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Facts and Festivals
Scientists' engagement in Science Communication and Science Outreach

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Abstract: This master thesis investigates how and why scientists and researchers engage in communication activities with the public and whether new channels of communication have an impact on the engagement. Science communication is seen in the light of Social Sciences where Mertonian science ethos as well as social constructivism constitute the theoretical framework. Communication models, namely the deficit model, the dialogue model and the participation model are applied when analysing science communication between scientists and non-specialists. An online questionnaire was distributed to seventy scientists and researchers in Applied mathematics and Data science at French national institute. The results from this survey show that the scientists engage in communication activities for personal and social reasons. A possibility to improve communication skill was seen as the main personal benefit. The respondents think that their research field engage the public and the respondents are interested in communicating the social and ethical implications of their research. Scientists and researchers are motivated to engage in activities organized on an institutional level, such as science festivals, but the results from this study suggest a preference for other communication activities i.e. writing articles online. Social media and other tools enhance visibility in general but are also perceived as possible threats to scientific values such as objectiveness and accurateness. Lack of time, inadequate communication skills, fear of superficiality in discussions on social media are factors that give rise to tensions in communication with the public, whereas institutional support and events targeting a wider public may alleviate tensions in this context.

Key words: Science communication, science outreach, scientists' engagement, communication models, information gap, dialogue, participation, science festivals

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1.Introduction

Scientific communication, in a wider sense, has always been present in human societies. It has been of great importance to convey and transmit knowledge as facts, but also, to convey techniques and technology to fellow workers and to younger generations. In the Western world, the works of Greek philosophers and Arabian scientists have influenced our way of thinking and reasoning. Thoughts and ideas dealing with both physical and spiritual phenomena have been communicated to us mainly through written sources, some of which have been discarded and forgotten, but others retained and developed.

Traditionally, a university’s main mission was to provide for academic learning and research where the scientist’s engagement in and devotion to a subject was the driving force behind academic activity. The outcome of this engagement was knowledge equal to facts that were shared, mainly within the academic world and to a lesser extent, transmitted to a broader audience. However, in recent years, there has been a clear ambition from official academic establishments to reach beyond the academic world , which is referred to as the “third task” (Rödder, 2012) in order to convey knowledge to the public with the ultimate goal of having a beneficial impact on society.

On the one hand, there are researchers and scientists engaged by universities and institutes who dispose of knowledge. On the other hand, this knowledge is supposed to be conveyed to society and individuals that can make use of this knowledge in order to fulfil specific goals and contribute to the well-being of individuals and society. The degree of interaction between these two spheres is a question dealt with by, among others, sociologists and researchers in science communication. In a word, scientific communication occurs when scientists and the public meet and share scientific findings directly or via mediators. Another term in use in this context is science outreach, which stresses the pedagogical format during which this communication takes place, for example lectures, workshops or science festivals. This thesis deals with researchers’ and scientists’ engagement in communication with the general public.

As mentioned above, science communication and science outreach deal with the conveying of knowledge. In this context libraries have always held a prominent position. In recent years academic libraries have been highly involved in a form of publishing within scholarly communication which is known as Open Access. As a model of publishing it stipulates that scholarly publications and materials should be free and accessible for everyone through Open Access journals, special repositories and websites online. Open access to academic literature and new knowledge is thus not only a concern for scholarly communication between scientists and researchers but also an important issue for official academic establishments in order to fulfil their mission formulated in the “third task” (Rödder, 2012). Although the internet is supposed to give full access to information and knowledge of any kind, libraries remain the institutions that give researchers as well a wider public the methods and the tools to organize, seek and find information. In addition to this, libraries give valuable support to researchers in the disseminating process targeting peers or the general public for a more efficient outreach. As researchers in the field point out (Trench & Bucchi, 2010) science communication and science outreach are emerging disciplines which attract and need researchers from different disciplines. Taking all these aspects into consideration, this thesis finds its relevance within the field of Library and Information Science.

1.1 Aim

Researchers and scientists who choose to engage in communication with a wider audience and outreach activities are faced with a number of questions that can turn into challenges. Even though a multitude of issues are involved, this study will deal with the following topics:

- ✓ The reason for participation in science communication activities
- ✓ The role of science in society
- ✓ The meaning of science
- ✓ Communication models
- ✓ Language matters– rephrasing, simplification
- ✓ Choice of channel, mediator, and control of tools used in an outreach context.

