European Commission

Communication role on perception and beliefs of EU Citizens about Science

Teaching science communication in Europe
Deliverable 1.4

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4	FyG	SME	Spain
5	Danmar	SME	Poland
6	Instituto de Ciências Sociais da Universidade de Lisboa	University	Portugal
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1. Summary of the project

CONCISE aims to generate a European-wide debate on science communication, involving a wide array of stakeholders, from media outlets to policy makers, from scientists to business companies, from science communicators to civil society organisations. CONCISE aims at providing qualitative knowledge through citizen consultation on the means/channels (media and social networks, life experience, relatives, religion, political ideology, educational system...), by which EU citizens acquire their science-related science knowledge, and how this knowledge influences their beliefs, opinions, and perceptions.

For this purpose, CONCISE will explore the understanding of 500 citizens (representing the 500 million EU citizens), regarding four selected topics: vaccines, complementary and alternative medicine use (CAM), genetically modified organism (GMO), and climate change. CONCISE will carry out a citizen consultation in five countries: Lisbon (Portugal), Valencia (Spain), Vicenza (Italy), Trnava (Slovakia) and Lodz (Poland), with the participation of 100 citizens in each country (selected volunteers and representatives of different social groups, considering gender, age, educational level, ethnic minorities, impaired people, and professional careers). Their understanding and position on these four scientific topics will be evaluated, validated, compared and analysed, in order to publish the results in open access by the CONCISE team.

Citizen opinions will be recorded; transcript and analysed with a corpus linguistics software in order to get different indicators that will help all stakeholders to have a more direct and fruitful communication, avoiding the danger of discourses that generate distrust and misunderstandings. CONCISE results will be scalable and its methodology could be applied to other European countries in order to increase the communication of science in terms of quality and quantity all over Europe.

To reach CONCISE's overall goal, the following sub-objectives have been established:

- **OBJ1**. To increase our understanding of **how beliefs, perceptions and knowledge of science- and technology-related issues originate** among European citizens (WP1).
- **OBJ2**. To **review the existing structural obstacles** that scientists and other R&I stakeholders, including policymakers, currently face when attempting to communicate science successfully (WP1).
- **OBJ3**. To **evaluate the existing models for teaching** science communication to communicators and scientists in Europe, and to analyse how to elaborate an action plan, including recommendations and the issues that should be explored (WP1).

- **OBJ4**. To enable **active citizen participation** in scientific research processes, in line with the concept of responsible research and innovation (RRI), by employing a public consultation methodology (WP2).
- **OBJ5**. To measure **the positive or negative perception** of citizens participating in the public consultation on a selection of stories related science (WP3).
- **OBJ6**. To **disseminate actively** the project results and activities, exploring new well-defined communication strategies (WP4).
- **OBJ7**. To **review and assess the work** carried out, such as the project **outcomes**, and to ensure that the consortium partners comply with their contractual obligations (WP5).

2. Introduction to this deliverable

W1 of CONCISE project, among other tasks, reviews the existing models for teaching science communication to communicators and scientists. This deliverable is the result of a literature review process and the analysis of 26 individual semi-structured interviews with science communication teachers of 15 different countries.

Here we present the literature review, the methodology used, and summarize the obtained results in order to study different models for teaching science communication to different publics and with different objectives. This results will complement the overall understanding of science communication processes gathered from CONCISE consultations and the review of the existing structural obstacles that scientists and other research and innovation stakeholders currently face when attempting to communicate science successfully. These results will fit Task 1.3 and D1.5 to propose a database of inspiring practices and recommendations to engage scientists and communicators with science communication.

3. Introduction

The academic field that studies science communication, or public communication of science and technology, is relatively young (Dunwoody, Brossard, and Dudo 2009; Horning Priest 2010). However, in recent decades a real effort is being made to reach a consensus on the bases that define this field -professional, "disciplinary", thematic-, as well as to find empirical evidence and theoretical frameworks on which to advance (Fischhoff 2013; Fischhoff and Scheufele 2019; Kahan 2015; Trench 2008). Science communication is accepted as an individual academic 'field' but not yet 'discipline' status (Gascoigne et al. 2010).

According to the Analytical Framework of Science Communication Models, public communication of science tends to adopt different approaches that can be grouped into three models: dissemination model, dialogue model and conversation model (Trench 2008). Today we could probably substitute the term "conversation" for a broader term of "participation", including not only the notion of cross-talk (Bucchi 2004) but also a range of activities that look for a stronger engagement of citizens with science (i.e.: Do it yourself, fab lab and social labs, maker movement, citizen science, etc.), and also new approaches of science itself (engaged research, science shops, public-patient involvement, etc.).

On the other hand, changes in the communication ecosystem have generated profound transformations in current scientific communication both in the channels and formats used, languages, products, media, etc.; as in the actors that take part in communication and the interactions that are established between them (Revuelta 2019). These transformations involve new questions about what is actually science communication, what are its functions, how to recognize a practice of excellence, etc. In the same way, the coexistence of different actors with different objectives and professional standards also raises new ethical dilemmas. Jean Goodwin suggests that in order to understand ethical issues that emerge in this new panorama, it is useful to think that science communication takes place through speech acts, emphasizing the communicator's ethical responsibilities towards an active audience. The author concludes finally that from the speech act approach, science communication is only effective because it is ethical (Goodwin 2018).

In public information on science, medical and the environmental issues, it is important that communication professionals carry out their work with quality. Therefore, it is increasingly considered necessary that these professionals have proper training for this (Allgaier et al. 2013; Baram-Tsabari and Lewenstein 2017; Moreno-Castro and Gómez-Mompart 2002; Turney 1994; UNESCO 2018).

3.1 Training science communication

Science communication training is emerging as an object of study and research; in particular, we can easily find some literature about the training of future science communicators (scientific journalists, institutional communicators from universities and research centres, professionals from science museums and outreach centres) and, to a lesser extent, the training of scientists and future scientists in communication.

3.1.1 Teaching science communication as a profession

The current existence of numerous training programs in science communication around the world offers a valuable material to explore and extract more empirical evidence about the contents, competencies and learning outcomes that are -or should- be included in these education programs, as well as their adjustment, or the lack of it, to the real needs of the professional practice.

The first efforts made towards this topic were published in the 1990s, being one of the first, and most influential, the work in which John Turney (1994) identified three types of science communication training: 1) training in skills to work with and in the media, 2) mixed training, skills and theory; and 3) complex training, which combines learning skills with different scientific disciplines content.

A few years later, the European Network of Science Communication Teachers (ENSCOT) gathered information regarding the training programs in which its members taught, coming from different countries in Europe. A first series of recommendations and training modules (ENSCOT 2003) were stablished. Years later, ENSCOT brought together many of the leading trainers in science communication in Europe, collected the resources of its predecessor network and expanded its experience in training communication scientists (Miller and Fahy 2009).

From these early investigations and efforts to achieve collective knowledge on science communication training, there have been published a number of works about teaching programs around the world (Gascoigne et al. 2010; Massarani et al. 2016; McKinnon and Bryant 2017; Mellor 2013; Murriello 2014; Reynoso-Haynes 2009; de Semir 2009; Trench 2009; Vogt, Knobel, and Toledo Camargo 2018). But there are many other teaching programs that have not been documented at the scientific literature. We know their existence because their presence on the main international and national conferences of the field and by their presence on networks.

Based on the results of two seminars held during the 10th International Conference of the Public Communication of Science and Technology network (PCST network), Mulder, Longnecker, & Davis (2008) analyse "The State of Science Communication Programs at Universities Around the World" and proposed a model of four areas of knowledge under which science communication training would be framed (science, educational studies, social studies of science and communication studies). Also from the opinions of specialists in science communication, but this time coming from a study based on the Delphi Method, Bray, France & Gilbert (2012) identified 10 essential statements in a science communication course.

