Communication role on perception and beliefs of EU Citizens about Science

Hurdles and incentives to science communication in Europe

Deliverable 1.3

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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

One of the objectives of WP1 of CONCISE is reviewing the existing hurdles and incentives for scientists, communication and other R&I stakeholders to engage in public science communication. This deliverable is the result of a literature review process (scientific literature, policy documents and grey literature) and the analysis of 26 individual semi-structured interviews with science communication researchers from 15 different countries and one online workshop with 18 science communication practitioners (journalists, communication officers, science museum directors etc.) from 16 different countries.

Here we present the literature review, the methodology used, and summarize the obtained results in order to identify incentives and barriers to engage in science communication. This results will complement the overall understanding of science communication processes gathered from CONCISE consultations and the review of different models for teaching science communication to different publics and with different objectives. These results will fit Task 1.3 and D 1.5 to propose a database of inspiring practices and recommendations to engage scientists and communicators with science communication.

3. Background and literature review

3.1 What do we understand as “public communication of science and technology”?

During the past two decades, science communication has experienced profound transformations and the number of activities, courses, and practitioners has increased. For example, the great number of information sources and content creators concerning science and technology has grown, also the high amount of information available on the

internet, and the citizens' behaviour while consuming information has changed (Dietz 2013; Schäsignfer 2009).

Many journalistic media have reduced the resources designated to cover scientific and technological issues during last decade (Bauer and Bucchi 2008). But at the same time many other organizations such as research centres, universities, research and innovation companies and businesses or civil society organizations have increased the amount of resources devoted to this and their role in communication is becoming more active.

Furthermore, social networks, big digital platforms and search engines (e.g. Google, YouTube etc.) have a more important role in information distribution. Moreover, mass media algorithms and the immediate reactions of the audience (clickbait, etc.) are key in information flows.

Because of all these changes for now, there is no single definition of science communication. "Science communication is typically thought of as the activities of professional communicators (journalists, public information officers, scientists themselves)" or simply as "the promotion of the public understanding of science" (Treise and Weigold 2002).

But also may be defined as Burns et alt. suggest (2003):

"The use of appropriate skills, media, activities, and dialogue to produce one or more of the following personal responses to science (the vowel analogy):

a) Awareness, including familiarity with new aspects of science.
b) Enjoyment or other affective responses, e.g. appreciating science as entertainment or art.
c) Interest, as evidenced by voluntary involvement with science or its communication.
d) Opinions, the forming, reforming, or confirming of science-related attitudes.
e) Understanding of science, its content, processes, and social factors."

So, what do we mean when we talk about "public communication of science and technology"? As Brian Trench (2008) claimed in the Analytical Framework of Science Communication Models, public communication of science and technology can be grouped into three models: dissemination model, dialogue model and conversational model. Nowadays we can understand the term "conversation" as "participation", including cross-talk (Bucchi 2004) but also a range of public engagement in science activities (e.g. DIY, social labs, citizen science, etc.) or new approaches of science itself (engaged research, science shops etc.).

In this report we are going to take into account this last broad conception of science communication with the objective of exploring the main barriers and incentives for different actors to engage in it.

3.2 Actors in modern science communication

One of the great changes that scientific communication has experienced in recent times is the kind of actors that take part in communication and the interactions established between them. Modern science communication may involve journalists, professional science communicators, science practitioners, mediators, and other members of the general public, either peer-to-peer or between groups (Burns, O'Connor, and Stocklmayer 2003). The coexistence of different actors with different objectives and professional backgrounds needs to be explored in order to properly understand their role.

3.2.1 Science communication as a profession

Relations between citizens and sources of information in science and technology has also changed. Surely the most prominent change in recent years is the progressive rise of Internet as a means of accessing information (Peters et al. 2014). However, we cannot say that Internet is replacing conventional media, since the main websites consulted belong to traditional media; newspapers, radio and television (de Semir and Revuelta 2017).

Much of the population stops studying science and technology from higher school. This implies that during most part of their lives society will acquire scientific-technical knowledge through the information they receive in an unregulated manner. So, in public information on science, medical and the environmental issues, it is important that communication professionals carry out their work with quality.

The sector of science and technology is increasingly competitive and more aware of the benefit of communicating its activity to the public. This implies that the number of actions to the mass media is increasing and that scientific entities have also increased the actions directed to the public such as public engagement activities, outreach activities and direct digital communication (websites, social networks, etc.). This transformation has been carried out thanks to the appearance of a new professional profile of scientific communicator, formed for institutional communication and the promotion of scientific culture (Nisbet and Scheufele 2009).

3.2.2 Science communication as a part of the regular professional tasks of a scientist

The role played by science practitioners acting as experts is equally decisive: researchers, doctors and other professionals trained in scientific disciplines. Scientists are increasingly present in the field of public communication either acting as sources of information or directly as communicators.

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 researchers 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). In previous studies, Besley and Nisbet (2013) reported that scientists strongly believe that they should have an active role in public debates, especially with policy makers.

Therefore, it is necessary to further explore the role of scientists in this regard to understand the barriers and problems that currently hold back science communication.

3.2.3 Other actors involved in science communication

The relationship of citizenship with information has also undergone substantial changes. On the one hand, the pattern of active search among citizens has been extended (Revuelta and Corchero 2011). On the other hand, the possibilities of citizen participation in the information itself have increased: as a source of information (user generated contents), as a reference or "prescriber" of information among their social networks (like, retweet, share ...), as content curator. Or even through the dissemination of citizen participation movements in the science and technology system (public engagement, citizen participation, citizen science) and in related sectors (e.g. e-patients) (Hockfield 2018).

Around the world, thousands of this kind 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 high variety of topics (Bonney et al. 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; to engage volunteers, to maintain the relationship between citizens and the research team, to understand the main goals etc. (Jordan, Ballard, and Phillips 2012; Newman et al. 2012). At this point we can see great opportunities but also serious risks, this implies that the role played by all the different actors involved in communication is a key element for study.

3.3 Hurdles and incentives to engage in public science communication

3.3.1 For science communication professionals

Concerning science journalism, staff cuts and lack of resources due to the economic crisis, added to the bad adaptation to the new digital panorama and the competence with non-journalistic media, have caused the decline of critical assessment and reporting of science. In general, new media and tools prioritize the immediate impact which makes it difficult for communicators to invest time in their works. This barrier is difficult to overcome because the problem not only depends on journalists that deal with science, but also involves the whole communication system and the citizens’ behaviour and

information consumers. If clickbait works out well for sensationalistic headlines and superficial content, journalists have more pressure to cover topics in this way. For all these reasons, it is increasingly considered necessary that these professionals have proper training for this (Allgaier et al. 2013; Baram-Tsabari and Lewenstein 2017b, 2017a; Revuelta 2018; Turney 1994; UNESCO 2018).

For science communication professionals, incentives are important to support better practices in their work. Awards and public recognitions help to benchmark excellence both for the public and for professionals of the field.

3.3.2 For scientists doing science communication

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. 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). Therefore, the only determinants will be their inner capacity for it or their years of experience.

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 2017b; Leshner 2007; Llorente et al. 2019; Mulder, Longnecker, and Davis 2008; Rensberger 2009; Sharon and Baram-Tsabari 2014)

In addition to the lack of training, other barriers can restrain the participation of scientists in communication such as lack of time, lack of support and lack of professional recognition (Sanz Merino and Tarhuni Navarro 2019; Besley et al. 2018; Illingworth and Roop 2015; Gascoigne and Metcalfe 1997). As a response, numerous initiatives have been issued to support scientists' communication activities. These initiatives range from adding dissemination requirements to grants to creating a more favourable social and professional context for communication. For example, rewarding researchers for their public engagement activities or using it as an evaluation criterion.

Governments can influence these rules through their research funding bodies. Palmer and Schibeci (2014) claimed that there is currently a preference for approaches which "educate the public about science". But engagement suggests a two-way process which encourages dialogue. To move research bodies along the continuum to this kind of approach a more formalised policy for funding is required (Palmer and Schibeci 2014).

Moreover, there are contextual factors which may be disincentives to the involvement of researchers in science communication such as the increasing competitiveness in the research sector (with the consequence that scientists have to spend more time on research) or the growing efforts necessary for scientists to get funds. In addition, it is still thought that, if researchers participate in outreach activities, they are losing their

time, or that they are doing it simply to attract attention. Fortunately, this negative vision of the scientists that communicate is disappearing, specially between the youngest ones.

To sum up, it is important to better understand the existing structural obstacles that scientists and other research and innovation stakeholders (including policymakers) currently face when attempting to communicate science successfully in order to effectively promote engagement.

For this reason, also incentives in science communication (funding programs for science communication activities, science journalism awards, formal recognition of communication activities in the scientists' curricula, etc.) are a possible path of study. For now, we do not know how widespread these incentives are and what their impact on science communication is.

3.4 Research objectives

As we have seen, there is a need to explore what are, or what should be the incentives to promote science communication either among scientists and communication professionals. It is also necessary to further explore the different hurdles to engage in science communication in order to be able to propose effective strategies to solve them.

This research address this issue by interviewing science communication researchers and academics and contrasting the preliminary results with a group of science communication practitioners in order to identify the above mentioned incentives and barriers. Therefore, this research seeks to answer the following research questions:

> RQ1 – What are the main barriers to engage science communication in Europe?
> RQ2 – What are the main incentives to engage science communication in Europe?

4. Methodology

To answer these questions, we conducted 26 semi-structured interviews with science communication researchers from 15 different countries and one contrast online workshop with 18 science communication practitioners from 16 different countries. We chose a qualitative methodology, as our intention is to explore the personal perceptions of these science communication researchers and practitioners, and their arguments regarding different barriers and incentives to engage in science communication. The specific interview script (see Annex 1. Semi-structured interview script) and workshop structure (see Annex 2. Contrast online workshop structure) were 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 science communication researchers or academics, and their likely knowledge of the subject of study. CONCISE consortium members proposed a list of science communication researchers of their own countries, we also include relevant candidates selected from literature. Among these we identified science communication researchers that also where involved in science communication teaching programmes (see deliverable 1.4) either for scientists, communicators or future science communication professionals.