Skills linked to linguistic matters such as rephrasing and presentation could be acquired and improved. The same applies to the choice and the control of tools and channels. What is more delicate and requires a different kind of reflexion is the researcher’s attitude to different ways of communication and their impact on society. Furthermore, he or she will always have to consider advantages and drawbacks, both personal and social, when engaging in communication activities where a broad audience is targeted. Even though one of each of these issues are objects for research, the researcher’s challenge is to take all these factors into account when taking on the communication task with the public. For this reason, it seems important to look deeper into the issues at stake and investigate how they are related to engagement in communication activities with the public. To answer these questions, a survey among researchers and scientists in the field of applied mathematics and computing is conducted.

Today, science communication is explicitly encouraged by state policies and this desire is conveyed to researchers and scientists via academic institutions. Even though this has not always been the case, science has been communicated to the public in some way through channels that have been available and acknowledged by either the academic sphere or institutions in society such as radio, newspapers and television. The challenging task to communicate involves different key players who represent diverging values in society, and where these players meet, tensions of some kind are liable to occur. Consequently, accommodating linguistic as well as scientific norms may very well be one of the tasks that the scientist has to face. Despite these tensions researchers and scientists do engage in communication with the public for a number of reasons and refrain to do so for others.

The main aim of this study is to identify how and why researchers and scientists choose to engage in communication activities with the public. As different channels and tools are involved in the communication process it seems important to also consider their impact on communication activities in this study.

1.2 Research questions

The focus of this study is on how a group of researchers engages in and communicates scientific information. The current research addresses the following questions:

- What are the personal and social drivers that incite this group of researchers and scientists to engage in communication activities with the public?
- How does this group of researchers want to communicate their findings to a wider audience?
- To what extent do new channels and tools enhance communication outreach and alleviate tensions?

1.3 Thesis outline

This study is divided into seven chapters and their corresponding sections. The introduction gives a general presentation of the topic chosen for this study which is science communication and science outreach. In this presentation the term science communication refers to communication between scientists and the public. The first chapter includes the aim and research questions. The second chapter deals with background and gives an overview of previous literature in the field. Chapter three introduces explanations of basic concepts that are referred to in this study, and provides three theoretical models: the deficit model, the dialogue model and the participation model which are widely used in science communication. In this chapter there is also a presentation of two sociological theories that give two different perspectives on the relation between science and society. Method, data collection, methodological limitations and ethics are accounted for in chapter four. In chapter five the results are presented and analysed in the light of earlier studies in the research field. A further discussion will be found in chapter six. The conclusion and the most important findings close the thesis.

2. Background and previous research

2.1 Background

Why and how science communication takes place in society is due to a number of factors. As mentioned above, governmental policies impose the obligation on universities to fulfil their mission to share their new findings, not only within the faculties but also outside, targeting a wider public. This reason is thus politically grounded and supports the idea that people who understand, are aware of, are interested and engaged in scientific matters are more likely and apt to participate in a democracy and are also better equipped to make rational decisions. To this end, scientists have thus, more explicitly, been given the task to share the knowledge which is produced in academic institutions with the public and is done through communication activities initiated by the scientists involved.

Many researchers in the field include a historical background in their studies (Schiele, 2008; Trench, 2008: Trench & Bucchi, 2010). It seems important to refer researchers who put new findings into a context in order to understand how the discipline and the role of science communication have developed over the years.

Parallels are drawn between the development of techniques and new professional groups in society on the one hand, and the change of focus in science communication on the other. The phenomenon of mass media communication has made it possible to reach out with a message to a great number of people, and at the same time, scientific journalists appeared as professional mediators between scientists and the public. These mediators were expected to play an important role in the mission of closing the gap between the majority of consumers and a minority of experts (Schiele, 2008). As scientific journalists, they had the power to make a selection of interesting scientific features, transforming, changing and reformulating the content in order to adapt to their readers. In later years, new information and communication technologies have launched parallel and supplementary means of exchange of information. Even if mediators still have a role to play, a direct exchange between experts and the public on the one hand, and between individuals or groups of individuals on the other, is a better description of how science communication takes place today. Science communication is more a matter of how scientists and the public participate in debates and engage in scientific activities than a matter of transferring facts in a top-down model (Burns et. al.,2003; Horst, 2008; Schiele, 2008; Trench, 2008).

