CONSTRUCTING KNOWLEDGE SOCIETIES: PUBLIC COMMUNICATION OF SCIENCE (PCS) AS A CULTURAL PRACTICE OF THE SCIENTIFIC COMMUNITY IN MEXICO

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Abstract: Knowledge societies (Olive 2012) require Public Communication of Science (PCS) to become a cultural practice of the scientific community. Communicating scientific work, and promoting critical thinking, provides society with better elements to identify and solve their problems, make appropriate decisions to their particular situation, and take part in the use, promotion and regulation of scientific knowledge and its application (OECD, 2003).
To know how researchers in Mexico establish these kinds of practices, we designed an exploratory quantitative study, based on a survey among members of the National Researchers System (SNI).
With the collaboration of the Consejo Nacional de Ciencia y Tecnología (CONACYT) and the Academia Mexicana de Ciencias (AMC), the Direccion General de Divulgacion de la Ciencia (DGDC) opened an online questionnaire from February 10, to March 10, 2014.
The results of a sample equivalent to 20 percent of the SNI showed that participants consider it important to communicate their research to audiences outside academia but they pointed out, there are not enough funds or forums to accomplish it. From their point of view, evaluations do not take into account properly these activities. Another relevant point was the need to include Public Communication of Science (PCS) in the study plans of scientific careers, and the public's participation in the definition of policies related to science and technology (S&T). Notwithstanding, researchers' answers reflected that even though they are interested in social engagement, their communication with particular sectors (indigenous communities, politicians, NGO's, and other groups) is still weak. They perceive science outreach as an opportunity to educate people, but not yet as a commitment to discuss with the public their concerns regarding science and its applications in society.
Keywords: Public communication of science, Science engagement, Knowledge societies.

INTRODUCTION

At the end of 2013, Mexico established the Citizen Agenda for Science, Technology and Innovation, and modified the CONACYT's law regarding open access to scientific knowledge. In this context, the CONACYT, the AMC, and the DGDC considered it important to have a diagnosis of PCS as a cultural practice within the science, technology, and innovation (STI) system, to achieve a connection with the various social sectors, and to contribute toward building a knowledge society.

The SNI is a governmental organization that recognizes the academic quality, relevance and impact of scientific and technological research, and gives a salary supplement to researchers from all knowledge areas that publish in peer review magazines.

To explore SNI's membership activities regarding PCS, target audiences, incentives, and obstacles, CONACYT sent to all of them, via e-mail, an invitation to answer a questionnaire. Some questions were about the situation of PCS at their institutions; researchers' perception

about media and science news; as well as public and governmental interest in research carried out in Mexico. It also explored researchers' willingness to accept public participation in the design of science, technology and innovation policies, and to maintain a dialogue with different audiences, beyond the academic scope.

Importance of PCS

As soon as the citizens assume a greater role in decision-making, it becomes essential that the scientific community respond to questions, concerns and public needs. It is also necessary that researchers help in the detection, analysis and solution of social, environmental, political, cultural and economic issues, and that they enhance their interaction with different stakeholders and with the citizens in general, in order to translate their needs into questions that can be solved by science.

PCS covers all efforts intended to disclose or to disseminate scientific content to audiences outside the scientific and academic scope, with the purpose of achieving social appropriation of scientific knowledge and its applications (Calvo, 2003).

The practice of PCS relates to multiple disciplines, including museology, journalism, informational science, communication, philosophy of science and sociology, among others. It has various forms such as conferences, science journalism, symposia, museum exhibitions, plays, scientific demonstrations, recreational activities, blogs, social networks, workshops (Cazaux, 2008:16), and citizen science, among others.

PCS increases scientific literacy by giving the citizens the ability to solve problems with rational criteria (Lemarchand, 2005), and the tools necessary for the assessment of science and technological developments, to facilitate decisions regarding their adoption, use, or rejection.

It also implies a commitment to promote changes in the consciousness of readers and their reasoning skills, and not just the transfer of highly specialized information to a simpler version for the sole purpose of informing a wider audience (Parodi, G., and Ferrari, S., 2007).