Once science communication researchers 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 less represented gender in the sample. Finally, 41 researchers 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 researchers. 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 research	**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 research and 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), this protocol was validated by CONCISE consortium and two interviewers conducted Skype interviews. 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 and 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. Contrast online workshop was the strategy used to ensure validity or trustworthiness.

4.3.1 Online workshop with science communication practitioners

After conducting the interviews and having performed the first preliminary analysis of the transcripts, we organized an online workshop with scientific communication practitioners (professionals who are working as journalists, communication officers, science museum directors etc.).

The main objectives of this workshop were:

1. Contrast whether the results obtained from interviews with researchers are aligned with the experiences and / or professional perceptions of scientific communicators
2. Identify new analysis items
3. Validate the established categories
4. Get a new perspective with which to review the results of the interviews

4.3.1.1 Online workshop sampling

Also intentional sampling was used to select participants for the contrast online workshop. We select a sample of strategic subjects based on their work positions as science communication practitioners and their first-hand knowledge of the work of a scientific communicator and his interaction with other actors involved in the communication of science. CONCISE consortium members proposed a list of science communication professionals (of their own countries and beyond) and the contact of the

president or a representative of their own countries science communication association. We also made an open call to recruit participants through the Public Communication of Science and Technology network (PCST). Among these we identified science communication practitioners what where currently working in different science communication fields.

Once workshop participant candidates were identified we sent them an e-mail describing the project and invited them to participate in an online workshop. 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 less represented gender in the sample. Finally, 34 science communication practitioners were contacted. Of these, 25 responded, 7 declined to participate and the online workshop was carried out with 18 people.

The average age of workshop participants was 42 years old (SD=5,1), and there were 8 male and 10 female science communication practitioners. All participants completed higher education. Special effort was made to have representation of science communication professionals working in different science communication fields (see Table 2). We have to take into account that most of science communication association representatives also are currently working in science communication, so they have a double role. Just one of them was only working as science association president, 2 of them are also communication officers at research institutions, one of them is working as a science journalist and the last one owns a science communication private company.

Science communication work position	N	% sample
Journalist	3	17%
Science communication association representative	5	28%
Communication officer from research institution	2	11%
Science communication consultancy officer	2	11%
Public engagement officer from a research institution	2	11%
Science museum personnel	2	11%
Science communication private company	2	11%

Table 2. Workshop participants' job description

Before participating, all participants were informed of the nature of the study and data processing policies and freely gave their consent. All of them were free to stop participating at any time.

4.3.1.2 Workshop data collection

Once preliminary results from above mentioned interviews were ready we elaborated a research workshop protocol to get extra information on the dimensions of study. In addition to the 18 participants, 3 members of the Pompeu Fabra University (UPF) research team (including the two interviewers) and 3 members of the CONCISE consortium were present during the entire workshop. The online workshop was conducted in January 2020 and lasted an hour and 8 minutes. The entire session was recorded, including both audio and written interventions.

5. Results

5.1 Scientists' engagement in science communication

In the following section we summarize all the results of the qualitative analysis of the interviews on the incentives and barriers that researchers have to participate in communication of science. The results are contrasted with the contributions of the participants in the online workshop.

5.1.1 Scientists' incentives to engage in science communication

From the interviews we identified 3 groups of incentives for scientists to engage in science communication. Table 3 summarizes the identified incentives, findings and frequencies from this dimension of study from all the interviews.

Identified incentives' group	Findings	Frequency
As a social commitment	• As payment to citizens who fund science by paying their taxes • To improve democracy • To inform society • To raise awareness • To promote science • To increase cientific culture • To promote scientific vocations	19/26
As a strategy to get personal or professional benefit	• To attract funding • To attract scientific collaborations • To reach a broader audience • To convince strategic publics • To enjoy themselves	15/26
As part of researchers' job	• Included as a mandatory issue in research projects • Promoted by the research institution • Criterion by funding bodies	9/26

Table 3. Qualitative results of the "scientists' incentives to engage in science communication" dimension of study, analysed through categorization system.

5.1.1.1 As a social commitment

During the interviews, incentives for scientists to engage in science communication as a commitment between science and society were the most mentioned (N=19). In this category we have included all references to scientists' motivations to fulfil this social commitment through science communication; as a payment to citizens who fund research by paying their taxes, as a contribution to democracy, to raise awareness, to increase scientific culture or even to promote scientific vocations.

In this regard, some interviewees' (N=7) mention the *"sense of duty"* (e.g., Interviews 11,17,21), the *"moral"* necessity (e.g., Interview 8), *"social justice"* (e.g., Interview 8) or the researchers' *"responsibility towards society"* (e.g., 14) as the main incentive for scientists' to engage in science communication. Even one of the interviewees (Interview 17) considers that researchers have a duty to communicate their research to society *"in*

a free and an open fashion". Most of these references consider science communication as a *"return"* (e.g., Interview 25) or *"payment"* (e.g., Interview 2, 7) to *"giving knowledge back to society"* (e.g., Interview 2, 25) because most research is funded under public grants. But also some interviewees mention scientists' *"love for knowledge"* (e.g., Interviews 24, 25) as a strong motivator for researchers to communicate science.

> *"Well, one incentive is the need that scientists do have to give back to society what they have received in form of grants. So, they receive grants and they receive support from society for them to do their work, so it is very important for them to communicate what are they doing" (Interview 2)*

> *"There is a social justice aspect to it where it's good to educate as many people as possible about things that potentially have impact on them especially when public money is contributing to that research happening" (Interview 8)*

> *"They feel it's a duty to communicate what they are doing to other people, so it's a very strong motivator." (Interview 21)*

One of the interviewees considers that scientists are engaging in science communication *"because they are achieving one of their ambitions which is to make the world a better place"* (Interview 3). This idea of communicating science because it has as a social benefit appears in other interviews (e.g., Interviews 7, 11, 22, 24, 26). For example, another interviewee mentioned that scientists have the *"obligation"* to communicate with the public because *"science does important work for society and help people to live better lives"* (Interview 7).

> *"They feel that they can maybe improve people's lives by sharing some science for them that they can actually use in terms of making better choices about their own health or about their own lives." (Interview 11)*

> *"They wanted to communicate publicly because they had a social political, philosophical point of view that you know, science could contribute to a better world and a different world." (Interview 22)*

One of the interviewees mentioned *"the survival of science itself"* (Interview 26) as a stronger motivation for scientists' engagement in communication. In the sense that researchers want to be involved in science communication to promote science, its benefits and the importance of scientific work. On the other hand, another interviewee mentions the willingness to share *"their wonder, their curiosity about science"* (Interview 22) as the main incentive for scientists.

> *"A very important motivation that we have today among scientists is the survival of science itself. I think they realize that society don't' know the importance of science or the type of work they do" (Interview 26)*

Along the interviews there are some mentions to science communication as a contribution to *"democracy"* (e.g., Interviews 1, 3, 15) or a *"justice activity"* (e.g.,

Interview 8). For example, one of the interviewees considers that one stronger incentive for scientists to communicate science is that *"their inputs are needed in order to build society"* (Interview 15).

> *"they have a role beyond just the ivory tower academic pure knowledge environment and that they have something to say in how society develops as a whole, and that society as whole impacts how they work." (Interview 15)*

Most of this mentions are related to democracy relate scientists' contribution *"to science-related political debates"* (e.g., Interviews 3, 7, 11), "*to inform people in making better decisions"* (e.g., Interview 1, 7, 9, 11) as a major incentive.

> *"The other one is about how information influences decision making and policy processes and democratic processes, and this is very important but is way harder for scientists to get an awareness of the importance of these issues because traditionally politics and policy have always been sort of detached from science, artificially detached" (Interview 1)*

> *"They somehow feel that is an obligation for scientists to communicate with the public. That obligation is partly based on the idea that science is important for democracy, which means that they think that democratic dialogue and decision making will be improved when more it's either more evidence based or more scientists participate and so." (Interview 7)*

> *"Scientists also want to see the results of their research used in some way, whether it's to inform policy or to help people in making better decisions, so particularly in the applied science or the more applied scientists that I think is a driving force." (Interview 9)*

This idea of contributing to improve information in science-related issues also appears when some interviewees talk about *"raise awareness"* (e.g., Interview 21) of specific topics such *"environment"* (e.g., Interview 4), *"climate change"* (e.g., Interview 22) or even about the *"need for funding or need for investment in research"* (Interview 21). Also some interviewees mention the need to *"defend science"* (e.g., Interviews 7, 18) against misunderstandings, false facts or misconceptions as a strong incentive for scientists to engage in science communication.

> *"So, when there is controversy about science in the news or science is disregarded as fake or biased then, at least the scientists we talked to, they feel urged to do something about it to counter that" (Interview 7)*

> *"Starting about 10 or 15 years ago, there was much more recognition about the climate change problem or about the autism problem or about genetically modified foods issues and so the incentive to say, "it's my science being attacked" became more widespread, it wasn't just the evolutionary biologists, it was the climate change scientists and everybody else. So, there was an*

incentive of "I see a problem, I need to address it", and I think that has also changed as I said, in the last 10 years 15 years." (Interview 18)

"they realize that they need to do this to raise awareness about the need for funding, for investment irresearch, […] we have very low funding, so this is very important motivator." (Interview 21)

There are some mentions to scientists' willingness to contribute to *"increase scientific culture"* (e.g., Interview), to *"improve science education"* (e.g., Interview), to *"raise scientific literacy"* (e.g., Interview 5), to *"increase citizen knowledge"* (e.g., Interview 7) or to *"improve citizen understanding"* (e.g., Interview 24) as a major incentive for researchers' involvement in science communication. Additionally, one interviewee mentions *"open science to everybody"* and *"giving knowledge to everybody"* (Interview 8).