Trench & Bucchi (2010) point out that there are no set of rules or criteria which clearly define an academic discipline. It is, however, according to the authors of the article “Sciences of Communication, an Emerging Discipline” (Trench & Bucchi, 2010) possible to enumerate a number of conditions that are usually met with in order to obtain the status of discipline. Trench & Bucchi (2010) stress the importance of a theoretical framework, with defined terms and concepts within a field with shared interests. According to Trench & Bucchi (2010) the discipline of Science Communication is still looking for its own identity. The main reason for this, according to Trench & Bucchi (2010) is that the field of study developed in the intersection of already established disciplines, namely mass communication, social studies of science and education science, to mention a few. It should also be noted that the research field of communication is vast and well-established but is nevertheless constantly developing into new domains where sharp field boundaries are difficult to draw, risk communication and health communication could be given as examples.

Science communication studies have been conducted within general communication studies and applied theories in line with this research area. Over the years, different subdivisions within this field have developed into separate specialized research fields with their own theories and concepts.

Today we encounter research findings not only in Science Communication (SciCom) but also in (PCST) Public Communication of Science and Technology, and with (PUS) Public Understanding of Science (Horst, 2008; Schiele, 2008) and (SC) Scientific Culture, (SL) Scientific Literacy (PEST) Public Engagement with Science and Technology. Even though there is a point in making a clarification of these concepts as Burns et al. (2003) point out, several articles dealing with science communication cover adjacent fields. When Burns et al. (2003) present a mountain-climbing analogy of science and society, the structure holds elements of public awareness of science, public understanding of science, scientific culture, scientific literacy and science communication.

2.2 Previous research

This study deals with how and why scientists choose to engage and communicate with a wider public outside the academic world. The answers to these questions are closely linked to the development of communication processes in society. Literature in the field of science communication is mainly focused on methods and the best way to reach defined aims which are liable to fluctuate over time. Logan (2001) chooses to study science communication in the light of mass communication. From his article we learn that mass media and its entertainment-orientated culture was accused of being the reason for peoples' poor education level and as a counterbalance to negative influences , scientists decided to use the means of mass media in order to provide explanations of sciences and medical processes, and why it was important to know. In contrast to mass media flow, in general, the scientific message has a pedagogical aim as "a flow of knowledge from the scientific community through the press to citizens" (Logan, 2001, p. 135). The intervention is here presented as an initiative from the scientific community, and the science literacy model of that time postulated that science was both true and unchangeable. In this light, scientists had the authority and obligation to enlighten a very broad public whose only task was to listen to what scientists chose to transmit for a better understanding of the world (Logan, 2001).

If earlier literature deals with the scientists and their engagement as a collective activity, later studies are more focused on the scientist as an individual and why and how he or she chooses to mediate in science communication.

Besley, 2014; Besley et al., 2018; Neveu, 2003 and Fleury-Vilatte & Walter, 2002 are researchers who focus on scientists' engagement in science communication which is at the heart of this thesis. In a recent article from 2018, Besley et al. (2018) describe the factors that are linked to the willingness to engage. The study was conducted in the United States and comprises 4,700 answers from scientists and investigates scientists' willingness to engage with the public. Besley et al. (2018) incorporate no less than ten variables in their study: age, gender, scientific field, what the scientist thinks about the public, perceived personal engagement skill and what the scientists think about their colleagues, enjoying the experience to engage with the public, have the time needed to fulfil the engagement and belief that the engagement will make a difference. The engagement involved was divided into three different modes: face-to-face engagement, engagement through media and on-line engagement. At a theoretical level this engagement is treated as planned behaviour (TPB) which implies that effort can be made to change this behaviour. When Besley et al. (2018) refer to engagement they choose to “include any effort that might see members of the scientific community trying to engage, primarily through communication, with people outside of their area of research” (Besley et al., 2018, p. 2). The chosen ten variables were tested either in the form of hypotheses or by using direct questions. To give an example of the hypothetical formulation, the one for gender was: ”On average, male scientists will report higher levels of engagement willingness than female scientists.” In the same way the hypothesis about attitude towards the audience was*:* *“*Scientists who have a relatively more positive attitude toward those with whom they would likely engage will be more willing to engage, regardless of mode.” The results from this comprehensive study showed that scientists were, to a very limited extent, influenced by their colleagues’ attitude to engagement which, according to the authors, implies a certain degree of independence of normative behaviour. The results of the study showed, however, a difference between men and women in willingness to engage with an audience in a media-based media mode, whereas there was no difference in face-to-face mode and on-line mode. Another difference that was highlighted was that of science field and willingness to engage, where scientists belonging to the ‘ecology society’ (Besley, 2018) showed more engagement in face-to-face mode than the other ‘science societies’(general science, biology 1, biology 2, chemistry, geophysical, geological and ecological) included in the study. According to the authors, this finding raises the question whether some predominant and topical issues like climate change could influence the result, or if some disciplines have a longer tradition of direct exchange with the public. There is, however, some evidence from similar studies that disciplines that deal with environment and health questions are more liable to evoke engagement (National Science Board, 2016, chap. 7, cited in Besley, 2018). These areas of science are prevalent in adjacent and sub-branches of communication and science communication, for instance risk communication which has developed into a separate domain with its literature and reviews e.g. *Effective Risk Communication*. *Journal of Risk Research.*