The national context

Scientific and technological development in Mexico takes place mainly within public universities and public research centers. The country's performance in the OECD Program for International Student Assessment (PISA) in mathematics and science remains below average, and a National Survey about Mexicans Self-perception in Science and Technology showed that citizens 15 years of age or older, consider their knowledge in these areas to be 5.2 points on a scale of ten.

The gap between the scientific community and society in Mexico is reflected in poor public and private investment in science, technology and innovation. According to the World Bank, there is a small number of researchers (386 per each million inhabitants in 2011), and a weak connection between academia and the productive sector, causing a deficit in the technology balance of payments (TBP) with an income of 96 million USD *versus* 1,874 million USD in expenses in 2013. There is also scarcity of jobs for scientists and technologists, and a lack of social recognition of their work (Franco, 2013). This state of affairs is due largely, among other reasons, to a lack of proper communication between the scientific community and society; therefore, to a lower use of knowledge, products and services generated in this sector (Cabrero, 2016). Although in recent years, the number of science communicators has

increased, and even the mass media have more science news (Reynoso-Haynes 2013), there is a shortage of clear and permanent strategies and policies generated by the institutions in order to build bridges between science and society.

In Mexico, the participation of the scientific community compared to other social sectors has not had an effective hearing (due to late arrival or non arrival at all**)** to the legislative chambers during the discussion of techno-scientific knowledge issues (Castellón, 2012), such as stem cells, transgenic crops, nanotechnology, and others. This failure to include the scientific community negatively affects the decision-making process where **s**cientific evidence is necessary for development of recommendations and laws.

Within this context, it was essential to have a diagnostic feature about the developing of PCS by the scientific community, represented by the SNI, to guide public policies on this matter in the STI system.

METHODOLOGY

The target population was all members of the SNI. The system is classified in two categories, Candidates and National Researchers, with the latter divided into levels 1,2, 3 and Emeritus. All members received an invitation to answer an online questionnaire with 69 questions that explored their opinion on the importance of communicating their research outside the scientific and academic arena, the kind of activities they do, their training in PCS, and the language they use. It also inquired about the institutional support for PCS, the audiences reached, and the incentives for doing these practices.

The questionnaire considered several surveys developed in the United States, the European Union and Argentine (Jennsen, P., Croissant, Y. 2007; Kreimer, P., Levin, P. 2011; Peters, H., et al. 2008; Loaiza, C. 2012 and Bennasar, A. 2010).

The survey launched on February 10, was open until March 10, 2014, and was fully answer by 3,938 researchers, resulting in a quota sampling.

RESULTS

Sample characteristics

For Level 1, the main category within the SNI, differences with the sample according to the chi-square test (X^2) were not significant. In the same way, the differences were not significant, neither for the average age from 40 to 49 years, nor for gender. The margin error was 1.39 percent. Their participation, according to the different science areas, was as shown in Figure 1.

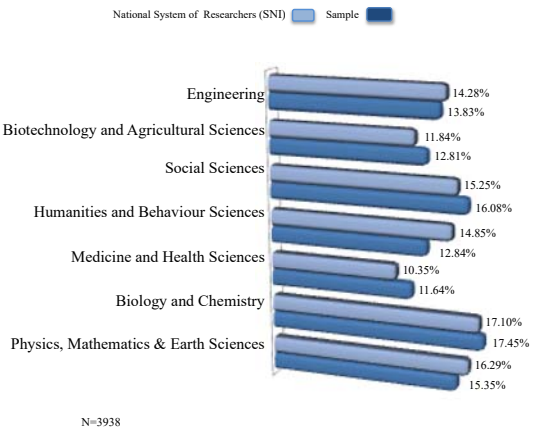


Figure 1

Importance of communicating science to the public

About the importance of communicating their research to non-specialist audiences, almost all researchers considered it relevant to varying degrees (Figure 2).