"But they are also very concern with the social impact of their research and I would say maybe as a third reason is their sense of a mission, a bit like the third mission of the universities, this idea of contributing back to society in terms of raising scientific literacy, raising a positive attitude of citizens towards science." (Interview 5)

"Another [incentive] should be also to interact with society so society understands what they are doing and they also understand the impact of their work in the society" (Interview 15)

Also one of the interviewees (Interview 20) mentioned that scientists engage in science communication to promote a real perceptions of researchers. And another one considers as an incentive for scientists the willingness to *"make people enthusiastic about science"* (Interview 7).

"they feel it's important that the public have a better understanding of what scientists are like" (Interview 20)

During the interviews we found several references (N=5) to scientists' interest in promoting scientific vocations as a key incentive to engage in science communication. Interviewees specifically mention *"attract new scientists"* (e.g., Interview 2), *"attract new people for science"* (e.g., Interviews 2, 18), *"encourage more students to take STEM subjects"* (e.g., Interview 21), being a *"role model to inspire young people to become a scientist"* (e.g., Interview 11) or *"to contribute to the development of interest in studying scientific subjects and taking up science careers"* (e.g., Interview 22)

"Many scientists […] are specifically motivated by the idea of being a role model, they feel that they want to inspire young people to become scientists, especially the black scientists and specially the female black scientists. They know that we are very too far too few black women in science so, if you are a young black female in science that's a big incentive for you to go out to communities." (Interview 11)

"They want to encourage more students to take a STEM subjects. […] Right now there needs to be more science students but more of so, we need more ICT and Engineering, ICT and Engineering, a lot of students are shifting to more vocational studies and that's worrying some academics over here" (Interview 21)

As we have seen, there are slightly differences in motivations or incentives to engage scientists in science communication. However, we grouped all this references in the same category because all of them are scientists' responses to a commitment that they feel to have with society. Thus, the common meaning of all these variety of incentives is the conception of science (and its production) as a social commitment.

5.1.1.2 To get personal or professional benefit

In 15 of the 26 interviews we there were mentions to get some kind of professional or personal benefit as an incentive for scientists to engage in science communication. Thus, in this category we have included all interviewees references to these benefits, for example to attract funding or scientific collaborations, to reach a broader audience, to convince strategic publics or to enjoy themselves.

Perhaps, the most representative quote of this category is the one from interviewee 11 when says that scientists only engage in science communication when *"they could see concrete benefits for them"* (Interview 11):

"Just when scientists perceive that they could see concrete benefits for them, so they want a higher profile, they want to recruit students, they see that their funder is asking so they strategically, because it would be better for their evaluation, actually include SciCom, so they do it with a very strategic objective in mind and they are looking for concrete benefits." (Interview 11)

During the interviews, we found several references (N=10) to scientists' interest to attract a wider attention to their own research or to get social recognition as a key incentive to engage in science communication. For example, some interviewees consider that appear in the public sphere through mass media or social media makes scientists and scientists' production *"acquire a bigger audience"* (e.g., Interview 1) and, therefore *"more people would read their papers, think about their ideas and respond to those ideas"* (e.g., Interview 3).

"If you think not only on publishing your paper in a specialised research journal but you are also trying to disseminate this widely, even from an intuitive stand point, it makes sense that it would be more attention to your paper, just because you acquire a bigger audience. Just speaking from this point of view of the formalised metrics you are already gaining benefit as a scientist if you are attracting more attention." (Interview 1)

"Direct communication with the public using for example Twitter, which is the one they certainly were preferring, was a way to somehow talking directly to the media or to journalists, so to have

your work recognized immediately by a public sphere and in this sense, you know, you have yourself recognized" (Interview 10)

However, other interviewees talk about just gaining recognition as the main incentive for researchers to engage in science communication. Specifically interviewees menioned *"put their own research on the map"* (e.g., Interview 5), *"to become known"* (e.g., Interview 15), *"broadcast their work"* (e.g., Interview 20), *"to position yourself publicly in a much more popular way"* (e.g., Interview 24), *"that people know more about the science they do"* (e.g., Interview 26) or "*to tell people how great they are"* (e.g., Interview 20) as scientists' motivations, specially for younguest ones (e.g., Interview 3, 10, 18).

"There are many more young scientists for whom having a public presence just seems natural and I attribute a little bit of that to social media, and Facebook, I mean is just sort of having yourself be out in public so that more people know about you is a much more common thing now than it used to be." (Interview 18)

Another one of the most mentioned incentives has been to attract funding (N=9). Some interviewees mentioned it as a *"primary purpose for researchers"* (e.g., Interview 9) or a *"need for scientists"* (e.g., Interview 21) and other ones as an institutional strategy to fundraising for research (e.g., Interview 1, 10). One interviewee specifically mentioned that *"those groups that are really competitive and get funding calls are also the ones that best communicate, so there is also a cause and effect relationship"* (Interview 24).

"Financial reasons, attracting funding also requires being able to publicise what you do. Essentially fundraising for research requires publicising your own work, being able to do so in simple terms, because funding bodies they also monitor media, they monitor what's going on around the world. Whenever I talk to scientists I try to imagine situations, imagine you are writing a grant proposal, so it's very nice for a reviewer to read your grant proposal but it's even nicer if at the same time he is seeing your face on TV and realising "oh! this research is actually quite famous". It will influence his behaviour whenever it is for the good or for the bad" (Interview 1)

"It could also be funding that they think that by being in the media and by having a higher profile on social media they are more likely to attract funding" (Interview 11)

Also, some interviewees consider attracting scientific collaboration (Interview 3), *"recruit students"* (Interview 11) or attract people as subject of study for your research (Interview 9) as incentives for researchers to engage in science communication activities.

"We've had instances where scientists who put out a media release, they've been reported in the paper and the next day their phone has rang and it has been not a member of the public but another scientist who want to have a meeting with them to discuss some possible collaboration, so I thing that's a further incentive" (Interview 3)

"Some scientists particularly medical researchers need people involved in their research and so they would then of course need to communicate" (Interview 9)

But we also found mentions to *"get feedback from the people"* (e.g., Interview 16) or *"give them new research ideas"* (e.g., Interview 11) as an example of benefits or *"unexpected benefits"* (e.g., Interview 11) that scientists' can get from participating in science communication. This could be also considered as an incentive for them.

"They do find that they get unexpected benefits that they never thought of before in the sense that somebody in the audience might ask a question that really made them think about their own research and even give them ideas for their research" (Interview 11)

"it is very rewarding for them to do science communication with audiences to get that feedback from the people on the importance and impact of their work for society" (Interview 16)

Two interviewees mentioned that scientists engage in science communication because they *"find it very enjoyable"* (Interview 11) or they *"love science and talking about science"* (Interview 18). Thus, scientists are getting some kind of personal satisfaction or reward by engaging in science communication. Finally, one interviewee summarizes different personal rewards for scientists even "*be better prepared for grants"* (Interview 14):

"Scientists themselves feel they gain something, and that they gain either from having their work being acknowledged or they feel fulfilled that others also find their subject exciting or they sometimes also mentioned things that, participating in this type of science communication activities helps them organize their own thoughts and be better prepared for grants or whatever" (Interview 14)

As we can see, there are many incentives in this category and despite some of them are really different all have in common this idea of rewarding, having potential benefit or *"gaining something"* (Interview 14) for scientists doing science communication.

5.1.1.3 As part of researchers' job

During the interviews, incentives for scientists to engage in science communication as part of their job where mentioned (N=9). Thus, in this category we included all references to scientists' motivations to consider science communication as part of the researchers' job; because it is included as a mandatory issue in research project, because it is a criterion of funding bodies or because it is promoted by their research institution.

In this regard, one of the interviewees mentioned science communication as a *"natural pathway for scientists"* (Interview 24) because science community only considers that something is scientific *"when you communicate your results, when you publish them in a peer review journal or in a conference"*. Similarly, another interviewee mentioned that it *"is considered to be as scientists' work"* (Interview 16).

Additionally, most of the interviewees (N=8) consider science communication specifically demanded in specific calls or grants as a major incentive for researchers. There are some mentions to specific calls for science communication activities performed by scientists (e.g., Interviews 6, 23), for example:

> *"This agency fund science projects and they have a dedicated budget for what they call EPE, Education and Public Engagement. So, from that section of funding that comes, scientists would get funded for communicating their work. That is an incentive for them to do so, one of the main ones." (Interview 6)*

> *"We've had research funding in particular, the research funding that goes to institutions, has an obligation of SciCom attached to it, so research units are evaluated, why the kind of SciCom, the amount, the quality that they do, and there are financial incentives for that of course, and also individual terms, also in research projects some calls for research projects have designated 15% of the budget for SciCom" (Interview 23)*

But most of the mentions referred to general research funding calls where science communication is a criterion for evaluation (e.g., Interviews 8, 12, 14, 18, 26). Some of the interviewees specifically mention the inclusion of science communication in grants as an *"obligation"* (e.g., Interviews 8, 23, 26) for scientists to be involved.

> *"Science communication and public engagement is built into a lot of the structures around funding and impact and whether you end up getting grants, […] so I think for scientists, they almost have to do it otherwise they are not going to get money, and money is a really good incentive for everyone beyond this of being, well good for other things I guess." (Interview 8)*

> *"It already appears in European projects, it is mandatory in your project to have a part devoted to science communication, you have to communicate at different levels the project for which they receive funds." (Interview 12)*

However, one of the interviewees doubts if this incentive is really effective or it is something that is written in the proposal but that is not done afterwards or, is not really considered important:

> *"There is an incentive in the sense that more and more grant applications have this aspect of dissemination and science communication, so at least at the time they are writing the grant proposals, scientists are considering this and thinking that they would have to do something, so there is the incentive in the grants applications to at least consider this option. I have this idea that sometimes this is considered, at the time of application, not so much during the project but this would really depend on the researchers, I*

think some of them do take this seriously, for some of them is just a few lines in the application" (Interview 14)

Also, some interviewees mention science communication activities as an *"impact measurement"* (e.g., Interviews 4, 8, 18), thus being involved in such activities could be an incentive for scientists.