In this context it seems important to introduce the Norwegian researcher Hetland (2014) who studied science and technology communication in the light of the three models referred to in this thesis. In his study he shows how science and technology policy has evolved from 1975 to 2009 in Norway. In Hetland’s (2014) approach ten white papers were studied in a textual analysis. The equivalence to the Swedish university policy and the third assignment is found in the *Act Relating to Universities and University College* which provides for Norwegian public communication of science and technology. Its main mission is to contribute to science and technology communication and innovation, but also to ensure the participation of staff in public debates (Hetland, 2014). According to Hetland (2014) the policy framework can be studied by applying three dominant models in science communication research: the dissemination model, (also called deficient model) the dialogue model and the participation model. In general, researchers look back on and critically discuss an evolution from the disseminating model via the dialogue model to the participation model over time (Horst, 2008; Trench, 2008). In line with this, Hetland (2014) shows that these three models to a lesser or larger extent can be found in Norwegian policy papers published from 1975 to 2009.

Quite a few researchers interested in scientists' engagement have recalled the importance of demographic factors like age and gender (Besley, 2014; Jensen, 2011; Rödder, 2012). In Rödder (2012) the question of age is not a study object in itself, but his study shows that older scientists hold higher positions in the hierarchy and therefore are expected to engage in communications activities. In this way, they have gained legitimacy to represent their peers (Rödder, 2012). Even though this relation between age and engagement has been found in several studies, there is also an example from France where Jensen (2011) found that junior scientists were more likely to participate in science communication activities where maintaining social networks was included. There is, as Besley (2014) points out, also a difference depending on the mode of communication – younger scientists prefer online engagement, whereas older academics have a preference for offline engagement.

Jensen's (2011) study gives us valuable information about how scientists and researchers actually put their communication with a wider public into practise. Jensen (2011) works with the term *popularization* as a synonym to *public engagement* in order to describe communication activities targeting a wider public. His study was conducted over a period of seven years and involves 7,000 scientists from six different disciplines: chemistry, environment, biology, engineering, sociology and physics. It is a statistical picture of popularization practices where the author analyses the influence of different factors: discipline, age, academic productivity and position. The practises are divided into: conference, press, TV/radio, schools, open days, exhibitions, school, books, Web, associations and other. The results from Jensen's study show that the number of actions has increased by nearly 60% between 2004 and 2009. One interesting outcome of earlier studies by Jensen, Kreimer, Rouqier and Croissant (2008) is the relationship he found between academic records and public activities. Activities of less symbolical importance e.g. association collaboration, open days, website and school conferences appeared to engage scientists with low academic records, whereas scientists with high academic records engaged in popularization activities like radio/TV, books and press. The author suggests that the partition between the activities could be seen as a question of offer and demand (Jensen, 2011). One explanation is that senior researchers with a high academic record "have legitimacy to speak to the public in the name of the institution" (Jensen, 2011, p. 33).