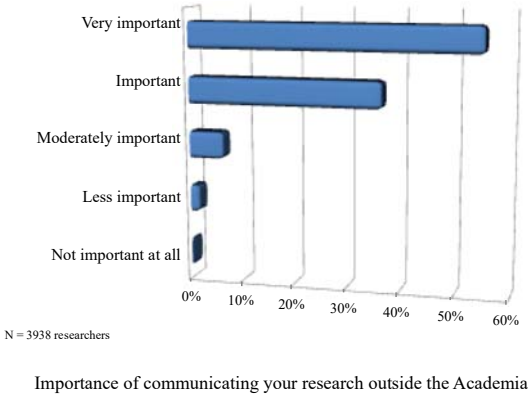


Figure 2

Seventy-seven percent of researchers carried out PCS in the last two years; 30 percent made presentations about their research, nine percent about other scientific subjects, and 36 percent about both. Twenty-two percent did not perform PCS (Fig. 3).

The main activities carried out in the last two years by 36 percent of the researchers in this sample (Fig. 3) were talks for general audiences; twenty-one percent of researchers wrote dissemination articles. Twelve percent participated in interviews or press conferences. Less frequent activities were science divulgation books (4.51 percent), blogs, and social networks (two percent). Public debates were less than one percent.

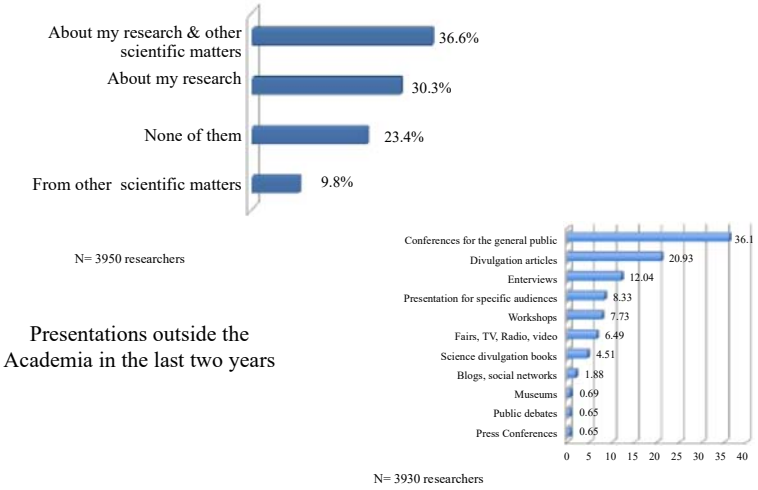


Figure 3

Twenty-nine percent of those who did science communication employed between two and five percent of their time on these tasks. Twenty percent dedicated between six and ten percent of their time, seven percent 16 to 20 percent of their time, six percent, 21 to 30 percent, and four percent, from 11 to 15 percent (Fig. 4). Most of the researchers reported between one and three activities (Fig. 4). Among the researchers who invested at least 15 percent of their time in PCS activities, 74 percent performed up to ten activities over the past two years.