"One way of showing you have had impact is to say that you have been out there talking to people and communicating what you do" (Interview 4)

"There is a requirement that your grant proposals have to demonstrate what's called "broader impact", that's the name of the requirement. And broader impacts don't have to be public communication, they could be employment, or they could be economic impacts, but it's widely been understood that the easiest way to kind of demonstrate broader impacts is to do some science communication." (Interview 18)

Along the interviews, there were some mentions to institutional promotion of science communication as an incentive for researchers' engagement. For example, there were mentions regarding this involvement as a *"criteria for career promotion"* (e.g., Interview 4, 6, 20), *"formal recognition of their effort"* (e.g., 12) or as part of the *"mission of the institution"* (e.g., Interview 14).

"I guess, in a lot of ways, the evaluation, the impact reviews that happens now for scientists require that they build into their science, public engagement and science communication, so I think that is the biggest incentive perhaps that our scientists have" (Interview 6)

"There is a general incentive because the SciCom is understood as also a mission of the institutions, so this is always in the backgrounds. Of course, if you want to have, so people are expected to do this, and this is an incentive in that sense" (Interview 14)

"There's quite a lot of encouragement in institutions for scientists to do SciCom, so there is a sense in which it might be good for your career even in terms of the institution." (Interview 20)

As we have seen, all the references included in this category have slight differences but all the incentives mentioned in this section share a common meaning of being somehow included as part of researchers' work.

5.1.2 Scientists' barriers to engage in science communication

From the interviews we identified 5 groups of barriers affecting scientists' engagement in science communication. Table 4 summarizes the identified incentives, findings and frequencies from this dimension of study from all the interviews.

Identified barriers	Findings	Frequency
Lack of rewards or recognition	• Not included in formal evaluation of scientific careers • Not included in governments, institutions or project objectives • Not enough promoted by research institutions, funding bodies or government	18/26
Lack of time	• Excessive bureaucratic burden to get funds and projects • Competitiveness of science (publish or perish)	18/26
Lack of specialized training	• No formal training in science communication included in research degrees	12/26
Fear to be discredit by peers	• Fear to be considered less scientific • Have been considered less important	9/26
Fear to be misunderstood	• Fear that public misunderstood their messages • Fear that journalists or communicators missunderstood their messages	3/26

Table 4. Qualitative results of the "scientists' barriers to engage in science communication" dimension of study, analysed through categorization system.

5.1.2.1 Lack of rewards or recognition

During the interviews there were 18 mentions to lack of rewards or of recognition as a barrier for scientists' to engage in science communication. Some of them talked about *"not get rewarded for making part of science communication activities"* (e.g., Interviews 3, 7), *"lack of rewards for doing science communication"* (e.g., Interview 19) or directly mentioned that *"there are no incentive to motivate them"* (e.g., Interview 21) or that scientists' *"don't get credit for it"* (e.g., Interview 18) as the main barrier for scientists but without specifying what kind of rewards.

On the other hand, most of the interviewees who made references included in this category (N=13) specifically consider that the main hurdle is that science communication is not a criterion included for career promotion. Some of them suggest that such activities are not included *"in the recognition system of their institutions"* (e.g., Interview 9), *"in a formal recognition"* (e.g., Interview 12) or *"as part of a good scientific career"* (e.g., Interview 17).

> *"Researchers want to get promoted, they want to get appointed, they want to get additional funds and so that would put the efforts with the most likely to get promoted, and if you are not going to get promoted for talking to newspapers or going to public meetings, well science would shrug their shoulders." (Interview 3)*

> *"Now often people say of course I would like to talk to groups of citizens or I would like to go into public or into the city and contribute*

to local activities, to local projects but at the end of the day I'm only rewarded looking at the number of my publications, my citation index, the amount of new projects I acquired and the forth classical evaluator is the amount of PhD students you have supervised. Those four criteria are still the most prominent, so public engagement has not been part of that," (Interview 7)

"So, in general considering this fact I would say, they should have a clear idea of how, in formal terms, in terms of their career, it can be useful for them to engage in SciCom, especially for young students, researchers, because otherwise, they always feel that they are wasting time because it is not a knowledge in their curriculum" (Interview 12)

However, some of them (N=5) consider that science communication is starting to be included somehow in the evaluation but it still is a minor criterion. Thus, *"the criteria of publication, research, projects, money coming in, teaching and PhD supervision still are the higher priority"* (Interview 22). Even, one of them considers that *"there is a will from policy makers to include science communication as part of the evaluation as a researcher, but now it does not happen"* (Interview 5). For some interviewees this situation means that researchers *"don't' take it seriously"* (e.g., Interview 4)

"In terms of career progression, here […], university professors have to fulfil four areas where they have to work, so their evaluation takes into account research, education, management and what we call university extension where we include different things, so university extension could be outreach but it could also be of technology transfer, it depends, and here it would be taken into account. How much this components weight in the total evaluation depends on different institutions, not all the institutions have the same formula let's say for calculating this, but this would be taken into account for that." (Interview 14)

"The university teaching careers, which most researchers are, does have a system of evaluation that comprises science communication or outreach and of course, it's one of the most minor issues because they are evaluated for their teaching, they are evaluated for their research and publication and to a much lesser degree, for science outreach." (Interview 23)

Moreover, some interviewees referred to a lack of institutional *"commitment"* (e.g., Interview 5) or *"support"* (e.g., Interviews 9, 10) as an important barrier for scientists' to engage in science communication.

"There is also a need from organizations who engage the people with science to provide the researchers with opportunities and platforms for them to communicate. I would say that it is an obstacle for a researcher per se to engage in SciCom outside the policy of his or her institution if you don't have a place to do it, you cannot just go in the streets and start doing your SciCom, you have to be invited, you have to be part of a projec" (Interview 5)

"There should be more support at the level of the institution, otherwise it is only at the level of the person that has maybe a personal interest or see a personal advantage. So, I think that to promote this aspect, we should work more at the level of the institutions." (Interview 10)

There were also some mentions regarding the need of a *"governmental commitment"* (e.g., Interview 25), *"political support"* (e.g., Interview 5) towards science communication as a big issue which prevents scientists from devoting part of their time to the communication of science.

"If you don't have from the government a clear sign that that attitude is valued, and for the scientific institutions that stands is also valued in terms of the funding, in terms of the assessment of those institutions, in terms of the political support that the institution receives from providing that kind of service." (Interview 5)

Aligned with this idea of more structural support, both from the research institutions and the government, there are some references to the need of specific funding devoted to perform science communication activities. Some of them talked about *"specialized services available inside the institution"* (e.g., Interview 11) but others referred to the *"need of stable money sources"* (e.g., Interview 26) or the *"lack of stable funding"* (e.g., Interview 23) to perform science communication activities.

"Funding can be a barrier specially if you need specialized communication products to be developed etc., so that's why I think that it's a good idea if there can be specialized services available inside the institution. A researcher cannot do everything by their own" (Interview 11)

There are slightly differences in all references included in this category. However, all of them share the common meaning of a lack of formal recognition of scientific communication as part of the researchers' work and, therefore, of their career evaluation.

5.1.2.2 Lack of time

In 18 of the 26 interviews we have found mentions to the lack of time as the main barrier for researchers to engage in science communication. Most of the interviewees consider that scientists see science communication as an *"extra thing"* (e.g., Interview 6), a *"buzzing thing"* (e.g., Interview 19) or *"another job for them"* (e.g., Interview 3) that they have to do. In other words, *"science communication isn't the priority"* (e.g., Interviews 3, 20). For example, some interviewees defined researchers as *"busy"* (e.g., Interview 20), *"high pressed to time"* (e.g., Interview 9), *"overloaded"* (e.g., Interview 11) or *"drowned in work"* (e.g., Interview 26). Even, one of the interviewees said that "*researchers really struggle with work load and unless I can like give them payed time to do an activity they will not do it, even if they see it has enormous value"* (Interview 8).

"So for scientists then they would feel this is an extra thing they do maybe better for their career, profile for their institution, but it is no way an easy thing for them to do and I suppose it is two parts for that

because one is that if it is not part of their daily job it makes it more difficult for them to spend time doing communication work." (Interview 6)

Some interviewees (N=5) consider the *"excessive the bureaucratic burden"* (e.g., Interview 1) that scientists have to carry on them as one of the main barriers for researchers.

"The amount of bureaucracy, of reports, of things they have to do, is crazy, so a part is the lack of time because they dedicate themselves to bureaucracy things." (Interview 26)

Interviewees mentioned *"fight for funds"* (e.g., Interview 3), *"chasing grants"* (e.g., 20) or *"write reports"* (e.g., Interview 3, 16) as examples of this bureaucratic burden.

"Across Europe scientists are getting more and more busy that chasing grants is harder and harder, scientists are becoming more and more competitive and they can't buy baby a new frog unless they get back grants and that really is dominating everything" (Interview 20)

Also, there are mentions (N=5) to the *"competitiveness of scientific research"* (e.g., Interview 4) itself, or the *"competitive environment that scientists have to live in"* (e.g., Interview 14) not only for the search for funding above-mentioned but also due to the researchers' evaluation system and the *"publish or perish"* (e.g., Interview 26) dilemma.

"It's partly about time, it's partly about the intense competitiveness of scientific research and the increasing reliance on metrics, so measuring people's performance within science. And therefore, scientists being under more and more pressure to perform as scientists having to, you know, journal papers, get all the big grants, all the international conferences." (Interview 4)

"Research careers become very demanding in terms of what you should do and how much you should publish and how much money you should bring to the institution and so, this pressure for publishing and for getting money tends to detract people from wasting too much time doing science communication." (Interview 23)

One the other hand, one of the interviewees specifically mentioned that science communication itself is so time consuming by its own characteristics.