Rödder (2012) contributes to this study with his discussion about the tensions that are present in communication between scientists and the public. Rödder (2012) conducted a study where he made 55 in-depth interviews with researchers from France, Germany, the United Kingdom and the United States. The study focused on how "visibility" defined as "repeated prominence in media in more than one context" (Rödder, 2012, p. 161) was experienced by scientists. One of the questions asked was: "How much tolerance can a visible scientist expect in a peer community?" It has to be pointed out that this question was raised in a context where an international research project, *The human genome project (HGH*), was given a considerable media attention. The research area, however, was dominated by a hierarchical structure with its proper values and attitudes towards public engagement. According to Rödder (2012), scientists were exposed to split loyalty which arises when a scientist in an interview with a journalist or other mediators has to make concessions by communicating in both directions. On the one hand, language and content are expected to be adapted to a non-science public, on the other hand the scientist feels obliged to show loyalty to the peers in being scientifically correct and trustworthy. As a representative of a team of researchers, the mediating scientist is thus ambivalent towards engaging outside the academy (Rödder, 2012). The interviews conducted by Rödder (2012) show how 'old school' thinking remains in the realm of research. Being mentioned in a newspaper could for example be regarded as being equal to notorious behaviour and one of Rödder's respondents made the comment that media prominence "smells" (Rödder, 2012, p. 162). The conflict that is met within science communication can be illustrated with the citation from another of Rödder's respondents "He is the most modest man and he is a true scientist *although* he does some media presentation and you see him on the BBC (28:189, my emphasis)" (Rödder, 2012, p. 162). At the other extreme, scientists are confronted with the slogan "Thou shalt communicate" which is, perhaps expected to appeal to a younger generation. Still, in Rödder's (2012) study, junior researchers in the project expressed their reluctance to doing so for two reasons: their position in the hierarchy was not suitable for responsible contacts with media and appearing too often in media could endanger a future career. The role of "public figure" was instead held by the head of the institute with the main purpose of fundraising funds (Rödder, 2012).

Variables related to attitudes

Similar to Besley (2014), Poliakoff & Webb (2007) chose to study scientists' engagement as planned behaviour, a model that belongs to the social - cognitive research field. This approach, according to Poliakoff & Webb (2007) allows an examination of the relationship between intentional beliefs, in this case about public engagement, and decisions made, rather than asking people to reflect upon why they choose to act. Thus, the direction and strength of the intention is considered to be the best predictor of participating (Poliakoff & Webb, 2007). The authors' aim is to depict the factors that influence the scientists' decision to take part in public activities or not.

In this survey, staff and academics from all career stages (1,000) were randomly selected to participate, with a return of 169 participants. The questionnaire presented 12 constructs or measures that had to be responded to on a 7-point scale from strongly disagree to strongly agree, if nothing else was stated. The table below gives an outline of the constructs and type of items involved in the survey.

Table 1. Examples of constructs found in the article "What Factors Predict Scientists' Intention to Participate in Public Engagement of Science Activities?" (Poliakoff & Webb, 2007)

Constructs	Questions (examples)
Attitude	Taking part in a public activity would be…(pointless-worthwhile)
Perceived suitability of research	My research is too complex for public engagement activity
Recognition of participation	Taking part in public engagement activity would help my career.

Subjective norm	My academic colleagues would approve of my taking part in a public engagement activity
Descriptive norms	I have a duty as a scientist to take part in public engagement activities
Perceived behaviour control	I do not have enough training to participate in public engagement activities.
Intention	I intend to participate in a public engagement in the next 12 months
Fear	My research is too controversial for public engagement activities. I would fear repercussions if I took part in a public engagement activity.
Time constraints	I don't have the spare time to participate in public engagement activities.
Money constraints	I would participate in public engagement activities if there was money to support participation.
Past behaviour	Have you ever participated in a public engagement activity? Yes/No

The result of this study suggests that scientists' intention to participate in public engagement activities in the near future is linked to four factors: past behaviour, attitude, perceived behaviour control and descriptive norm. Out of these four, past behaviour was the most influential predictor. This could, according to Poliakoff & Webb (2007), be interpreted as result of routine rather than a result of a behavioural decision as a scientist who participated earlier is more liable to repeat the action. It is worth noting that perceived behaviour control which involves a scientist's own ability to participate, is a strong predictor. Poliakoff & Webb (2007) underline the importance of media training programs for scientists during which they can develop their techniques of communication. Furthermore, the findings from this study show that descriptive norms are better predictors than subjective norms, which means that duties and what other scientists actually do perceived more important than what the colleagues think about public engagement (Poliakoff & Webb, 2007).