A problem of the science communication teaching programs, according to their directors and promoters (Trench 2009) is that some programs are particularly exposed to the rationalization affecting higher education institutions in many countries. An essay in *Nature* by Boyce Rensberger explains that the science journalist has gone from a primitive role of "cheerleader" to that of "watchdog" (Rensberger 2009). However, there is very little literature to explore this claim and even less to conclude if in science journalism training students learn those functions in which it is supposed their profession will focus.

3.1.2 Teaching science communication as a part of the regular professional tasks of a scientist

The role played by people acting as experts is equally decisive: researchers, doctors and other professionals trained in scientific disciplines. Whether acting as sources of information or directly as communicators, scientists are increasingly present in the field of public communication. In this regard, we must bear in mind that professionals in scientific disciplines not only communicate with the media, but also directly with the public or with specific groups.

Despite outreach activities being organized and managed by communication professionals, the participation of people representing the scientific community is also expected (Bauer and Jensen 2011). The implication of scientists in public engagement activities is one of the things that the public values most, because they talk from a first person perspective and with a deep knowledge of the topic (Revuelta 2014). Some studies suggest that scientists strongly believe that they should have a role in public debates but that they specifically view policy makers as the most important group to engage with, rather than wider publics (Besley and Nisbet 2013). Also, science communication is seen as a shared responsibility between scientists, journalists and science communicators working at universities and research centres (Llorente et al. 2019). Torres-Albero et al. (2011) coined the term 'trapped in a golden cage' which means that scientists are caught between dissemination activities governed by moral values and a scarcely favourable social and professional context.

In this context, it is paradoxical that the vast majority of professionals from scientific disciplines have never received communication training (Brownell, Price, and Steinman 2013; Revuelta 2018). Either their inner capacity for it or their years of experience will therefore be the only determinants. In recent decades, the risk of this situation has been highlighted and the need to promote the communication training of scientists has been raised (Baram-Tsabari and Lewenstein 2017; Leshner 2007; Mulder, Longnecker, and Davis 2008; Sharon and Baram-Tsabari 2014).

Every year, hundreds of thousands of scientists in the world are consulted as sources of information or take part in communication actions for non-specialized audiences. Enabling a training for scientists that allows them to be better communicators and at the same time as providing them with tools to anticipate and face the barriers and problems that currently hold back science communication will have a multiplying effect, guaranteeing that in the future, the communication of science could be able to expand and improve its quality.

According to Baram-Tsabari & Lewenstein (2017) different courses might be tailored for scientists (for those who remain in science, wish to become journalists, wish to work for museums, etc.) but conceptual coherence can help course designers identify important goals. In a recent study in which trainers from North America have been interviewed, it is suggested that, of the four selected communication objectives (increasing knowledge, fostering excitement, building trust, and framing issues), only the first (increasing knowledge) is clearly referred by the trainers in a regular way without prompting (Besley et al. 2016).

3.1.3 Training other actors in science communication

Over the last two decades' numerous attempts to stimulate participation in research and embed participative processes in science are emerging. A general trend towards broader stakeholder engagement in technical and scientific projects can be seen in a wide range of research and coordination activities (Hockfield 2018).

Around the world, thousands of research projects are engaging millions of citizens in collecting, categorizing, transcribing or analysing scientific data. These projects, known as "citizen science", are heterogeneous and cover a breadth of topics (Bonney et al. 2014). A wide variety of terms and expressions are being used to refer to this concept and its practitioners (Eitzel et al. 2017) but the most widespread definition is the one included in the Oxford English dictionary; "the collection and analysis of data relating to the natural world by members of the general public, typically as part of a collaborative project with professional scientists" (Citizen Science 2014).

In citizen science projects many different societal actors such as researchers, agencies, politicians and civil society are involved. In this scenario, communication becomes a key tool of these research projects; to engage volunteers, to maintain the relationship between citizens and the research team etc. In addition, citizen science projects usually incorporate an initial phase of training participants that implies that the project managers have to understand key concepts of communication and evaluation of learning outcomes (Jordan, Ballard, and Phillips 2012; Newman et al. 2012).

A successful citizen science project requires a development team comprising multiple disciplines. Form the research team in order to explain the project's importance and significance to participants, to develop clear and comprehensive project support materials, to ensure appropriate participant feedback etc. is crucial (Bonney et al. 2009). However, the type of training in scientific communication to the different actors involved in this type of project has not yet been explored.

3.2 Research objectives

As we have seen, it is necessary to further explore what are, or what should be the functions and practices of science communication be, whether these functions are included or not in the current training programs and the degree of effectiveness of those teaching programs. It is also necessary to further explore the objectives of the communication carried out by scientists, if these objectives are thought in training programs (at university, out of the university, compulsory or optative) and the degree of effectiveness of such communication and teaching.

This research address this issue by interviewing science communication teachers in order to identify different approaches to teach science communication to different publics. Thus, the specific research questions are:

> RQ1 What are the different models of teaching science communication to scientists?
> RQ2 What are the different models of teaching science communication to communication professionals?

4. Methodology

To answer these questions, we conducted 26 semi-structured interviews with science communication teachers from 15 different countries. We chose a qualitative methodology, as our intention is to explore the personal perceptions of these science communication teachers and their arguments regarding different approaches to teach science communication to different publics. The specific script (see annex 1) was elaborated by the research team and reviewed by CONCISE consortium.

4.1 Sampling

Intentional sampling was used to select the interviewees, we select a sample of strategic subjects based on their position as academics and science communication teachers and their likely knowledge of the subject of study. CONCISE consortium members proposed a list of teachers of their own countries, we also include relevant candidates from literature. Among these we identified science communication teachers directing, coordinating or involved in master programs, science communication workshops or specific subjects on science communication included in other degrees both communication (journalism, social communication etc.) or science-related studies (biology, chemistry etc.).

Once science communication teachers were identified we sent them an e-mail describing the project and invited them to participate in an online interview. Up to three follow-up e-mails were made to solicit participation from those who did not respond. An additional effort was made to guarantee at least 40% of the gender less represented in the sample. Finally, 41 teachers were contacted. Of these 32 responded, 6 declined to be part of the study due to lack of time and interviews were completed with 26 people.

The average age of the interviewed representatives was 51 years old (SD=13), and there were 15 male and 11 female science communication teachers. All interviewees had completed higher education, and most of them were involved in science communication teaching for more than 20 years (n=9). Exact sample description is summarized in Table 1.

Number of years working on science communication	**N**	**% sample**
10 or less	6	23%
11 to 20	8	31%
21 to 30	9	35%
31 or more	3	12%
Number of years teaching science communication	**N**	**% sample**
10 or less	8	31%
11 to 20	9	35%
21 to 30	7	27%
31 or more	2	8%

Table 1. Interviewees' involvement in science communication and teaching

Special effort was made to have representation of teachers of different levels of studies (undergraduate, masters, PhD workshops etc.) and different students' profiles (see Table 2). Just one of the interviewees teaches at one undergraduate program devoted to form science communication professionals, 3 of them teach science communication subjects in communication studies (journalism, social communication etc.) and the majority (N=8) teach this kind of subjects in science and technology degrees (biology, physics, chemistry, engineering etc.). As we can see in Table 2, the most common scenario was teaching science communication in masters' studies and with mixed students (coming from different backgrounds) who wants to become science communication professionals. Most of the interviewees teach science communication in more than one course (e.g., in a masters and in an undergraduate program or in a masters and workshops etc.) and to more than one audience (N=22).