"Perhaps today the main barrier is that communication also needs a lot of time, it needs a lot of specialization, it also needs a lot of investment in self-training and not all scientists can evidently reconcile the two things." (Interview 24)

As we have seen, all references included in this category have in common the overwork of researchers and, therefore, the lack of time or the feeling of lack of time they have to devote to communicating science.

5.1.2.3 Lack of specialized training

During the interviews, 13 of 26 people considered the lack of specialized training in science communication to a broader audience as a barrier for scientists' to engage in. Some of them (N=7) consider that there is a lack of formal training in science communication skills during research careers.

> *"They are only taught to communicate with their peers and they do it in a close circuit and the professors and the people at the universities do not try to show them the importance of communicating with society, communicating with younger people, with older people, reaching some groups in society that do not know anything about science." (Interview 2)*

> *"They don't have a sophisticated understanding of the public, they think of science communication simply as a transmission of information from scientists to the public, they don't see that it's a relationship, they don't see that the public have good reason to doubt sometimes science and so the main barrier to doing good science communication is when scientists have not asked themselves what they think of the public, what they think about science, why they are doing this work, that's the main barrier for doing science communication." (Interview 20)*

> *"It is not yet part of the curricula in most cases, but it begins to form, even indirectly of the important curricula of the scientific world." (Interview 24)*

On the other hand, other interviewees (N=3) talk about a *"perceived lack of skills"* (e.g., Interview 7), *"the feeling of not having the right skills"* (e.g., Interview 9) or *"not feeling comfortable or with enough experience"* (e.g., Interview 26) as a barrier for scientists.

> *"I think also an important barrier is the perceived lack of skill, so many scientists have the feeling that they are not capable of communicating that science in public so it's difficult for them to communicate in a more, this is both like with one-way communication is difficult to communicate about their science in an accessible way, and also two-way it's difficult for them to have these conversations, that's what I also talked about, this negative feedback effect that they experience, they want to have respectful conversations but at the same time they don't feel respected as a scientist and they don't really know how to deal with that and they would rather stay away from the debate." (Interview 7)*

Is interesting to highlight that some interviewees (N=3) consider science communication as a tandem activity, where science communication *"professionals"* (e.g., Interviews 1, 9) or *"units"* (e.g., Interview 8) can *"help"* (e.g., Interview 16), *"assist"* (e.g., Interview 8) or *"support"* (e.g., Interview 9) scientists with their science communication activities.

"And another thing is probably having the skills to do it but I think we are quite lucky here at (UE?) because we've got a whole SciCom unit and team that kind of assist scientists with what they are doing and we have training course that people can attend" (Interview 8)

"A lot of them don't have the skills so they need that support to be able to do that, either through training or through professional Science Communicators to get that help to communicate in a timely way because time is a big pressure." (Interview 9)

"I think they also need help from scientific communicators, also having a set of science communicators to help them out, would be nice, because not all research institutes and universities have SciCom offices and it really makes a difference." (Interview 16)

5.1.2.4 Fear to be discredit by peers

Along the interviews there were 9 references to the fear to be discredit by peers as a barrier for researchers' to engage in science communication. For example, some interviewees talked about *"being mocked by colleagues"* (e.g., Interview 3) or *"not beeing taken seriously if they are too much time in the public eye"* (e.g., Interview 11).

"They can be mocked by the colleagues, you know, the failing is "you're not a serious scientist, you are just trying to be a media star" and so, it's not always a constructive environment, and they don't always get a welcoming view with the colleagues who are trying to go out and communicate" (Interview 3)

"Then we still find that scientists are concern about the norms of science, in other words, what would my colleague say, would they think that I'm out there promoting myself you know, would they take me seriously if I'm spending too much time on working at a science festival or speaking at to children or whatever. So, you know that whole spillover effect of what was known as the 'Sagan effect'." (Interview 11)

However, other interviewees mentioned this fear as a self-perception of individuals not as something that is actually happening in scientific community.

"They consider that doing science communication probably lowers their value. It is in their minds, but they don't want to do it then" (Interview 6)

"Also in all the generations there is a perception that science communication is a minor task that good researcher, excellent researchers cannot spend too much time on that and so, that may work as a disincentive for some" (Interview 23)

In this regard, two interviewees referred to this fear as an *"attitude among senior scientists that is not appropriate for scientists to engage in science communication"*

(e.g., Interview 18) or as *"ssomething that years ago, at the beginning of scientific communication, was frowned upon by colleagues"* (e.g., Interview 24).

> *"This, sometimes this is called "the Carl Sagan effect", where he was literally prevented from being a member of the National Academy of Sciences because people were jealous of his public profile. So, you know that attitude is certainly there, I think is going down, I don't think it's as prominent of a barrier as it used to be but is certainly still there, to some extent. At least among senior scientists" (Interview 18)*

One interviewee, also add the gender dimension to this fear:

> *"There'll be other things as well, I like for instance, we might think a bit about the role of social media which in some ways makes it easier to scientists to reach out but as in all walks of life you put yourself out there in social media and you shut down. So, there's been cases in this country of female academics, particularly female academics, who appear on the media and there's blast and mounts of nasty social media responses to that. And I think all the obstacles that come even more acute for women who already, in some ways, that's the disadvantage within science because of maybe needing career breaks or just being in very male-dominated environment. So for woman to make that step, that seems to be a step out of science in doing more communication, they are more likely to suffer from or feel they might be vulnerable to losing some sort of status within the science because they are seen as doing something that is separate from the science, because it is seen as being separate from the science" (Interview 4)*

As we have seen, all these reference have in common the fear of beeing discredit by colleagues and the scientific community because of their science communication engagement.

5.1.2.4 Fear to be misunderstood

Another fear has been categorized as a barrier for scientists to engage in science communication by three interviewees: the fear that public misunderstood their messages or that journalists *"misquoted"* (e.g., Interview 3) them.

> *"They don't feel confident in standing in front of audiences and talking them about their work, maybe being misunderstood, maybe being misquoted by journalists and so they see problems there" (Interview 3)*

> *"I think sometimes scientists probably don't want to talk to some, at least some communicators, because they are worried about how they would be represented to the public, how public is going to understand what they are going to say. They feel that they are not in control of that representation" (Interview 8)*

> *"I think it scares them because No. 1, they are afraid of being misinterpreted or misunderstood and No. 2, they are shy, you know*

they just don't feel comfortable communicating to sort of non-initiates" (Interview 15)

5.2 Professional engagement in science communication

In the following section we summarize all the results of the qualitative analysis of the interviews on the incentives and hurdles that communicators have to dedicate themselves professionally to science communication. The results are contrasted with the contributions of online workshop participants.

5.2.1 Communicators' incentives to engage in science communication

From the interviews we identified 3 groups of incentives for to engage in science communication professionally. Table 5 summarizes the identified incentives, findings and frequencies from this dimension of study from all the interviews.

Identified incentives	Findings	Frequency
As a response to new specialized positions	• New job possitions related with sicence communication • New job possitions as a response to the communication/journalism changing world • Alternative job possitions for researchers	14/26
To fulfil a personal interest or curiosity	• See science as a challengin and stimulating topic • Learning new things every day • Get personal satisfaction	11/26
As a social responsibility	• To defend science • To increase public knowledge • To help people make decisions • To be a facilitator in scientists and non-scientists dialogues	10/26

Table 5. Qualitative results of the "communicators' incentives to engage in science communication" dimension of study, analysed through categorization system.

5.2.1.1 As a response to new specialized positions

During the interviews, 14 people mentioned the offer of new job positions related to science communication as a main incentive for communicators. There were several mentions (N=6) to changes in the communication world that ended up with new job opportunities. For example, interviewees referred to *"many opportunities for communicators"* (e.g., Interview 12) to be involved in science communication or to *"a system where science communication is actually thought as a key aspect of research, so universities and research centres are promoting hiring"* (e.g., Interview 14). Thus, there is a common thought where this new communication situation offers specialized job opportunities in science communication.

"Now we need people to do this full-time and so there are universities with open positions to hire people to do SciCom full time and to fully dedicate themselves to it" (Interview 16)

"Communication world gives many professional opportunities and is an incentive because there are new job positions, you don't have to think only of writing in a newspaper, there are professional opportunities to maintain a website, maintain a blog, maintain a community manager, do news impact analysis studies, in short, there are many specializations in science communication that can be done" (Interview 24)

"The biggest incentive is the network of new paths of specialization in scientific communication demanded by universities, museums, municipalities, etc.." (Interview 26)

Also, one interviewee mentioned the highest potential of science communication through social media and how this opens new specialized job positions into the market as an incentive for communicators to engage in science communication:

"I think that maybe with the new media like the social media and so on, they might be opening some new opportunities because I think it's not the same to work with the social media, to work with the general media or to work as a public relations in general. And so, I think there are some opportunities coming from those new sectors, thinking about the social media side. In the social media, I think there are more questions on how to communicate, how to be effective in social media, how to balance these problems of polarization, of fake news and so I think that there might need really professional figures, similarly probably to a science journalis" (Interview 10)

In addition to these mentions of new more general work positions, we have found 4 specific mentions along the interviews to the figure of the *"communication officer"* (e.g., Interviews 5, 18). Other interviewees referred to the same position under different labels such as *"professional communicators inside institutions to assists scientists"* (e.g., Interview 11), *"public information officers"* (e.g., Interview 12) or *"people who work for research centres"* (e.g., Interview 18).

