismo*. Buenos Aires: Centro Editor de América Latina.

Vessuri, H., and E. Díaz. 1983. *La ciencia periférica*. Caracas: Monte Avila Editores.

Zachary, G. P. 1997. *Endless frontier: Vannevar Bush, engineer of the American centur*y. New York: Free Press.

Jorge Núñez Jover is a professor of science and technology studies at Havana University. He has a BS in chemistry and a PhD in philosophy. He is coordinator of the Cuban interuniversity STS Program and director of postgraduate studies at the University of Havana. He has research interests in science policy and technological innovation in Latin America, and in the evaluation of postgraduate university programs and research.

José A. López Cerezo is a professor of science and technology studies at University of Oviedo, Spain. He has a PhD from the University of Valencia. He is the coordinator of the science program of the Organization of Ibero-American States and academic coordinator of the Observatory of Scientific Culture of the University of Oviedo. His research interests include new approaches to scientific literacy and its measurement and the evaluation of public participation methods and experiences.