The conclusion drawn by the authors of this study was: "scientists who decide not to participate in public engagement activities do so because (a) they have not participated in the past (b) they have a negative attitude toward participation (c) they feel that they lack skills to take part, and (d) they do not believe that their colleagues participate in public engagement activities" Poliakoff & Webb (2007, p. 259).

Poliakoff & Webb published their study in 2007, more than ten years after the Wolfendale Committee had decided that research that had received public funding not only had the duty to communicate findings to the public but generally also asked to attach a communication plan to their research funding application.

3.Theory

Theoretical framework is used in order to establish relationship between different phenomena and is a useful help when we feel the need to describe reality and its components. Merton (1973) investigated the relationship between science and society which later developed into a new discipline, the Sociology of science. As his theory deals with the scientist's obligations and responsibilities in society these ideas are relevant in a context where science communication is a major issue. In the same way social constructivism offer a theoretical framework for understanding the present and historical links between science and society but with a different approach.

Sociology of science and social constructivism offers the perspectives needed to understand how science and its findings interact with society. Furthermore, they constitute a valuable background to models in science communication. In this context science communication is mainly a question of dealing with information and its nature. Is information and knowledge accumulated facts or constantly created, and is it transferred, conveyed, disseminated or negotiated? Similar questions such as information use and information policy are approached within Library and information science where this study is presented.

As mentioned above the discipline of science communication works with communication models and concepts which are accounted for and commented upon below. Moreover, the theories referred to above, namely sociology of sciences and social constructivism will be outlined.

3.1 Concepts

Concepts important for this study will be accounted for below. As this study deals with the topic of science communication and outreach, it is necessary to give an initial explanation of *science* and *communication* which are indeed in themselves two vast domains. In communication theory the relationship between the concepts of *information* and *knowledge* is an issue for discussion which calls for an introductory explanation in this chapter. Furthermore, when the scientific sphere communicates with an interlocutor outside the science corps he or she could be referred to as a member of the public, member of the audience, a lay person or a non-specialist. Researchers in the field work with one of these terms or use them synonymously.

In this study the terms *the public*, *the audience*, *the non-specialist*, *lay people* will be used synonymously.

Moreover, it is important to point out the ambiguity that is found in the use of *science communication* and *scholar communication*. Finally, there is a place for the concept *science literacy* which is described as the ideal situation where all the aims of science communication are reunited (Burns et al., 2003).

3.1.1 Science

When The Panel on Public Affairs of the American Physical Society suggests a definition of science, we learn that "Science is the systematic enterprise of gathering knowledge about the world and organizing and condensing that knowledge into testable laws and theories" and "...the success and credibility of science is anchored in the willingness of scientists to expose their ideas and results to independent testing and replication by other scientists…(and) abandon or modify accepted conclusions when confronted with more complete or reliable experimental evidence" (American Association of Physics Teachers, American Journal of Physics 1999, p. 659, cited in Burns et al., 2003, p. 185). The definition is taken one step further in the report *Science for all Americans* where the social aspect of science is added: "science is carried out, and consequently influenced by, its social context" (American Association for the Advancement of Science,1989, cited in Burns et al., 2003, p. 185).

In science communication literature, the reader may encounter various definitions of the concept *science* according to linguistic and cultural praxis. The German term *Wissenschaft* covers the whole range of disciplines available for academic studies which includes humanities as well as social sciences whereas *science* mostly refers to MST (Medicine, Science, Technology) disciplines. According to Bragesjö et al. (2012) the standpoint that valid scientific knowledge can only be generated through rational scientific methods built on experiments and falsifications theories, has created a deep divide between science and culture. Bragesjö et al. (2012) point out that since the days of Descartes this split between nature, culture, body and mind has been prevalent in our society. Is there reason to claim that this gap has diminished over the years and that *science* is a more inclusive concept today? The fact is that over the years, the number of research fields that are characterised as interdisciplinary has increased; ecology and information science could be given as examples. This is a tendency which, not only contributes to a grow in closeness between nature and culture, but also widens the concept of *science.* Furthermore, in activities where scientists engage in communication with the public, *science* is a broad concept. Science festivals, for instance, usually include MST as well as Art, Humanities and Social Sciences. There are, of course, activities like the *Fête de la science* (science festivals) referred to below as one of the activities targeting a wider audience where *science* is equal to computing, automatization and mathematics. However, this fact does not exclude an approach of a more artistic nature in which computing plays an important role in creating artistic audio-visual experiences.