Level of teaching	**N**
Undergraduate	12
Masters	22
PhD workshops	6
Other workshops	7
Students' profile	**N**
Communication studies	3
Science studies	10
Mixture of backgrounds	22

Table 2. Description of interviewees' teaching

Before participating, all interviewees were informed of the nature of the study and data processing policies and freely gave their consent. All of them were free to answer each one of the questions as well as to stop participating at any time.

4.2 Data collection and processing

We developed a semi structured interview protocol following the guidelines of Silvia Rabionet (2011) and two interviewers conducted Skype. The first interviewer conducted 14 interviews, the second conducted 12 interviews. All interviews were conducted between October – December 2019. The average interview took 41 minutes to complete, with the range spanning from 24 minutes to 80 minutes.

4.3 Data analysis and interpretation

A sequential analysis of the interviews was carried out and observational notes were included in the transcription of the interviews. Qualitative content analysis was used to analyse data and interpret its meaning with the support of the research software *Atlas.ti* (version 8.4). As a research method it represents a systematic and objective means of describing and quantifying phenomena (Schreier 2012). To do this we reduced data to concepts that describe the research phenomena by creating categories, a group of content that shares a commonality (Elo et al. 2014). However, the number of times a code appears linked to the quotes from the interviews has a limited value for interpreting the content, while a single quote may be highly relevant in terms of meaning. Triangulation, peer debriefing and member checking were the strategies used to ensure reliability.

5. Results

5.1 Training for scientists in communication

From the interviews we have identified three different models of teaching science communication. Table 3, summarizes the different models, findings and frequencies of this dimension of study from all the interviews.

Identified model	Findings	Frequency
Practical model	It refers to educational models focused on learning tools and skills to perform specific activities of scientific communication (for example, writing, public speaking, etc.)	20/26
Reflective model	It refers to an educational model that makes researchers understand the importance of science communication, how that world works (journalistic times vs. times of invention etc.) and how to interact with professional scientific communicators.	14/26
Disruptive model	It refers to an educational model in which structural changes are proposed in the traditional roles of researchers, the other groups of actors with whom they interacts and the production of scientific knowledge (concepts related to public engagement, open science, citizen science etc.)	5/26

Table 3. Qualitative results of the "Models of teaching science communication to scientists" dimension of study, analysed through categorization system.

5.1.1 Practical model

During the interviews, the practical model for teaching science communication to scientists was the most mentioned (N=20). In this category we include all interviewees' references to training models or personal educational experiences focused on teaching to scientists' tools and skills to perform specific science communication practices by their own.

Some interviewees directly refer to *"practice-oriented"* (e.g., Interview 1, 16), *practically focused"* (e.g., Interview 4) or *"interactive"* (e.g., Interview 20) training programs specially for one-day or half-day workshop for researchers (e.g., Interview 8, 11, 23), PhD students (e.g., Interview 3, 10, 11, 26), but also workshops or complete subjects (e.g., Interviews 9, 13, 18, 24, 25) for undergraduate science students.

"Is very practically focused, you just focus on skills, communication skills." (Interview 4)

"The thing that we do in these courses which are very intensive courses, because our PhD activities are like 5 days, is that in each activity, addressing topics on sustainable development for example, we include some skills, soft skills for Science Communication, and this is another topic, in other format, because you have a graded activity and then you have this particular day or half day devoted to this topic." (Interview 10)

It may seem that there is a lot of diversity between these courses, but the main commonality of all these programs is that are oriented to people with science background either undergraduates, early stage researchers or senior researchers in a practical approach. This practical teaching approach is devoted to fill scientists' "*skill gaps"* (e.g., Interview 8) and to recreate *"practical experiences close to the real world"* (e.g., Interview 3, 4, 7, 11, 20) or *"learning by doing"* (e.g., Interview 15) such as how to behave with journalists during a media interview (e.g., Interviews 3,12).

> *"But then for scientists themselves I think it just depends on what they perceive their own skill gaps to be, because we do also this sort of Continuum Professional Development training with scientists but we've got so many things from kind of working with children to writing to public speaking to strategy and digital communication and just working out what people want and giving that to them rather than just sort of saying "yes, this is the most important thing for scientists to know" (Interview 8)*

> *"[A course] focused on some practical activities, they could be involved in like, to give an interview, to give a talk and so on." (Interview 12)*

> *"Working with people, teaching through example and practice and probably because I think that a lot of these is very difficult to actually teach unless you do it. Using some sort of flip classroom method where you know, the theory may be all on videos or whatever and you work with the students, the scientists on the actual practice on the actual doing of it, so that there is more learning by doing and the theory is just the background that helps you get to the practice" (Interview 15)*

Some teachers mention specific topics they teach for those students during the interviews. For example, *"writing skills"* (e.g., Interview 8, 11, 24), *"public speaking"* (e.g., Interviews 6, 14, 24) or "*social media skills"* (e.g., Interviews 3, 11). However, we have unified all this mentions in the same group because the global meaning lies in the practical teaching to solve communication problems in researchers' routine work.

> *"I teach them practical skills, like how to write a press release, how to construct tweets, how to draw up a communication plan" (Interview 11)*

> *"Almost it's about familiarizing scientists with the media and how the media work, it's about breaking down your science into edible digestible "tapas" rather than big meals" (Interview 22)*

Is interesting to highlight that one of the interviewees talk about teaching *"scientific writing"* (e.g., Interview 14) as a sort of first step to engage researchers in science communication training.

> *"The idea was to, because scientists are very aware that they need to publish papers, we would wrap the Science Communication into the scientific writing process so we would do a whole week and then we*

start to writing papers and then we went from writing papers to making a presentation when they are talking to an audience which are not scientists, and then how to talk to journalists and it was a very organized in this sense." (Interview 14)

Indeed, one of the interviewees specifically mention that scientists *"wanted to talk about the story directly with the journalists"* (e.g., Interview 3) as an example of an added value of this kind of practical training. There were also mentions of involving *"journalists"* (e.g., Interview 3) or "*professional actors"* (e.g., Interview 14) in teaching to recreate scenarios to put in practice communication skills.

"I think certainly in terms of media skills we found fairly quickly, they didn't want to talk to us, the people who ran the course, they wanted to talk to science journalists, and they wanted to talk about the story directly with the journalists. They saw that as a challenge, an entertaining challenge, so over time our workshops have become smaller and we've involved more journalists because the scientists want practical experiences, as close as possible to the real world that they are going to get." (Interview 3)

"We have been now working with a professional actor, so the main idea is to help people overcome stage-freight, that's what we started with, but then it's more than this, is to help you not be afraid of telling a person a story, don't think that science has to be just about the facts, it can also be about the stories and I think this is again an important aspect of the training of Science Communication." (Interview 14)

During the interviews some demands, criticisms or reflections of this model have raised. For example, some interviewees consider that practical science communication teaching should be a *"compulsory subject*" (e.g., Interview 9) or at least *"be present"* (e.g., Interview 24) either for undergraduate and master students (from science studies).

"It should be a compulsory subject at least in say on masters degrees, people who are looking at becoming career scientists, they should learn about Science Communication and potentially should it be in undergraduate subject where they learn how to talk simply about their research, they learn how to explain things and it needs to be an on-going thing throughout their career." (Interview 9)

"Science degrees should have communication subjects, whether optional or not, but at least be present. And this is still a pending subject in most science faculties" (Interview 24)

Other comments were related with the lack of reflecion of the objectives in science communication practical workshops (e.g., Interveiw 18).

"I think a lot of people who teach Science Communication have not thought very deeply about why they are teaching what they are teaching, they just, you know, they are journalists so they teach how to write, they are visual persons so they teach how to produce visuals, or they really believe in this "improv" tool, and really stepping back

and say, what are my objectives, am I trying to teach certain kinds of skills" (Interview 18)

This teaching model is effective to teach specific communication skills, especially in short courses like workshop where one or two learning objectives can be addressed. This type of learning is useful for competing the training of scientists in scientific communication, specifically to improve specific skills (such as writing, speaking in public or interacting with journalists during an interview). It is the kind of training courses offered in research institutions for continuous development learning workshops but it can be also beneficial for PhD students to complete their researchers' skills.