"There are cases where outside these projects, where you can have a contract with an institution where you can perform SciCom only. This is the case exactly of what we started by talking of this communication Officers, these group of Communication Officers is growing. I would say that now […] it is very difficult to find scientific institutions or a university department that does not have a permanent cabinet office in which people can be seen as Science Communication officers. And they are a bit a combination of Science Communication and public relations, so in this mix it is possible to have a stable career doing SciCom" (Interview 5)

"There are a lot of opportunities to become public information officers in different institutions such universitie or, research centers or to be employed in publishing stuff, for scientific publishers at an educational level for instance, for high schools, these publishing houses we are realizing need a lot of authors to update the books in

physics, mathematics, biology, directed to high school students for instance." (Interview 12)

"That was also the time that I think we got the growth of this separate SciCom world where there were people who never wanted to be journalists, they just wanted to communicate science and those were the people who worked for science centers, they organize science festivals, they may write for media outlets but they think of themselves as being science first and not media first" (Interview 18)

There were also some references (N=3) to these new positions as science communicator professional as an alternative to a research career. For example, one interviewee mentioned that *"there is a personal intrinsic incentive, and is the question "I can still be contributing to science even without being a researcher?""* (e.g., Interview 18). And another one claims that *"many communicators have PhD in science and then with these opportunities decide to move on science communication"* (e.g., Interview 23)

Beside this, 2 inerviewees added the gender dimension to this view. They claim that this offer of new job possitions devoted to science communication are specially atractive for women due to the *"stability"* (e.g., Interviews 18, 23) , *"less working hours"* (e.g., Interview 18) and *"less travel demands"* (e.g., Interview 23).

"This is particularly true for women, for women who either faced barriers because of sexism or who were making positive choices that said "I like working with people more than I like working at the bench", or "a science communication career is easier if I want to have a family and I have to be the one, in a traditional…", and again, for all that we would like to be modern, there are still some traditional roles that men and women play. And so for women who say "I want to be at home with my children, I don't want to work full-time, I don't want to have to spend 25 hours a day in the laboratory or stay there overnight watching my tests", or "I don't want to go out into the field", for women it became a positive choice, that this is something they could do. So that was an incentive as well." (Interview 18)

"Science communication it is a career that is perhaps less demanding, more stable with more regular hours and that it's why I also think it attracts a lot of women, because that's more predictable than when you have to feed the laboratory mice on Sunday or do experiments throughout the night or things like that. It also demands less travel which, scientists nowadays have to travel a lot so, science communicators have more stable and predictable lives I think, I think that is an incentive to choose this path" (Interview 23)

5.2.1.2 To fulfil a personal interest or curiosity

10 of the 26 interviewees consider having a personal interest or a personal curiosity for science related issues as an incentive to engage in science communication as a professional career. In the case of science journalism, some interviewees mentioned that *"is more interesting"* (e.g., Interviews 2, 4, 15, 18) because you *"are always learning*

new things" (e.g., Interview 2), you can write about many different things (e.g., Interviews 18, 24) or to fulfil your own curiosity (e.g., Interview 22).

> *"The incentives for the journalists are, science has a great story, you know, there are a lot a great stories there and there were always new stories." (Interview 18)*

> *"People are innately curious, and science is driven by curiosity and science raises many more questions than it answers which stimulates curiosity and you know, that's a good reason at least if not a compelling prescription, it's a good reason to be more engaged with science" (Interview 22)*

Also, there were some mentions to *"passion for science",* (e.g., Interviews 4, 8) "*love science"* (e.g., Interview 2), *"enjoy science"* (e.g., Interview 5), enjoy *"sharing knowledge"* (e.g., Interview 5) even to see science as a *"thrilling and exciting world"* (e.g., Interview 26) as incentives to engage in science communication as a profession.

> *"We are doing that, we are doing that because we love what we do, I was a Science Journalist, I love to transmit science to the public but there are really no incentives for people to do this." (Interview 2)*

> *"They are science fans and because they like science,..., they have become sport journalists because they like sports so much and science journalists have the same, many of them just like science very much maybe they have been in science but maybe moved out but they still are here very strong into the scientific view and they want to communicate that and they want to make people enthusiastic about science to share the amazing stories about science." (Interview 7)*

On the other hand, some interviewees mentioned *"the importance of talking about science"* (e.g., Interview 8) or the feeling of *"making a difference"* (e.g., Interviews 9, 11) and *"helping people"* (e.g., Interview 9) as examples of the *"satisfaction"* (e.g., Interviews 11, 15, 17) that people can have when works as a communication professional.

> *"I think the satisfaction of meaningful science communication, you know really making a difference in people's lives adding to the impact of the research I think that's a big incentive that makes it worthwhile for professional communicators, the fact that they can also see that it makes a difference" (Interview 11)*

> *"You are taking something that has a certain level of complexity and you are sort of untying some of the nods, so the structure becomes clear for people. You ask about incentives well, for me as a communicator there is an enormous sense of satisfaction in doing that. It's sort of what we are born to do." (Interview 15)*

5.2.1.3 As a social responsibility

Finally, 10 out of 26 interviewees consider science communication as a social responsibility, something that by itself can be considered as an incentive to engage

professionally in this field. For example, we have some mentions to *"defend science against misconseptions"* (e.g., Interview 7*), "use science as a tool for truth checking and fact checking"* (e.g., Interview 14) or *"to combat fake news"* (e.g., Interviews 14 15) as examples of services to society and incentives to become a science communication professional.

> *"We are in a time where everybody is discussing these fake-news environment, I think scientific institutions should assume a role within their limits and I think this is important, I think science would do a best service to society and journalists if it goes beyond the limits where science say that you can give answers" (Interview 14)*

Along the interviews we have found references to *"increase public knowledge"* (e.g., Interview 7, 17, 22), *"help people understand"* (e.g., Interview 15) also as an example of a social responsibility to engage in science communication. Similarly, some interviewees referred to *"make a difference"* (e.g., Interview 9) in peoples' life or "*help people to make decisions"* (e.g., Interview 15) as an incentive for communicators.

> *"They see science as a pathway to making a difference to the big problems in society such as climate change, such as increasing degradation of our natural environments, such as medical issues and public health and so on. So, they see science communication as a broker role to generally make a difference to people's lives and the environment which they live. I think for most that would be a huge incentive because it's not a particularly well-paid profession and most of this can get a lot more Money doing something else." (Interview 9)*

> *"That's my job, I represent as an interviewer, as a communication professional, I represent the interest of your fellow citizens" and they have a right to ask some of this hard questions, they can't necessarily ask you face to face so I'm going to do it on their behalf and that is also a biggest incentive for science communicators, that they should be this kind of in-depth probing questioning." (Interview 17)*

Also, two interviewees mention *"help scientists tell stories"* (e.g., Interview 3) or *"being a facilitator in scientists and non-scientists dialogues"* (e.g., Interview 11) as an incentive to dedicate themselves to science communication. Even one of them considers science communication profession as a *"social benefit"* (Interview 11).

> *"I could help scientists tell the stories, I could rehearse scientists in the way they tell the stories that ordinary people could understand, I could help scientists focus on the main thing that the public is interested in, and the public is interested in not the methods the scientists use but they were interested on how the science would change their lives, how would benefit them as a member of the public, so I would rehearse the scientists in the ways they should tell a story to make the interest of the public." (Interview 3)*

As we have seen, there are slightly differences between all these references but all of them share the idea of fulfil a social responsibility as an incentive to engage in science communication.

5.2.2 Communicators' barriers to engage in science communication

From the interviews we identified 3 groups of barriers affecting communicators' engagement to become a science communication professional. Table 6, summarizes the identified incentives, findings and frequencies from this dimension of study from all the interviews.

Identified barriers	Findings	Frequency
Lack of resources	• Lack of economic resources • Lack of time • Lack of stable job positions (especially in journalism)	16/26
Lack of specialized knowledge	• Lack of scientific knowledge • Lack of knowledge on the social relevance of science • Impostor syndrome for non-scientists performing science communication • Lak of knowledge on how to do efficient science communication	16/26
Lack of strategic support	• Lack of support from research institutions • Lack of support from mass media • Lack of support from governments	15/26

Table 6. Qualitative results of the "communicators' barriers to engage in science communication" dimension of study, analysed through categorization system.

5.2.2.1 Lack of resources

During the interviews 16 of 26 interviewees referred to some kind of lack of resources as a main barrier to engage in science communication as a professional. The most widespread is the lack of funding (N=11) specially devoted to science communication. There were some general references to this *"lack of economic resources"* (e.g., Interview 26), the *"scarcity of resources*" (e.g., Interview 12), the *"lack of funding"* (e.g., Interview 23) or to science communication as a *"poorly economicaly valued profession"* (e.g., Interview 25) but also there were some specific references. For example, there were mentions to the lack of funding to perform *"specific science communication activities inside a research institution"* (e.g., Interview 1) or *"participatory science communication activities"* (e.g., Interview 9). This could be interpreted as a barrier to properly develop science communication.

> *"Research institutions don't have the resources to do innovative SciCom which means, I mean, the participatory example I gave you before is a very expensive SciCom exercise and quite a risky exercise. So, we need scientific institutions and governments willing to put resources in, so that professional Science Communicators can do SciCom in a different way, in a way that is more participatory, more democratic in its approach to SciCom." (Interview 9)*

Again, along the interviews appears the lack of governmental investment in science communication as a barrier (e.g., Interviews 9, 15, 16)

"We need financial incentives because is super important to have professional science communicators and you can do that only if you invest in it. So that is really really important because then you can better help to build the bridges between the scientists and the community which is the main job of a science communicator." (Interview 16)

But there were also some interviewees that consider that is difficult to get paid to only dedicate professionally to science communication (e.g., Interview 5, 15, 17, 19, 24).

"Science communication grew a lot here but again, you don't see a professional community of science communicators who are able to live only from science communication. So, what you have here in is more of a combination between, you are at the same time a Science Communicator and academic and a researcher, you wouldn't be able to live, there are 2 or 3 exceptions of course, but you wouldn't be able to live professionally only from science communication" (Interview 5)

"It's always about resources, because it's very challenging if you are just a young Science communicator and if you are trying to find a proper job, you should monitor, you should evaluate your financial stability, financial backgrounds, because there are some models you can work for a university, you are going to work for some media because it's, actually it's really hard to work in Science magazines these days" (Interview 19)

Many of these interviewees referred to the *"lack of positions in journalism"* (e.g., Interviews 2, 3, 5, 10, 12, 18, 24) as a key and broader barrier to dedicate professionally to science journalism.