3.1.2 Communication

There are a number of definitions of communication and their supportive models. Each one of these can be said to be a product of their time, linked to social and technical development (Case & Given, 2016). In the most basic communication process, there are at least three components: the sender, the message, the receiver. The middle part could be said to be the other components' 'reason for being'; which is a piece of information or knowledge that is transmitted or shared between the sender and the receiver, often via a channel, under certain circumstances. That is why theories of information where communication of information is dealt with, are applied in the field of science communication.

In the early years of communication studies, the linear model, in which information was sent to a receiver via a medium of some sort was prevalent.

Right at the beginning we find Shannon's *The Mathematical Theory of Communication* which was a communication model describing the transfer of signals in telecommunication (Bawden & Robinson, 2012). In the twentieth century, a major part of the research in the communication field was focused on new technical devices and media, and a great number of people were involved in mass media production. Still a one-way communication concept, the scientists had access to a new professional group, scientific journalists, whose task was to adapt scientific language and content to a wider public. The latter group was described as the "receivers of messages at the end of information transmission" (McQuail, 1997, cited in Trench, p. 124). Over the years, as Burns et al. (2003) point out, more attention has been given to the complexities of communication which is demonstrated by the fact that context and social negotiation of meaning is included in the concept of communication. The wording from Schirato & Yell (1997) tells of a more expanded definition in which communication is seen as "…the practise of producing and negotiating meanings, a practice which always takes place under specific social, cultural and political conditions" (Schirato & Yell, 1997, cited in Burns et al., 2003, p. 186).

3.1.3 Information- knowledge

Information and knowledge are central concepts not only in our daily surroundings but also in academic disciplines, within which more precise definitions are required. The concept of *information* is closely linked to our time and society where the ideas of 'information society' and 'information age' often are highlighted and discussed (Bawden & Robinson, 2012). Researchers in the field also deal with questions that are closely linked such as 'information behaviour' and behaviour 'needs' (Case & Given, 2016). According to Bawden & Robinson (2012) a distinction is made between the usage in social sciences on the one hand, and physical/biological sciences on the other, due to the fact that these disciplines have an opposed approach to information. While physical/biological sciences apply a very strict definition of information, social sciences work with a wider concept.

Buckland (1991) presents a typology where three different aspects of information are categorized: *Information- as-thing*, *information-as-process*, *information-as-knowledge*. In the first category, he puts documents and data. The second suggests that a person's state of knowledge is changed by the act of information, and in the final category, we find the knowledge which is equal to the information disseminated. In order to illustrate the relationship between data, information, knowledge, and wisdom the D-I-K-W hierarchically built pyramid has been put forward. In this pyramid, data constitutes the base for information, and knowledge is given the status of 'refined' information. This model has, however, been criticised by several researchers. The title of the article "A Critique of the DIKW Hierarchy" written by Frické (2009) reveals the content. Frické (2009) prefers putting information and knowledge on the same level.

3.1.4 Information equal to knowledge

Case & Given (2016) choose to treat *information*, *knowledge* and *data* as next to synonymous terms when approaching the field of information behaviour. Viewed from this angle, the only distinction which seems necessary is that

between data and information on the one hand, and knowledge on the other. (Case & Given,) suggest that knowledge is restricted to the human mind whereas information and data are reduced to physical objects. Another approach is made by Machlop (1983, cited in Case & Given, 2016) who focuses on the transfer process. The researcher suggests that information implies transfer of some kind, whereas knowledge is independent of an external source as it can be acquired by thinking. Even if information in general has a positive connotation, in the sense that it is supposed to clarify, enlighten and rectify, it is well-known that information can be inaccurate, deliberately deceptive and incomplete, which means that information is not equal to truth. Consequently, if our knowledge is based on external information, we run the risk of knowing things that are far from the truth.
In philosophy, studies in epistemology deal with the theory of knowledge which is a vast subject. Consequently, there are theories, concepts and definitions that are redefined as well as elaborated in new contexts. Some major concepts are, however, truth, belief and justification. By putting these concepts together, knowledge could be seen as true, justified and believed by someone for rational reasons (Bawden & Robinson, 2012).