5.1.2 Reflective model

All the teaching experiences and references (N=14) included in the reflective model category share a more theoretical approach with the objectives to provide some background on science communication and to reflect and increase understanding on science and communication relationship. Throughout the interviews we have found teachers' mentions referred to teaching practices to *"make scientists' understand science communication importance"* (e.g., Interview 2) and to reflect about the relationships between science, society and communication (e.g., Interviews 1, 3, 4, 12, 16, 17). Also, some interviewees mention the need of a *"intellectual context"* (e.g., Interview 4), a *"critical reflection"* (e.g., Interviews 3, 4) or *"conceptual or theoretical approach"* (e.g., Interviews 11, 16) to train scientists on science communication.

"And the other, embeds that within a more intellectual context and encourages scientists to reflect on the nature of science and the nature of society and the nature of that relationship between them. With the idea that, through that sort of critical reflection, you become a better communicator, you've got to understand your audience and you have to understand the nature of your relationship with the audience to communicate better." (Interview 4)

"I teach them more conceptual skills about the relationships about science and society and why it's important, you know, the background, the theory and so on" (Interview 11)

In addition to this, one of the interviewed academics (Interview 9) talked about the need to make scientists' aware of the potential *"benefits"* of science communication as something to be included in this kind of courses.

"The other part of it is about an awareness and knowledge of the different forms of Science Communication and the opportunities of different types of Science Communication can give, like participatory Science Communication, like creating dialogues and they need to be aware of the tools they can use to create that and the benefits of creating that sort of communication" (Interview 9)

Moreover, the purpose, the different objectives or strategies of science communication and the evaluation of science communication activities were mentioned in some interviewees (e.g., Interview 14, 22) as aspects that should be included in scientists' training.

"A different strategy is that you engage researchers into thinking what Science Communication is for, what strategies we could use for that and again how could we know we have achieved it" (Interview 14)

"But I think we should always and continuously be asking the question and encouraging scientists to ask themselves the question, why does it matter to do public communication, not in order to give a simple answer which can be stated in one phrase but rather because, it will matter for different reasons in different contexts in relation to different sciences. So, that should get more attention, more emphasis I think, in training, and different kinds of answers to that question, why, as you might say in English [...] "why bother with SciCom?"" (Interview 22)

A *"multidisciplinary approach of teaching"* to fully understand the complexity of science and society relationship is mentioned in some interviews (e.g., Interviews 1, 12). Indeed, one of the interviewees referred to science communication as a multidisciplinary discipline, so through the training researchers should learn how *"to carry out this work together"* (Interview 1). So, these learning and understanding of how different disciplines work together will continue in researchers' activities beyond training.

"You can also provide them with an understanding of how Science Communication works more or less so that they can refer to professional science communicators and carry out this work together, that's sort of what I was teaching my PhD students" (Interview 1)

"The most difficult part is to let them understand the complexity of the relationship between science and society and also to let them understand that Science Communication has also a cultural value in terms of for instance, sharing identities and so on. What I would suggest for them is a multidisciplinary approach of teaching and multidisciplinary means that ideally, they should have different concepts from different fields, and we should take care of giving them some technical aspects of communication" (Interview 12)

Furthermore, one of the interviewees specifically mentioned that *"scientists need an understanding of the public as much as the public needs an understanding of science"* (Interview 22). Which, again, is aligned with this idea of science communication as a multidiciplinar and reflective discipline. During the interviews, this kind of approach is usually mentioned a *"mixture of theory and practice"* (e.g., Interviews 2, 21) course and mainly included in undergraduate subjects on science communication (N=10) rather than in specific workshops (N=4). This implies that scientists learn and experience all the issues above mentioned but also combined with a practical approach to acquire practical skills needed to do science communication.

"There are intensive programs like the one we organize, so they tend to be a mixture of theory and practice because you need to learn some things and then you need to practice that theory and what we try to do is balance the theoretical with the hands-on gaming skills" (Interview 21)

The main obstacle to offer this kind of course is that more time is needed than for practical approach learning. This means that is challenging to offer a reflexive approach for a one-day or half-day workshop. However, a reflexive approach to science communication is really interesting for science undergraduate students not only to understand science-society relations but also to place themselves as future researchers in this arena.

5.1.3 Disruptive model

On 5 occasions throughout the 26 interviews we have found references to what we called "disruptive model of science communication teaching to scientists". These mentions referred to educational practices where structural changes on traditional science and society relationships are addressed. Specially in the traditional role of researchers (e.g., Interviews 1, 3, 5, 7, 26), but also in other groups of social actors (e.g., Interviews 3, 5, 7, 26) or in the way scientific knowledge is produced (e.g., Interviews 5, 7, 26).

One of the interviewees referred to this kind of teaching approach where the traditional way of doing science is questioned as *"destruction of science"* (Interview 1). In this sense, the way knowledge is produced and the researchers' role are key concepts around which the teaching of science communication goes.

> *"Other way of teaching this would also involve like a "destruction of science" for scientists. Because they live in bubbles, they think that their way is the only one of achieving truth. Many scientists are still in this delusion so it would be interesting to actually bring some content from the sociologist science to reflect on how other kind of knowledge can be produced and the interactions that can have with science, society, politics etc." (Interview 1)*

One of the teachers interviewed specifically mentions changes in public willingness to be an active part of science production and how this participation can directly affect the way scientists do their research and also the related communication. Also, one of the interviewees mentioned *"the right of the citizens to have a say in the definition of the research agenda itself"* (Interview 5) as something that has to be thought in such courses.

> *"The general population is very willing to talk back and to ask questions and they expect the scientists to justify themselves and respond to their question and I think this is a very healthy thing. It has made quite a difference to some research projects I have been involved in and the feedback from people like farmers has in fact changed the way scientists have done their research and changed the way scientists have presented the results of their research, that's the second thing that they have to get used to" (Interview 3)*

"Knowledge co-production" (e.g., Interviews 1, 3), the *"different roles of publics"* or specific societal actors (e.g., Interview 3, 5), *"public engagement"* (e.g., Interview 7), *"citizen science"* (e.g., Interviews 3, 7), *"responsible research and innovation"* (e.g., Interview 1, 5, 7, 26) and *"democratization of science"* (e.g., Interview 7, 26) are concepts that emerge from the interviews in relation to this model.

“We emphasize the complexities of the interaction between science and society, we emphasize things like the importance of different legitimate perspectives on science, we emphasize the role of values and emotions, we emphasize the limits of knowledge, the uncertainty and ignorance, so these are all concepts that we derive from Science and Technology studies that are important for us in how we talk to our students about science and science communication, so we encourage them to take a more humble and a more dialogical approach” (Interview 7)

“We have already begun to talk a lot that there are models of involvement, that it is also important not only that non-expert people learn with scientists, but that scientists also learn with non-expert people and things like that" (Interview 26)

This approach of teaching science communication was considered especially important when *“communicating controversy”* (e.g., Interview 5), *“limits of science”* (e.g., Interviews 5, 7), the *“uncertainty”* and the *“ignorance”* (e.g., Interview 7).

“When you communicate science, you must always communicate also the controversy, also the limit of science, also what could be the impact of your research and what it can do in the future. So it's not just about communicating science as a body of knowledge, it's not only to educate the public into a body of knowledge, it is about the processes of science and science as a human endeavour, with its connections to society, with its limits as institution, as policy and in the dimension of the impact in society” (Interview 5)

The disruptive model starts from the base of instructing scientists in the structural changes that are taking place in the production and management of scientific knowledge. This model is closely linked to the reflexive model because, without reflection on the objectives of science communication and the interactions between science and society at different levels it is impossible to start talking about structural changes. The disruptive model can be seen as a step beyond the reflective model.