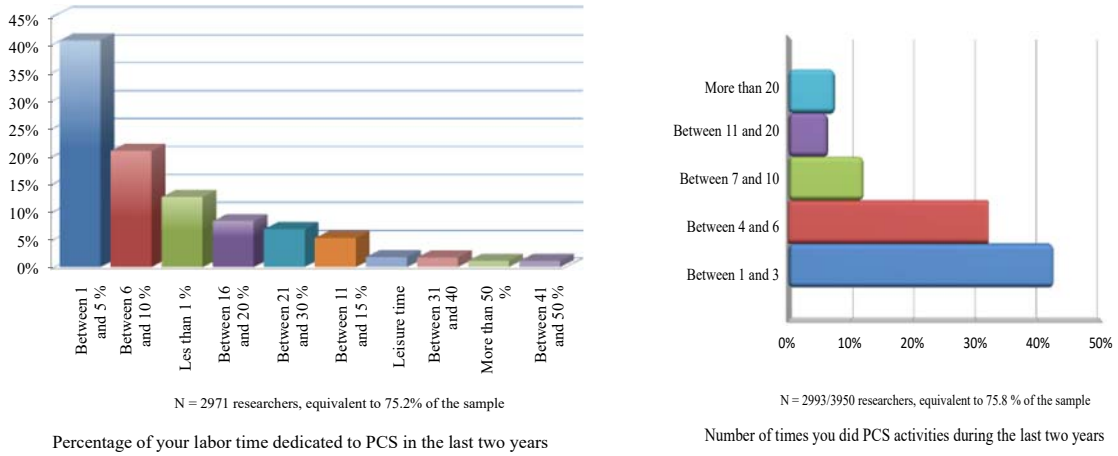


Figure 4

Reasons for doing science outreach

Scientists considered it important in communicating their research to show the importance of science to society. Other reasons were, helping the public to make informed decisions, spark technological development and innovation, enable citizens to understand their surroundings, and promote social discussion of scientific issues. Other answers were**,** to educate audiences, to help guide public policies, to being accountable to the society, to generate public support for initiatives in science, and to link their research with potential users (Figure 5).

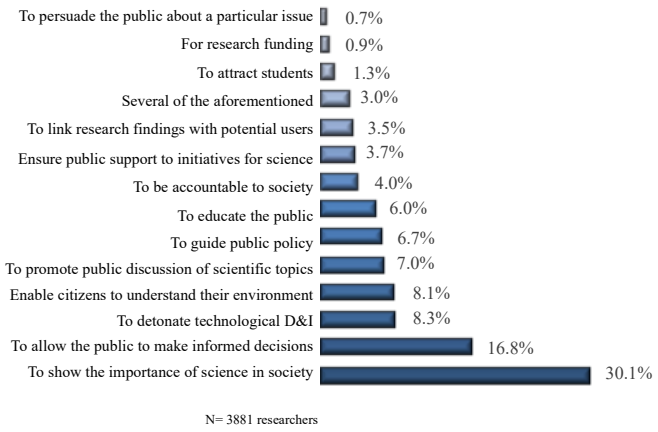


Figure 5

They considered it important to illustrate (Fig. 6) the relationship between their research and everyday life, and its usefulness for economic and social enhancements, as well as for technological development and innovation.

Discussing risks and uncertainties in the implementation of some of their research findings, and the details of their work and the scientific principles behind it were not a priority. Respondents considered that communicating their research to the public was primarily a social responsibility (Fig. 7).

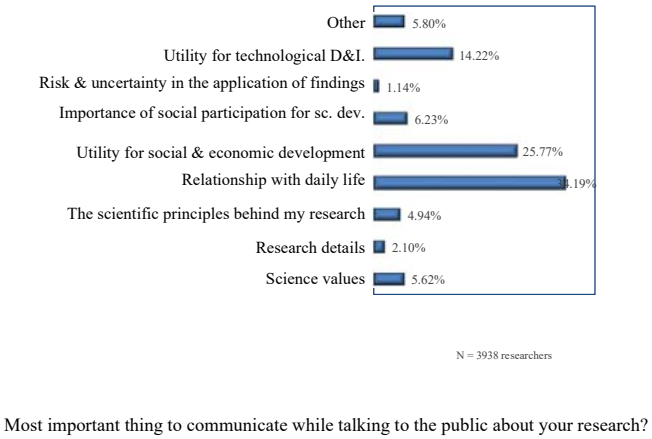


Figure 6

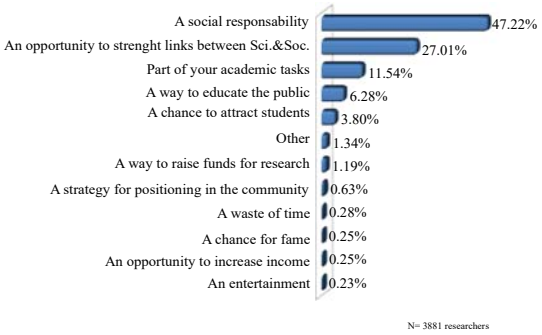


Figure 7

From researchers' point of view, the most important thing when talking to the public is to educate people (Figure 8).