"The newsrooms are getting shorter and shorter and shorter, and now in Portugal we only have a handful of Science Journalists. We don't have any Science Journalist in the radio or in the. There is no journalist who is doing science on a daily basis in television or radio. We only have a few journalists that work in newspapers and in magazines, that's all" (Interview 2)

"For journalists I think getting funding, or to enter in some editorial staff but the positions of a staff is very limited and most of the journalists we are working with, they are freelancers, so there is an urgency of, of course, getting funds. And also of somehow regulating the position with the editors because somehow they really feel the pressure of deadlines and so on" (Interview 10)

There were also specific mentions to the *"financial crisis in journalism"* (e.g., Interview 3) *"journalism crisis"* (e.g., Interviews 5, 12) and *"changes in the communication world"* (e.g., Interviews 3, 7, 24) as main barriers to become a science communication.

"Traditional media are declining, a lot of the advertisement money is going to the digital platforms and not to the media organizations, behind it, the journalists. Also you see a trend that instead of big editorial offices or editorial boards at these media organizations, they work with small internal editorial office and large pool of freelancers that are payed per job that they do or per article that they write or video that they make or whatever, so I think that a lot of their work is in some way unpaid or not payed enough, so I think this is an important barrier." (Interview 7)

"The main problem is related to I think, to financial difficulties because for instance, the traditional job of Science Communicator or Science Journalists suffer the same difficulties that all journalism is suffering." (Interview 12)

Again, many of these interviewees considered that this changes in how communication works nowadays has led to structural changes in communication demands. For example, some interviewees talked about *"communicators having to adapt all the time to new circumstances"* (e.g., Interview 3), communicators being *"forced to be an orchestra-man"* (e.g., Interview 18) or *"having to do many different things"* (e.g., Interview 7) to *"survive as science communicators"* (e.g., Interview 16).

"Communication is changing I think very quickly, every year something new, something different and so, communicators need to be adapting all the time to new circumstances, so maybe this year they are doing interviews or making videos on the smartphone and editing them, last year they were doing stuff for the web, next year they might be writing blogs and so on. They have to have so many different skills just to keep up with the rapidly changing pace of communication." (Interview 3)

"Asking for science journalists to also play new roles in how the political debate about science, like for example in the case of climate change evolves. Of course, if they want to play that new role, they also have to balance it with their commercial reality that they face, so I think that's an important barrier because you have to do many different things, and you have to do all of them well" (Interview 7)

"If you actually get a job in the media today, you are going to be expected to produce at least three stories a day and take your own video and respond to emails and tweet what you are doing, you know, all those things don't go together well. You can't do really good reporting and background and such at the same time that you have to produce so much work. So that I think is a real barrier in the journalism world. You are forced to be an orchestra-man!" (Interview 18)

All this implies a "*lack of time*" (e.g., Interview 19) as a barrier to properly develop science communication which can also be seen as a barrier for communicators. We also found interesting to highlight one interviewee reflection about the power or the

importance of building a community of professional science communication to improve or try to overcome all the above mentioned barriers:

> *"We believe that associating science communicators is very important because science communicators are very much alone in their institutions, they are a group of 1, 2, 3 and then if we get together nationally, we then understand what are our problems and what are our needs and we can understand better what can we do collectively. So, associating each other and talking to each other and trying to find collective solutions is a way that I think is interesting and perhaps the only way to survive as science communicators" (Interview 16)*

5.2.2.2 Lack of specialized knowledge

During the interviews, 16 people considers the lack of specialized knowledge as a barrier to engage in science communication professionally. There are some mentions to a *"lack of specialized knowledge"* (e.g., Interview 26) in general but most of them specifically referred to scientific knowledge or particularities of science. For example, some interviewees referred to the scientific language as *"inaccessible"* (e.g., Interview 8) or as a *"challenge"* (e.g., Interview 22). Also there were some mentions to the *"complexity of science"* (e.g., Interview 12) as barriers to engage in its communication as a profession for non-scientists.

> *"Probably, well science can be quite inaccessible in terms of the language that it uses and being very dense and so in the absence of things like press releases that will just spoon feed you what you need to know, people even if they have the inclination to go and do a bit more digging, that content might not be accessible to them." (Inerview 8)*

> *"there is some difficulties related to the complexity of science, because science, first of all, it is wrong to think science as something monolithic, because biotechnology is very different from theoretical physics, from archeology, so there are a general difficulties and intrinsic difficulties, which add another strong difficulty related with the media fragmentation of these times. I mean, a Science communicator beyond the others described before have to face the complexities of science and the media fragmentation." (Interview 12)*

> *"Because it's complex, it's not easy to understand, it's got specialists language, to read a scientific paper it's a big challenge for anybody who's not being educated in that mode. So, it is difficult, I mean, understanding how science is done and understanding the fruits and products of science is not easy so it's always tempting just to look the other way or look for somebody else to do you know" (Interview 22)*

But, there were also some references to the lack of knowledge of *"the social relevance of science"* (e.g., Interview 2) or *"how science is done"* (e.g. Interview 22) as main barriers for communicators to engage in science communication professionally.

"So, there's so many things that are happening in everyday life and in political life that have a scientific dimension that any journalist working in current affairs that's how we call it in English, is likely to have to deal with a scientific question sooner rather than later. So, why not we might say to them, why not dedicate some time during their training to understanding how science is done so that the next time a scientific question lands in front of you or a scientist offers an opinion on something that you are dealing with, you are able to make some better sense of it and just be completely passive and accept the wisdom of the authorities" (Interview 22)

4 interviewees mentioned a sort of fear to science as an important barrier. Specifically, they mention that non-scientists tend to view is as *"too difficult"* (e.g., Interview 4), *"too hard"* (e.g., Interview 15) or to be *"afraid of science"* (e.g., Interview 15, 21). Even one of them consider that non-scientists involved in science communication can have a *"sense of impostor syndrome"* (e.g., Interview 20).

"I suppose a journalist who hasn't had some sort of science background, I suppose that just think "oh that's just too difficult for me"" (Interview 4)

"That would be, I think the technical aspect of science, if they were afraid of science at school or they thought it was hard, and they don't really understand it, then it might be challenging for them." (Interview 21)

"So, these are likely to be humanities graduates, the main hurdle for them is they have been taught, they believe the propaganda that science is superior to the humanities and so they feel they can't get involved in science because they wouldn't know anything. That's the main hurdle, the main thing that everybody needs to learn is that science is just one, is just another form of culture, another form of knowledge." (Interview 20)

On the other hand, there were some mentions to the lack of knowledge of the *"science communication ecosystem"* on a huge variety of communication skills and competences (e.g., Interviews 7, 12, 16,) such as *"big data analysis"* (e.g., Interview 19). But also on *"how to evaluate science communication activities*" (e.g., Interview 13) and on how to perform efficient science communication (e.g., Interview 1) as barriers or disincentives to become a science communication professional.

"We don't know how to make our work more efficient, we are unable to assist or help scientists to make their work or make their science communication more efficient, this can be a disincentive" (Interview 1)

"I think it is partly related to skills and competences as well but professional science communicators need to have the skills to communicate better and more reflexively so that means taking the societal perspectives better into account, but skills and competences are of course something else than incentives but incentives, I would

say that you need incentives to make sure people develop those competences and also start working in that way." (Interview 7)

"But as long as we don't evaluate effectively what it is that we are doing, we are kind of walking in the blind, or walking in the dark rather, blind people walking in the dark and then if you have more people marching in the dark somewhere, that actually doesn't make a difference, it could only lead to people bouncing their heads off walls and pillars and get hurt whereas what matters would be to turn on the light a bit, illuminate the whole thing and then to guide those people in a certain direction which is a very tricky question because, who decides what good and bad communication is and why we should, is a very normative question, almost a political one" (Interview 13)

5.2.2.3 Lack of strategic support

15 of the 26 interviewees mentioned different kinds of strategic support (national, institutional, familiar etc.) as an important barrier for communicators to engage professionally with science communication. Most of the interviewees (N=11) made references to the lack of institutional support to science communication. For example, there were some mentions referring to the lack of structural support inside research institutions (e.g., Interviews 3, 5) but also inside mass media structures (e.g., Interview 10).

"Communicators are quite often not payed particularly well, quite often they are female rather than male, quite often they are junior staff rather than senior staff, quite often they are not respected by the management in an organization as they should be." (Interview 3)

"There you don't have the same treatment you know, from the editors or from the people that are asking the work, so they are a little bit I would say, frustrated, so if the whole work would be more regulated, maybe it would help them. I'm not sure what I mean with regulation myself, but the relationships are somehow there very difficult." (Interview 10)

Some interviewees mentioned this *"lack of institutional commitment"* (e.g., Interview 5) or *"lack of institutional recognition"* (e.g., Interview 9, 11, 15) to science communication in general. But, some of them specially referred to a *"lower status"* (e.g., Interview 18), a *"lack of respect"* (e.g., Interview 3), *"lack of recognition"* (e.g., Interview 3) as an example of this lack of institutional support.

"You are in a research institution, especially if you work for an university or an NGO or something like that, your status is lower, the money will go to the researchers rather than to the science communicators, so you might not have the resources you need." (Interview 18)

In the same regard, other interviewees consider the lack of stability of science communication as part of this lack of institutional support. For example, they mentioned that science communicators *"are not particularly well payed"* (e.g., Interview 3,6) or

that science communication is a *"very insecure job"* (e.g., Interview 6) because its funding is project-based or *"hired by scholarships"* (e.g., Interview 16).