5.2 Teaching science communication as a profession

After the analysis of the interviews, we have identified two models of teaching science communication as a profession. Table 4 summarizes the different models, findings and frequencies of this dimension of study from all the interviews.

Identified model		Findings	Frequency
Professional model	Theoretical learning	It refers to an educational model in which different theoretical models of scientific communication are taught as well as historical review and changes in science-society relations.	18/26
	Skills-based learning	It refers to an educational model in which the necessary skills and tools are taught (writing, video editing, social networks, how to interview etc.) to deal with practical work in the field of science communication.	12/26
Research model		It refers to an educational model in which the concepts, methodologies, tools and skills needed to investigate in scientific communication are taught.	5/26

Table 4. Qualitative results of the "models of teaching science communication as a profession" dimension of study, analysed through categorization system.

5.2.1 Professional model

This teaching model of scientific communication as a profession is based on learning processes that combines basic skills (writing, video editing, social networks, interview procedures etc.) that a communicator must have with the theoretical models and frameworks of science communication.

We have subdivided this model into two parts (skills and theory) because after the analysis of the interviews we have seen that the interviewees differentiated both learning corpus as to pillars of science communication. However, on all occasions the interviewees ended up mentioning both approaches as necessary elements in the complete training for competent scientific communicators. Even so, in the following sections we present both subcategories separately as there are specific interesting considerations for each of the teaching proposals that we want to analyse.

5.2.1.1 Theoretical learning

This learning approach includes teaching different theoretical models of science communication as well as historical background and reflection in changes between science and society relationships and on science communication itself. It means that *"nature of science"* (e.g., Interview 1, 4, 5, 14), *"nature of society"* (e.g., Interview 4, 10, 14) and *"science and society relationship"* (e.g., Interview 1, 4, 5, 10, 14, 17, 22) are key elements that a science communicator has to understand to be able to properly do their work.

> *"[Training science communication to professionals] needs more intellectual context and encourages the scientists to reflect on the nature of science and the nature of society and the nature of that relationship between them. With the idea that, through that sort of*

critical reflection, you become a better communicator, you've got to understand your audience and you have to understand the nature of your relationship with the audience to communicate better." (Interview 4)

"We are not just teaching tools to communicate, we have some of that but that's not the main point. What we want to discuss is what is science, what does science has in especial to have a master's in communication, what aspects of science do we need to communicate, how we can communicate this. We work into the strategies but then how can we make use of this, how can we engage different professionals into different activities…" (Interview 14)

As well as all the conceptual and theoretical framework of science communication. It means including as part of science communication training the *"history of science communication"* (e.g., Interview 8, 17), *"public understanding of science"* (e.g., Interview 17, 22), *"science of science communication"* (e.g., interview 22), *"theory of information"* (e.g., Interview 15) and *"philosophy of science communication"* (e.g., Interview 6). In this regard, one of the interviewees states that *"it's not enough for them to learn how to write or how to produce social media or whatever, they have to have that: they really need to be able to reflect, to become professional"* (Interview 18). Which is aligned with what we have mentioned at the beginning of the section that this professional model combines the teaching of practice and the theory of scientific communication.

"We can teach lots of people how to simplify, we can teach lots of people how to build an exhibit, but if you are going to be a professional science communicator, you need to be able to reflect on why are you doing it and who are those different audiences and why do you want to communicate differently with these different audiences and what are the ways that you are affecting social processes. So, there's much more need with that sort of background reflective I think for professional science communicators." (Interview 18)

"Formal education at the master's level for example, is also a form of education in understanding society, in understanding science as a social system and so on. And in short course training of scientists there is a very limited time and space to do something like that. In a master's program […] there should always be space for historical, philosophical, ethical, ideological, sociological, etc, dimensions of the relationships of science and society to be considered." (Interview 22)

Also one interviewee considers that *"a broad understanding of science communication as a profession"* (e.g., Interview 1) is something that should be included in this teaching model. It means that, interdisciplinary and multidisciplinary reappear throughout the interviews as a differential element of scientific communication and, therefore, of its teaching.

"Science Communication is not just building skills but building critical thinking and I think this interdisciplinary way of approaching

the teaching of Science Communication really goes in this direction which I think is a key feature for Science Communication, being it a Science Communicator or being it a Journalist, being it someone working on a museum, you know, there is a need to confront, to build together, also with citizens of course, towards being socially effective." (Interview 10)

"Even for them I think that it's necessary to have a multidisciplinary approach, which means not only science but sociology, ethics, communication and so on." (Interview 12)

Moreover, aspects that refer to the changes between science and society relations (e.g., Interviews 1, 5, 14, 17), how scientific knowledge is produced (e.g., Interview 14) and how science and technology are regulated (e.g., Interviews 1, 17) also appear throughout the interviews as elements that should be considered in the formation of science communicators. In that sense, *"public engagement"* (e.g., Interview 17) appears as another theoretical approach that should be included in professional teaching of science communication.

"People who are doing a kind of a communications orientated program, […] should have a lot more background in history of science communication, public understanding of science and public engagement. […] That background is really important, particularly if you don't want people simply to fall into a deficit style approach which is simply saying "right, these are the wonderful things you as a dumb citizen need to know about science"" (Interview 17)

"I feel there is a clear trend in the direction of participation, that the relationship between science and society has to be seen as a bidirectional relationship, as an ethical contract between the science communicator and the public. This contract means that you must take into account the needs, expectations of the public and their right to the truth, their right to deep communication of science" (Interview 5)

Also, regarding this science-society relationship some interviewees highlight the need of addressing ethical aspects of science communication during professional training.

"And then there is something else that i think we don't teach at all and that we should be teaching more and more and is ethics, ethics for communicators because i think that now with what's called the fourth industrial revolution where we have for the first time, machines making decisions in our place rather than just helping us make decisions, there are tons and tons of ethical questions, there has always been ethical questions around science and technology but now there are so many of them that if we don't start as communicators understanding what is our role Vis a Vis some of these ethical questions and what we need to do to deal with them and how far we should go with our communication in treating with them, I think we are remiss if we don't teach that." (Interview 15)

It is interesting to note that some of the interviewees criticized the educational model more focused on the development of the practical skills of the scientific communicator (e.g., Interviews 4, 13). They state that a master's degree focused on training future professionals in this field should focus mainly on more theoretical and rational aspects than in developing communication skills.

"So, there would be some that just focus purely on communication skills and some that sort of intellectualize that in some way and try to encourage Science Communicators to be more critical in their communication practice" (Interview 4)

On the other hand, other interviewee mentions students' expectations on a mainly practical approach of teaching during the masters' course:

"Students sometimes are a bit disappointed because they come and think that these programs are aimed at the profession of Science Communicator in the sense that we will teach them to make a science exhibition, to make a science activity for children or to write a news article about science and sometimes they are disappointed that we are too theoretical" (Interview 23)

Finally, there was also one mention to the lack of standardization in science communication masters' programmes. This interviewee claims the need of settle up a core of basic theories or corpus of knowledge to make sure that all the people who are in a masters' program on science communication ends up with the same (or a minimum) set of skills and theoretical knowledge.

"We don't have an agreed curriculum at least to an extent where we say, "are we all teaching the following five theories, do you make sure that there are certain methodologies, Survey design, evaluation, front-end and impact evaluation and whatever" (Interview 13)

Indeed, this interviewee considers that this lack of standarization bewteen masters ends up with a huge diversity of training programs and does not ensure that all communication professionals share the same skills and knowledge.