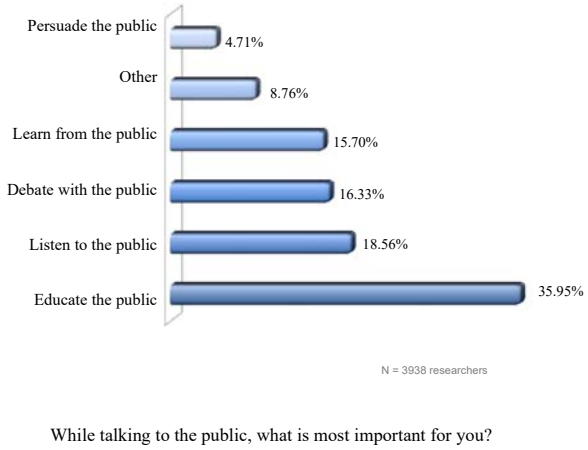
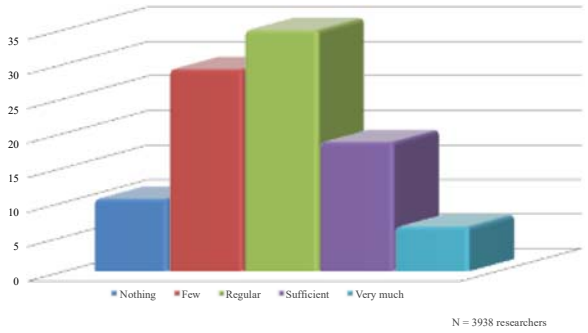


Figure 8

Public communication of science and institutions

As for the perception of researchers on the contribution of their institutions to public communication of science; 35 percent considered it regular; 30 percent thought it little; 19 percent found it sufficient; 10.5 considered they do nothing; while 6.48 indicated that they contribute very much. (Fig. 9)



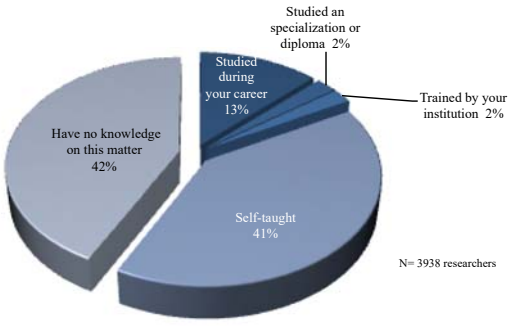
Contribution of your institution to public communication of science

Figure 9

Training in public communication of science

Forty-two percent of the surveyed scientists indicated not having any knowledge about PCS. Another very similar percentage claimed to be self-taught; 13 percent received training as part of their professional education, two percent attended some specialization or diploma courses, while another two percent received training at their institution (Figure 10).

Self-taught researchers showed a high interest or need to gain knowledge and skills regarding scientific outreach, a situation that nowadays, their institutions do not carry out. Of the respondents, 46 percent considered very important incorporating subjects related to PCS during scientific training, and 22 percent found it extremely important.



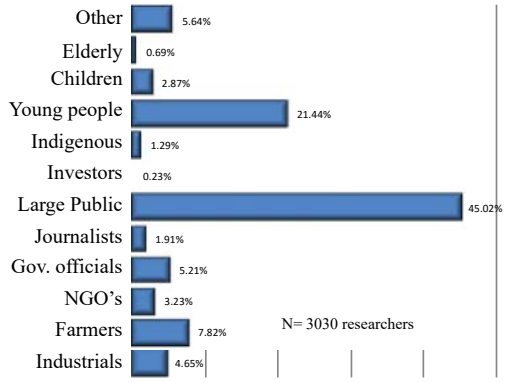
37.4 % of those who have knowledge or trainning in PCS, were men and, 20.1% women, equivalent to 58.5% and 55.79% of their respective populations.

Have you been trained in science outreach?

Figure 10

The audiences

Forty-five percent of the participants had, as their main audience, the general public, whereas 21 percent focused on young people. Farmers were reached by 8 percent, while government officials, and industrialists, by five percent each (Fig. 11).



Public outside the Academia to which you have spoken

Figure 11

We need to note that these last two groups were reached (8 and 22 percent, respectively) far from the proportion in which some researchers said they could be interested in their scientific work. These figures confirm the weak link in the country between scientists and other sectors, such as the economic and the governmental ones that could benefit from the knowledge generated by research centers, and would have the ability to nourish and influence the national scientific development.