> *"Thebig issue that emerges is that it is a very insecure job, because it is very project-based, there are no career advancement opportunities or very rare, for these professionals, and of course is a big issue for myself as someone who is running a master course, that we need to make sure there is a better career structure for them. […] But as a job itself it's not payed very well, certainly not in the beginning. And it seems finite, it seems project-based and not very sustainable. So, it's an issue that has emerged and certainly would be a major hurdle for Irish Science communicators." (Interview 6)*

> *"For many times, science communicators were hired with scholarships and now it's ending, they have to give contracts and contracts are more expensive so, becoming a science communicator when it was cheaper for institutions, they were more willing but now institutions have to ask themselves if they are willing to make the effort of spending, of investing money to hire professional science communicators" (Interview 16)*

Also, 5 interviewees mentioned that the figure of an institutional science communicator usually is beeing missinterpreted and ends devoted only to *"marketing purposes"* (e.g., Interviews 3, 7, 14, 16) or to *"people's awareness of the university"* (e.g., Interview 8) as a barrier to engage professionally in science communication and also as an example of this lack of institucional support. As example, we have these two quotes:

> *"I already talked about that with university, press officers, communication officers, the emphasis is more on marketing, on promoting science, I think you could also see that as a barrier, because it is understandable from the institutions point of view maybe but at the same time science marketing is not the kind of science communication that we need the most, so if you look at the more societal goals of increasing public knowledge, improving the role of the science in society, improving the democratic debate, then actually university marketing is maybe making the situation worse instead of better, because it shows that science also is guided by its own interest rather than working for the public good, so I think that's in some way also, a barrier." (Interview 7)*

> *"Many times the institutions want communicators just to do institutional communication, which is not science communication, science communication is not just selling your institutions, that's public relations and that's marketing, doing science communication is something else. So, it's a struggle and science communicators have to fight for themselves" (Interview 16)*

Moreover, 3 interviewees also referred scientists' actitudes as a barrier for science communciators and also as a symbol of the lack of institutional support. For example, they mention that *"some scientists who don't really want to take the time to talk you"*

(e.g., Interview 18), and this is *"especially hard for young science communicators"* (e.g., Interview 19).

> *"I think another barrier is probably scientists themselves, so again it is this issue of scientists having the time to sit down and explain stuff to people who need the information for an hour or whatever it is. I think scientists really struggle with finding an hour to be able to do it. And they are not as accessible as other kind of people in other professions, so I think that probably causes a bit of an issue as well but this structures, this communication duties should be promoted by the institution" (Interview 8)*

One interviewee referred to the lack of familiar and popular support to the figure of science communicator mainly due to the lack of knowledge of this specialization as a profession itself:

> *"As a technical communicator, even after decades of doing that work I have family members and friends who say "So, I still don't really get what it is that you do" and that's a problem, I mean, I think it's a minor problem but it is a problem for people to engage. […] We all like to be payed for doing our profession, the thing is, I think, the people who do this kind of work, it's kind of a humbling profession because the better we do the job the less obvious we are, so at some point, some sort of recognition not just inside our own profession but out in the world, would be nice, you know." (Interview 15)*

On the other hand, two the interviewees mentioned the lack of systematic governmental support as a barrier to engage professionally in science communication:

> *"Here is no, or very little, systematic support for science communication, so we don't get any government support really, especially for science communication. In a way sometimes systematic approach to science communication in a country or in a national / international level may be more important for providing the right incentives." (Interview 1)*

> *"If you don't have from the government a clear sign that that attitude is valued, and for the scientific institutions that stands is also valued in terms of the funding, in terms of the assessment of those institutions, in terms of the political support that the institution receives from providing that kind of service is difficult that you consider sicence communciation as a good profession." (Interview 5)*

As we have seen there are some differences in all the references included in this category but we decided to put them together due to the main common meaning of lack of strategic support as a barrier to be a science communicator professional.

6. Discussion and conclusions

6.1 Scientists' engagement in science communication

As we have seen, most interviewees consider that scientists' incentives to engage in science communication are related with a social commitment of science. For example, as payment to society, to inform society, to improve democracy, to defend science, to raise awareness, to increase scientific culture or to promote scientific vocations. On the other hand, along the interviews also raised incentives that see science communication as a strategy to get personal or professional benefit. For example, to attract funding or scientific collaborations, to convince strategic publics or to enjoy themselves. However, some of them consider that science communication is part of scientists' job because is included in their contracts, in their proposal, promoted by their institution or as a funding bodies criterion.

On the other hand, we also have identified some barriers for scientists to engage in science communication. The two main hurdlers are lack of recognition (formal and informal) and lack of time mainly due to the excessive bureaucratic burden to get funds and projects and the competitiveness of science itself. Also the lack of specialized training in science communication and fears to be discredit by pears or to be misunderstood (either from public or from journalists) are barriers for scientists identified through the interviews.

There are several incentives to engage scientists in science communication but this participation is not seen as part of researchers' work or, at least, is not normally included in the formal evaluation system. It means that generally this engagement appeals to a personal perception of it as a social commitment or as a means to gain some benefit (either professional or personal). If we really want to promote scientists' engagement in science communication, there are two key barriers that have to been solved. First of all, it is important to structurally change the evaluation system to include some kind of reward to all those researchers who are actually participating in science communication activities. In the same regard, if we are going to evaluate, consider or promote science communication as part of researchers' activities it is important to offer proper science communication training to scientists. For example, specific workshops for PhD students, postdocs or senior researchers or even include science communication subjects in scientific degrees as part of the necessary skills for scientists.

6.2 Professional engagement in science communication

As we have seen, most of the incentives to become a science communication professional are related to all the new specialized job positions that emerged as a response to journalism crisis and changes in the communication world. But also it has been seen as an alternative pathway for scientists to research careers. On the other hand, being a science communicator professional could be the response to fulfil a personal interest or curiosity. Because science can be seen as a challenging and stimulating topic to work with, or because you can learn new things every day or get some kind of personal satisfaction translating scientific knowledge to everybody. However, devote themselves professionally to science communication can be understand as a social

responsibility for communicators to defend science against misconceptions, to increase public knowledge, to help people make informed decisions or to be a facilitator in scientists and non-scientists dialogues.

Regarding barriers to become a science communication we have seen that the two main hurdles are the lack of resources (manly economics) and lack of specialized knowledge. This last category includes lack of scientific knowledge (or perceived) by non-scientists performing science communication but also lack of knowledge on the social relevance of science to decide a professional pathway and lack of knowledge on how to develop and evaluate efficiently science communication activities. Also we have identified lack of institutional support, both from research institutions and mass media organizations, and governmental support as barriers for communicators to engage in science communication.

The crisis of journalism and changes in communication world leads us to believe that the traditional scientific journalist working in a single medium is disappearing. On the other hand, these structural changes in traditional journalism and in communication world offer a new scenario for science communication with a mixture of incentives and barriers to become a science communication professional. As we have seen, there is an offer of new job positions for scientific communicators that demand specific knowledge and many skills. At the same time these work positions are not yet fully consolidated and in many institutions they are subject to temporality, depend on specific projects or do not just fit with the global strategy. However, specialized training in scientific communication and a clear commitment at the governmental and institutional level (national and international) can lead to the stabilization of these workplaces.

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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 1.1 "Hurdles and incentives to engage science communication in Europe", questions regarding this issue are the ones included in Dimension 1 and 2.

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...?

9. Annex 2. Contrast online workshop structure

9.1 Agenda:

Time	Content	Speaker
12:00	Welcome and presentations	Gema Revuelta
12:10	Workshop dynamics and objectives	Carolina Llorente
12:20	Brief presentation of CONCISE project	Gema Revuelta
12:30	Incentives to engage in science communication: Scientists	All participants
12:45	Barriers to engage in science communication: Scientists	All participants
13:00	Incentives to engage in science communication: Communicators	All participants
13:15	Barriers to engage in science communication: Communicators	All participants
13:30	Wrap up and end of the workshop	Carolina Llorente and Gema Revuelta

Workshop practical details:

- Date: 21/01/2020
- Hour: 12:00 pm, Central European Time
- Language: English
- Link to join the session: https://eu.bbcollab.com/guest/5116599246ba425fa636ac1d208c2c50
  Make sure you have a good internet connection, a microphone and a camera.

9.2 Insights from CONCISE interviews: preliminary results

9.2.1 Scientists

9.2.1.1 Incentives to engage in Science Communication:

- Social commitment
  - Sense of duty: as payment to citizens who fund science by paying their taxes
  - As a return to the societal group they have been studying
- Raise awareness
- Convince strategic publics
- Publicity of their own work
  - To attract funding
  - To attract scientific collaborations
  - To reach a broader audience
- Promote scientific vocations
- Recognition in research areas
  - Included as a mandatory issue in research projects
  - Promoted by the research institution
  - Criterion by funding bodies

9.2.1.2 Barriers to engage in Science Communication:

- Lack of rewards/recognition
    - Not included in formal evaluation of scientific careers
    - Not included in government/institution/project objectives
    - Not enough promoted by research institutions/funding bodies/government
- Lack of time:
    - Excessive bureaucratic burden to get funds and projects
    - Competitiveness of science (publish or perish)
- No specialized training
- Fear to be misunderstood
- Discredit by peers

9.2.2 Communicators:

9.2.2.1 Incentives to engage in Science Communication:

- Personal interest/will/curiosity
- Challenging and stimulating topic
    - Innovative ways to do journalism
    - Learning new things every day
- Social commitment
    - Being a facilitator in scientists and non-scientists dialogues
    - To have a practical impact in the world
- New specialized positions (Communication officer)

9.2.2.2 Barriers to engage in Science Communication:

- Lack of resources:
    - Lack of economic resources
    - Lack of time
    - Few specialized job positions (especially in journalism)
- Lack of knowledge on
    - How to do efficient science communication
    - The importance of science
    - Science itself
- Lack of strategic support (governmental, newspaper, companies)
- Changes in the communication world
    - Communicator as “orchestra-man”