"If I employ someone with a Masters in Science Communication, that this person has in any case the following skills, the following knowledge, the following capacities. At the moment this is absolutely impossible because we have a multi-coloured, super diverse landscape out there" (Interview 13)

5.2.1.2 Skills-based learning

12 of the 26 interviewees referred to teaching programs in which necessary skills are taught in order to deal with science communication professional work. The type of skills referred to by the interviewees can be hard or technical skills, soft skills or conceptual skills. For example, some of the technical skills identified as necessary for the scientific communicators during the interviews are: how to take *"videos and photographs"* (e.g., Interview 3), how to *"use social media"* (e.g., Interview 3), how to *"manage a web"* (e.g., Interview 3), how to *"make radio programs"* (e.g., Interview 17), how to *"do a podcast"* (e.g., Interview 8) etc.

"I think when you are teaching SciCom you need to be practical, you need to look at the situations that the students might face and if they are going to work for a research laboratory, they are going to have to sit down and talk to scientists, they are going to have to encourage the scientists to tell stories about their work, they are going to have to be good at taking videos and photographs, they are going to have to be good at using social media and confident in working with the web, so there is a whole range of technical aspects of the work that they have to be confident with doing" (Interview 3)

"We've got lots of optional modules, one of them is Science on Screens so that's looking at SciCom through broadcast either through TV or through radio or podcasts or web video or wherever it is. And one of them is Science Writing so that's all about journalism and different forms of journalistic writing, opinion writing, feature writing, blogs, press releases, and everything else." (Interview 8)

But, one on the interviewees specially mention this kind of hard skills as *"the first thing you have to teach to a professional science communicator"* (Interview 15). Which implies that there are more skills, in addition to these technical ones, that scientific communicators must learn. For example, some the ones we identified as soft skills such as how to talk to scientists (e.g., Interviews 3, 4, 17), how to *"listen"* (e.g., Interview 9), how to *"consult information"* (e.g., Interview 9), how to *"do face to face communication"* (e.g., Interview 8), how to *"speak in public"* (e.g., Interview 16), how to *"do different forms of journalistic writing"* (e.g., Interviews 8, 17) *or "how to approach a technology or a scientific discipline in order to learn enough about"* (e.g., Interview 15).

"So students at this area need to be confident enough to sit down with the scientist and say, "tell me about your work, why are you doing this, why are you doing that, no I don't understand, tell me in simple language because I do not have a PhD in science communication", so they have to be confident in dealing with scientists and encouraging them to tell the stories and specifically to tell the stories so they talk about the effect that their work will have on the population. Will it mean a cheaper loaf of bread? Will it mean more jobs? Will it mean a better environment? And that's the sort of thing that communicators need to be aware of, the best way to tell a story, so it's going to have the maximum impact on the people who hear the story." (Interview 3)

"Our students learn how to do face to face communication within things like stage shows or within science centres or interactive activities." (Interview 8)

"I think a Science Communicator needs to learn is the skill of listening and consulting and using that information and to help drive the communication strategies" (Interview 9)

Is interesting to highlight that in some interviews (e.g., Interview 12, 20, 22, 24), appears again the idea of science communication as a multidisciplinary profession. Which that is present during student training, starting with the composition of the class group (N=22) and is also considered as a potential benefit to *"learn from each other"* (e.g., Interview 22) and *"to enrich group dynamics during the formation process"* (e.g., Interview 24).

> *"If after your course they have a map, they have a way of orienting themselves in scientific fields, and to create this map, of course you need to understand which are the most important places, how to reach these places, whom you may ask to have information about this place, you need something that allows you to move in the field. It's more like a walk of cartographers, I think this is a way to understand concretely what multidisciplinary means, to let your students become cartographers of science. It means that you need someone that teaches you how to build your map." (Interview 12)*

In addition to above mentioned references to practical skills, throughout the interviews we have found several mentions of more conceptual skills to be included in science communication training programs for professionals. There are specific mentions regarding the *"need to understand science, or at least the scientific method, how science is organized, administered and governed"* (Interview 1) as basic conceptual knowledge for future science communicators. Moreover, some interviewees talk about the need to teach about *"different communication strategies"* (e.g., Interview 9, 24) *"ways of engaging public in science"* (e.g., Interview 9, 23) and *"how to evaluate science communication activities"* (e.g., Interview 9, 13, 14, 22).

> *"A SciCom professional needs to be trained on how to develop a good communication strategy for a project, for an organization, for an activity, how to evaluate that activity, how to revive what the scientist need to do the communication, then needs to be educated in the various forms of Science Communication that are available to them, it's not just about disseminating information or blowing out chemistry experiments in front of the public, that there are much more deeper, more important ways of engaging the public." (Interview 9)*

5.2.2 Research model

Only in 5 of the 26 interviews has the training of scientific communication students in skills and competencies related to research been mentioned. However, the intrinsic characteristics of this type of teaching seem to us different enough to group them into a different model.

One of the interviewees specifically talk about *"tensions"* (Interview 23) between masters devoted to train science communication practitioners versus maters with the objective of form science communication researchers. This let us think about two co-existing models of training science communicators.

> *"I think these master degrees as it take a bit between doing more practical teaching in the sense of teaching the students to*

communicate science versus teaching students to research Science Communication, that I think it's the only tension that I feel that exists in this programs because on the one hand, you have a master degree as something academic that you have to do research, to write a dissertation or a thesis and so you have to have the tools to research, to investigate, but at the same time, we try to provide them with the tools to do, to carry out science communication and so, I think all master programs here try to balance between these two" (Interview 23)

This idea of co-existence of teaching models also appears in other interviews. For example, one of the interviewees claims the need of an *"evidence-based practice"* (Interview 16) which means that teaching science communication strategies, abilities and concepts having into account the research done in this field. So, this model not only includes learning *"how to do research"* (Interview 13), but also understanding that *"there are people that is studding Science Communication to understand what's being more effective or not"* (Interview 16).

Moreover, some interviewees highlight the need to acquire research skills to be able to *"go into the whys and how's of your science communication practice"* (Interview 14), *"study the impact of every activity"* (Interview 16). Thus, research skills are useful to be able to define concrete objectives for science communication activities and design effective evaluation strategies (e.g., Interviews 13, 14, 16, 22).

"Teaching science of science communication is also useful for science communication practice. Understanding media studies, evaluation techniques, social science research strategies and all dimensions of science and society are key learning areas for future science communication professionals. (Interview 22)

Even one of the interviewees considers that such research skills training is better the professional model of training before described.

"I've seen masters degrees with no readings, like they did let's say there one year of training and never had a single Science Communication paper in their hand, they didn't even know that there was something like research in this field. So, this is a field of practice so all that's been trained are the practice. I don't think that's ok." (Interview 13)

However, other interviewee consider research in science communication as *"just an option"* (Interview 23).

"All master programs here try to balance between research and practice and I think we are trying to cater to both needs and perhaps I'm not sure that students are satisfied with that. You can be a very good science communicator without doing research. Research in science communication is just an option." (Interview 23)

6. Discussion and conclusions

6.1 Models of teaching science communication to scientists

As we have seen, from the interviews we identified three models for training scientists in science communication:

a) **Practical model**: where practical skills such writing, public speaking or how to behave in a media interview are taught.
b) **Reflexive model**: where background theory and history on science communication are taught in order to make researchers understand the importance of science communication and the relationship between science and society.
c) **Disruptive model**: were traditional roles of scientific-knowledge production as well as relationship and power roles on science are challenged.

These three models are not exclusive. It means, all of them can co-exist and even be part of the same educational program because the objectives they pursue are very different. These three models can be represented as concentric circles in which a model encompasses the previous ones. The outermost circle offers a more complete view of the scientific communication landscape (see Figure 1).