Researchers and mass media

Although not as their primary communication activity, 57 percent of the researchers surveyed took part in press conferences or interviews for newspapers, magazines, television, or radio in the last two years. Forty-two percent did it at a reporter's request (Figure 12). This percentage is surprising because there is a common complaint among the researchers regarding how little the mass media is interested in science. Researchers felt their experience with the media was mainly good, as shown below (Figure 12).

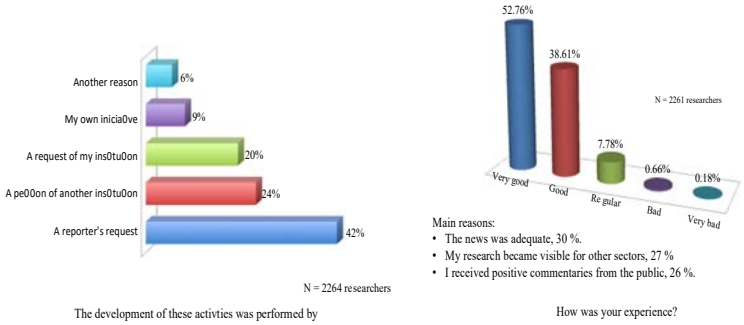


Figure 12

Regular participation in media

Thirteen percent of the researchers surveyed had a regular involvement in media. This regular communication was slightly higher among researchers of the Natural Sciences, Exact Sciences, and Engineering, since they constituted 53 percent of all institutional researchers, as opposed to Social Sciences and Humanities researchers, at 47 percent.

The types of media on which this participation took place were magazines at 26 percent; the Internet at 22 percent; newspapers at 15 percent, radio at 11 percent and TV at seven percent.

Researchers and news about science

The survey inquired researchers about their confidence in mass-media. They answered that magazines are the most reliable media with 26 percent, followed by the Internet with 25 percent, newspapers, 13.7 percent, TV, 9.77 percent, radio, 8.37 percent, and lastly, news agencies with 0.71 percent. Seventeen percent pointed not to trust media. Notwithstanding, when we asked them about the names of the media they trust, only 1,645 researchers answered, mentioning newspapers in the first place; secondly TV channels; thirdly radio stations, magazines in fourth place, and lastly news agencies.

The questionnaire included also questions to ascertain researchers' trust in national newspapers. Their answers showed that 54 percent of them occasionally trust the scientific information published; 24 percent trust the information frequently; 16 percent almost never trust; three percent never trust and two percent always trust.

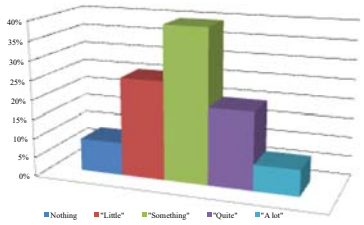
Three thousand one hundred and eighty-eight participants mentioned various reasons to trust the information published. Among these reasons were, scientists are reliable when talking to the media (37.2 percent); they explain their research clearly (25 percent); the science coverage appeared to be adequate and truthful (10 percent) and for a multitude of reasons including confidence based on the source of information, the journalist, the kind of information, their knowledge about the subject, and other reasons (13 percent).

On the other hand, 83 per cent of the surveyed researchers mentioned reasons for not trusting scientific information published in the media. Twenty-eight percent considered science coverage inadequate; 20.9 percent think reporters do not understand scientific concepts; 18.3 percent believed the mass media do not distinguish between science and pseudoscience, and 16 percent believed reporters are not objective when covering this type of information.

We also asked them which local or national media are more reliable in presenting scientific news. Researchers first mentioned the Internet, followed by magazines, newspapers, TV, radio, and finally, news agencies.

Science and society

To the question of how much scientific research in Mexico in their specific area, has contributed to solve national problems beyond generating knowledge and highly specialized human resources, 35 percent believe it contributes little or nothing, against 25 percent who consider the opposite (Fig. 13).



On a scale of 1 to 5, where 1 is nothing and 5 is a lot, how much would you say the science developed in your area in Mexico, besides generating knowledge and preparing human resources has contributed to solving any national problems?

Figure 13

The degree of interest that the general public, the private sector, or the government have about the research carried out in our country, from the respondents perspective is seldom or very few times as illustrated on Fig. 14. Notwithstanding, most of the researchers agreed on the participation of the public in the definition of public policies on science, technology, and innovation.