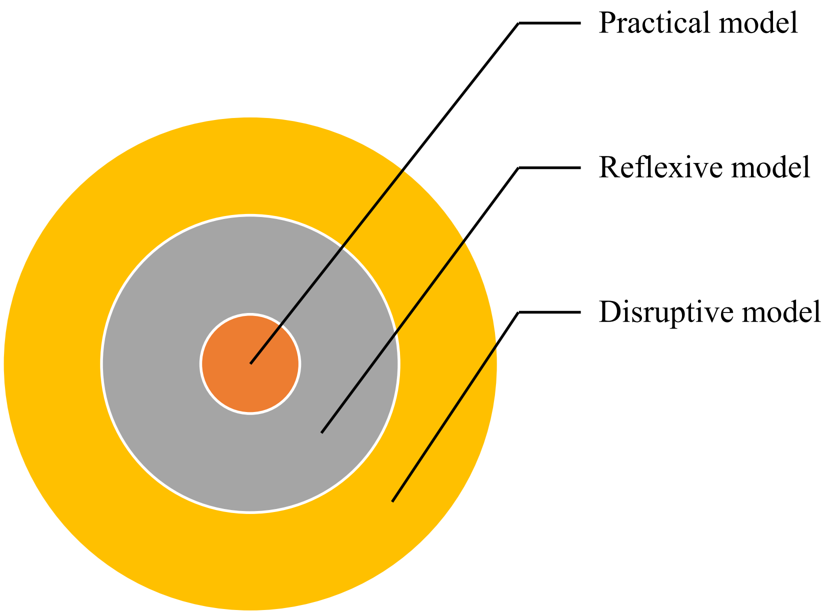

Figure 1. Models of teaching science communication to scientists

One thing that must be taken into account, is that in short-term educational courses (for example workshops) models with more ambitious objectives such as reflective or disruptive are much more difficult to carry out. On the other hand, in undergraduate science programs or in masters' programs for scientists courses based on the two last models could be easily implement in several teaching sessions over a longer period of time (allowing reflection). In these latter cases, an educational model based on workshops can serve as a "trigger" or "starting point" to initiate a deeper reflection.

6.2 Models of teaching to science communication professionals

Form the interviews, we have identified two different models of training science communication professionals:

a) **Professional model**: where practical skills are taught but also combined with theoretical models, historical review and science-society relations understanding.
b) **Research model**: where tools, skills, concepts and methodologies to investigate in science communication field are taught.

As we can see in Figure 2, we can represent the three different main skills identified as necessary to train future science communication professionals in three axis. As we move away from the centre we give more priority to one of the three bodies of knowledge. The professional model gives more weight to the teaching of practical skills and theory than to research skills. While the research model of more weight to the teaching of theory and research skills.

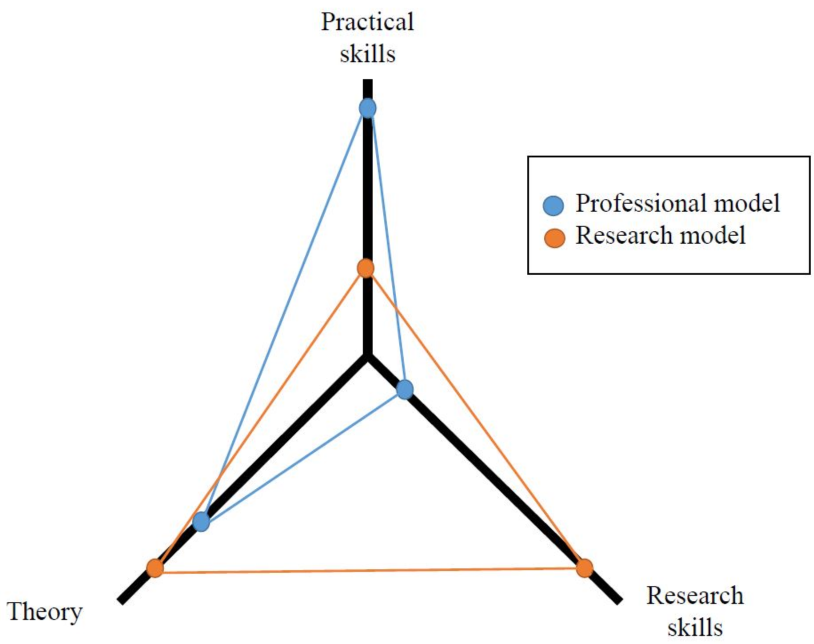

Figure 2. Models of teaching science communication to professionals

We can move a teaching program along the axes to find all varieties of science communication teaching approaches for future professionals. Some will devote themselves eminently to the practice and others to the investigation, with what the position of each one of the training programs in the axis will depend on the educational objectives and of the competences that want to develop. What is clear is that a science communication professional must have basic theoretical knowledge about the field, an educational model based solely on practical skills would not be enough.

7. References

Allgaier, Joachim et al. 2013. "Journalism and Social Media as Means of Observing the Contexts of Science." *BioScience* 63(4): 284–87.

Baram-Tsabari, Ayelet, and Bruce V. Lewenstein. 2017. "Science Communication Training: What Are We Trying to Teach?" *International Journal of Science Education, Part B* 7(3): 285–300.

Bauer, Martin W, and Pablo Jensen. 2011. "The Mobilization of Scientists for Public Engagement." *Public Understanding of Science* 20(1): 3–11.

Besley, John C., Anthony D. Dudo, Shupei Yuan, and Niveen Abi Ghannam. 2016. "Qualitative Interviews With Science Communication Trainers About Communication Objectives and Goals." *Science Communication* 38(3): 356–81.

Besley, John C, and Matthew Nisbet. 2013. "How Scientists View the Public, the Media and the Political Process." *Public understanding of science (Bristol, England)* 22(6): 644–59.

Bonney, Rick et al. 2009. "Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy." *BioScience* 59(11): 977–84.

———. 2014. "Citizen Science. Next Steps for Citizen Science." *Science* 343(6178): 1436–37.

Bray, Belinda, Bev France, and John K. Gilbert. 2012. "Identifying the Essential Elements of Effective Science Communication: What Do the Experts Say?" *International Journal of Science Education, Part B: Communication and Public Engagement* 2(1): 23–41.

Brownell, Sara E, Jordan V Price, and Lawrence Steinman. 2013. "Science Communication to the General Public: Why We Need to Teach Undergraduate and Graduate Students This Skill as Part of Their Formal Scientific Training." *Journal of undergraduate neuroscience education : JUNE : a publication of FUN, Faculty for Undergraduate Neuroscience* 12(1): E6–10.

Bucchi, Massimiano. 2004. "Can Genetics Help Us Rethink Communication? Public Communication of Science as a 'Double Helix.'" *New Genetics and Society* 23(3): 269–83.

"Citizen Science." 2014. *The Oxford English dictionary*.

Dunwoody, Sharon, Dominique Brossard, and Anthony Dudo. 2009. "Socialization or Rewards? Predicting U.S. Scientist-Media Interactions." *Journalism and Mass Communication Quarterly* 86(2): 299–314.

Eitzel, M V et al. 2017. "Citizen Science Terminology Matters: Exploring Key Terms." *Citizen Science: Theory and Practice* 2(1): 1.

Elo, Satu et al. 2014. "Qualitative Content Analysis." *SAGE Open* 4(1): 215824401452263.

ENSCOT. 2003. "Enscot: The European Network of Science Communication Teachers." *Public Understanding of Science* 12(2): 167–81. www.sagepublications.com (May 21, 2019).

Fischhoff, Baruch. 2013. "The Sciences of Science Communication." *Proceedings of the National Academy of Sciences* 110(Supplement_3): 14033–39.