	Public	Private sector	Government
Never	4.13%	4.53%	6.66%
Always	4.61%	6.71%	10.25%
Frequently	17.47%	16%	14.25%
Seldom	35.42%	38.43%	34.23%
Very few times	38.38%	33.92%	34.61%

From your point of view, are the public, private sector or the government, interested in learning about scientific and technological advances being made by universities and research centers in the country

Figure 14

DISCUSSION AND CONCLUSIONS

Although the researchers surveyed considered **it** important to promote their work outside of academia, they only dedicated between five and ten percent of their time to these tasks. Moreover, they performed them between three and four times during the past two years. From their point of view, their institutions do not sufficiently recognize this activity. PCS does not appear in science careers' study plans.

The institutions do not have enough programs to support PCS activities; researchers argued they do not have enough time to perform them because they are not properly accounted for in their academic assessments. Ninety-three percent of those who performed Public communication of science in the last two years indicated not having incentives, scholarships, or budgets for these tasks.

Most of them considered it important that young scientists learn how to communicate their research to the public.

Researchers in this survey think PCS is mainly educational, and this thinking is probably the reason why they talk to the general public and especially to young people, and very rarely to other groups such as policy makers, industrialists, NGO's or farmers.

Besides all of this, there is still no complete or coherent policy to make science part of our culture.

Achieving a real public communication of science requires understanding the production of knowledge in a complex framework of relationships and that is not always free of conflicts between the various parties and the social systems implicated. Furthermore, values and interests play a crucial role when making decisions that involve S&T (Lozano, 2013).

Additionally, informing and generating understanding and appreciation of science, communication in this area should contribute to the empowerment of citizens when making decisions to solve particular social problems identified by them.

Researchers' answers point to the *diffusionist* model, which refers to the process of communicating scientific and technological information to a public lacking of knowledge**,** through various means, to inform and to build understanding and appreciation for S&T (Lozano, 2013). Some of them point out their interest in listening to the public and to learn from them. Notwithstanding, it is important to achieve a communication system that fulfills the interests of both parties. The commitment of PCS is therefore, to produce a general awareness of science, promote critical thinking and debate on scientific issues with social implications. Among these points, we can find the proper direction regarding policies that matter and promote the utility of scientific knowledge for the prevention of risks, in small and large scale issues facing the general public (Alcíbar, 2004). "Communication is not only about speaking in a clear, compelling, and relevant manner, nor simply about promoting findings. Effective communication is an integrated process of understanding the audience and connecting with their terms. It requires listening as well as talking" (Smith B, Baron, N., et. al., 2013).

The data collected in our survey reflect a lack of policies that if in place could help to achieve greater scientific commitment beyond the isolated and individual efforts in communicating with general audiences with a unidirectional flow of information. Scientist's engagement requires the reorganization of their values, as well as those from the centers of scientific research and press offices to create opportunities for a dialogue with different audiences.

A proactive attitude by the institutions to foster public communication of science should include a new communication model, in which scientists play a paramount role, based on a broader knowledge of how to talk to the public. All these actions should be oriented toward obtaining the participation of groups involved in particular problems.

The scientific and technological knowledge, rigorous and balanced, must be available to the public, so it can detect, understand, analyze and address the variety of needs faced, and enable it to provide feedback to the scientific community, in order to find solutions to various social problems.

It is important to note that the lack of communication undermines the confidence of society towards the researchers' community and its commitment to support scientific activity. Moreover, it delays the establishment of a balanced and fruitful relationship between both spheres.

"A two-way communication model implies that the science and technology system receives and evaluates the information from other systems and social actors and, at the same time, that it is modified by such information." (Lozano, 2013)

It is desirable that institutions, responsible for assessing and financing ST&I in the country, align their policies, to improve the skills of researchers, agencies, and offices that promote PCS, to open forums in order to enhance the participation of "science in society".

This research has allowed us to gather information to explore further the PCS as a cultural practice. We must keep on analyzing this issue in the immediate future so that we may obtain a complete overview and be able to compare the situation in Mexico with the practice of PCS by researchers and scientists in other countries.

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