Fischhoff, Baruch, and Dietram A Scheufele. 2019. "The Science of Science Communication III." *Proceedings of the National Academy of Sciences* 116(16):

Gascoigne, Toss et al. 2010. “Road Maps for the 21st Century Research in Scincen Communication. Is Science Communication Its Own Field?” *JCOM, Journal of Science Communication* 9(3).
Goodwin, Jean. 2018. “Effective Because Ethical: Speech Act Theory as a Framework for Scientists’ Communication.” In *Ethics and Practice in Science Communication*, eds. Susanna Priest, Jean Goodwin, and Michael Dahlstrom. Chicago: University of Chicago Press.
Hockfield, Susan. 2018. “Our Science, Our Society.” *Science* 359(6375): 499.
Horning Priest, Susanna. 2010. “Coming of Age in the Academy? The Status of Our Emerging Field.” *Journal of Science Communication* 9(3): 1–9.
Jordan, Rebecca C, Heidi L Ballard, and Tina B Phillips. 2012. “Key Issues and New Approaches for Evaluating Citizen-Science Learning Outcomes.” *Frontiers in Ecology and the Environment* 10(6): 307–9.
Kahan, Dan M. 2015. “What Is the ‘ Science of Science Communication ’? Public Law Research Paper No. 539.” *Journal of Science Communication* 14(3): 1–12.
Leshner, Alan I. 2007. “Outreach Training Needed.” *Science (New York, N.Y.)* 315(5809): 161.
Llorente, Carolina, Gema Revuelta, Mar Carrió, and Miquel Porta. 2019. “Scientists’ Opinions and Attitudes towards Citizens’ Understanding of Science and Their Role in Public Engagement Activities.” *PLoS ONE* 14(11): 1–20.
Massarani, Luisa, Elaine Reynoso, Sandra Murrielo, and Ayelen Castillo. 2016. “Science Communication Postgraduate Studies in Latin America: A Map and Some Food for Thought.” *Journal of Science Communication* 15(5): 1–19.
McKinnon, Merryn, and Chris Bryant. 2017. “Thirty Years of a Science Communication Course in Australia: Genesis and Evolution of a Degree.” *Science Communication* 39(2): 169–94.
Mellor, Felicity. 2013. “Twenty Years of Teaching Science Communication: A Case Study of Imperial College’s Master’s Programme.” *Public Understanding of Science* 22(8): 916–26.
Miller, Steve, and Declan Fahy. 2009. “Can Science Communication Workshops Train Scientists for Reflexive Public Engagement?: The ESConet Experience.” *Science Communication* 31(1): 116–26.
Moreno-Castro, Carolina, and Josep Lluis Gómez-Mompart. 2002. “Science and Technology in Journalists Training.” *Comunicar* 10(19): 19–24.
Mulder, Henk A. J., Nancy Longnecker, and Lloyd S. Davis. 2008. “The State of Science Communication Programs at Universities around the World.” *Science Communication* 30(2): 277–87.
Murriello, Sandra. 2014. “Posgraduation Courses About Pus In The Argentinian Patagonia.” In *13th International Public Communication of Science and Technology Conference*, ed. PCST network. Brazil.
Newman, Greg et al. 2012. “The Future of Citizen Science: Emerging Technologies and Shifting Paradigms.” *Frontiers in Ecology and the Environment* 10(6): 298–304.
Rabionet, Silvia E. 2011. “How I Learned to Design and Conduct Semi-Structured Interviews: An Ongoing and Continuous Journey.” *The Qualitative Report* 16(2): 563–66.
Rensberger, Boyce. 2009. “Science Journalism: Too Close for Comfort.” *Nature* 459:

1055–56.
Revuelta, Gema. 2014. “Impacts of Science Communication on Publics, Cities and Actors.” *Journal of Science Communication* 13(1): 1824–2049.
———. 2018. “Formación En Comunicación En Los Estudios de Grado Análisis En Las Áreas de Ciencias de La Salud y La Vida, Ciencias Ambientales y Ciencias Naturales.” *InMediaciones de la Comunicación* 13(2): 159–82.
———. 2019. “Journalists’ Vision of the Evolution of the (Metaphorical) Ecosystem of Communication on Health and Biomedicine.” *El Profesional de la Información* 28(3).
Reynoso-Haynes, Elaine. 2009. “A Graduate Course for Science Communicators: A Mexican Approach.” *Journal of Science Communication* 08(01): C04.
Schreier, Margrit. 2012. *Qualitative Content Analysis in Practice*.
de Semir, Vladimir. 2009. “Master in Scientific, Medical and Environmental Communication.” *Journal of Science Communication* 08(01): C02.
Sharon, Aviv J., and Ayelet Baram-Tsabari. 2014. “Measuring Mumbo Jumbo: A Preliminary Quantification of the Use of Jargon in Science Communication.” *Public Understanding of Science* 23(5): 528–46.
Torres-Albero, Cristóbal, Manuel Fernández-Esquinas, Jesús Rey-Rocha, and María José Martín-Sempere. 2011. “Dissemination Practices in the Spanish Research System: Scientists Trapped in a Golden Cage” eds. Martin W. Bauer and Pablo Jensen. *Public Understanding of Science* 20(1): 12–25.
Trench, Brian. 2008. “Towards an Analytical Framework of Science Communication Models.” In *Communicating Science in Social Contexts: New Models, New Practices*, Dordrecht: Springer Netherlands, 119–35.
———. 2009. “Masters (MSc) in Science Communication. Dublin City University.” *Journal of Science Communication* 08(01).
Turney, Jon. 1994. “Teaching Science Communication: Courses, Curricula, Theory and Practice.” *Public Understanding of Science* 3(4): 435–43.
UNESCO. 2018. *Journalism, ‘Fake News’ & Disinformation Handbook for Journalism Education and Training*.
Vogt, Carlos A., Marcelo Knobel, and Vera Regina Toledo Camargo. 2018. “Master’s Degree Program in Scientific and Cultural Communication: Preliminary Reports on an Innovative Experience in Brazil.” *Journal of Science Communication* 08(01): C06.

8. Annex 1. Semi-structured interview script

Semi-structured interviews were used in WP1 of CONCISE project to complete Task 1.1 and Task 1.2. With this objective we developed a single interview protocol with questions regarding both tasks. In this report we are only focusing in results from Task 1.2 "Models of teaching science communication in Europe", questions regarding this issue are the ones included in Dimension 3.

Starting questions/information

- Name
- Age
- Institution
- Number of years working on science communication
- Number of years teaching science communication
- At what level; undergraduates, masters' programmes, PhD courses?
- To whom; scientists, communicators/journalists, future science communicators?

Dimension 1. Incentives to engage with science communication in Europe

- Which are the main incentives for scientists to engage in science communication?
    - What kind of incentives do you think would be necessary to promote this engagement?
    - Could you list some examples of involvement of researchers in public communication activities?
- Which are the main incentives for communicators to engage in science communication?
    - What kind of incentives do you think would be necessary to promote this engagement?

Dimension 2. Hurdles to engage with science communication in Europe

- Is science communication formally and/or informally considered an intrinsic part of the scientists' professional activities?
    - How?
- Is science communication a criterion for the formal evaluation of scientific careers?
    - How is this criterion included?
- What are the main hurdles and barriers for scientists to engage in science communication?
    - How can be solved/reached?
- Is science journalism attractive for communicators?
    - Why?
    - And Science communication?
    - Why?
- Which are the main hurdles for communicators to engage in science communication?

- How can be solved/reached?

Dimension 3. Models of teaching science communication in Europe

- Do you think that are different approaches in teaching science communication to scientists?
    - Which are these approaches?
- Are there different approaches of teaching science communication to students that want to become science communication professionals?
    - Which are these approaches?
- Can you identify any teaching inspiring practices?
- Do you think that, for science students, science communication is considered as a career option such as research, teaching, business...?