3.1.5 Public – Lay people – audience – non specialist

"The simplest and most useful definition of the public is every person in society" (Burns et al., 2003, p. 186). The public is to some extent a defined group, but as Burns et al. (2003) explain, it is a heterogenous group that can be divided into different kinds of 'publics' according to, for example, social belonging, interests, attitudes or level of knowledge.

Another term that is often used when talking about the public or receivers is *lay people*. In dictionaries we usually find 'lay person' rather than 'lay people' There are, however, two meanings of 'lay person' (lay person, 2019). The first one refers to the religious sphere where members of the church are either clergy or lay persons, the second meaning: " a person who does not have a specialized or professional knowledge of a subject." is commonly used in other domains in society. This means that scientists who are usually only experts in a particular field, will be lay people in another (Burns et al., 2003).

Audience is yet another term that is found in the literature to designate people who take part in a public activity (Rödder, 2012). This term is highly linked to the type of activity in question. Talks and television broadcasts have an audience. The activity usually refers to a one-way communication act. Finally, the term *non-specialists* which is widely used in science communication literature and corresponds to the second definition of 'lay people' given above. In addition, it could be mentioned that researchers in the field, in line with the development in communication theory, also refer to the plural forms of public and audience to underline the heterogeneity of these categories (Trench, 2008).

3.1.6 Science communication - scholarly communication

Science communication in this study deals with communication between scientists/scholars and the rest of the society. Another term in use, which is more informative, is *science outreach* holding the meaning of communication that reaches beyond peers. Consequently, the opposite, *science inreach* could be applied to communication between peers. In addition, the EU guide to communication underlines the difference between scientific communication and scientific dissemination, where the first refers to actions in which non-specialists or the public is involved, whereas the latter concerns publications destined to peers and to those who can make use of the results (EU Science & Innovation , What is Science Communication ? The EU guide to Science Communication, 2017).

As mentioned above, science communication is a term that is used in a generic sense in order to cover all sorts of communication within the academic world and communication between scientists and the public. Furthermore, the term refers to the art of writing and publishing a scientific paper.

3.1.7 Science literacy

The meanings of the general term *literacy* as well as the more specific term, *science literacy,* have gone through changes over the years. They have both extended their lexical sense and, the former has gained increasing attention in the linguistic field. Traditionally, science literacy referred to the capacity to read and understand scientific articles. In Miller's (1998) interpretation of literacy science three dimensions are involved: content, process and society. The content dimension refers to understanding scientific articles, the process dimension is about understanding scientific inquiry, and finally the social dimension which considers the impact of scientific and technological findings on individuals and on society. Yet another definition has been suggested by Hacking et al. (2001, cited in Burns et al., 2003) which gives a more holistic interpretation in a pedagogical context. The following citation focuses on the reason why science literacy should hold a prominent position is society.

> Fundamental to the ideal picture is the belief that developing scientific literacy should be the focus of science education in the compulsory years of schooling. Scientific literacy is a high priority for all citizens, helping them to be interested in and understand the world around them, to engage in the discourses of and about science, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions, investigate and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being (Hacking et al., 2001, cited in Burns et al., 2003, p. 188).

Burns et al. (2003) chose to highlight this particular definition because it represents an ideal that is not, according to them, attainable, but could nevertheless be considered as an important goal in a modern society. According to Burns et al. (2003) science literacy is the situation in society, where the aims of science communication are reached "science literacy is the ideal situation where people are *aware* of, *interested* and *involved* in, form *opinions* about, and seek to *understand* science" (Burns et al., 2003, p. 190). As mentioned earlier, the definition presented by Hacking et al. (2001, cited in Burns et al., 2003) was published in a review with a focus on education and learning. If there are societal ambitions to improve science literacy, measures have to be taken at an early stage and in a place where the message is likely to have an important impact on the future generation. Even though schools are traditionally considered to be the most appropriate place to learn, there are numerous complementary channels which are able to draw the attention of curious minds today. Some of these are open days, hands-on museums, online tools and science festivals through which scientific values that promote scientific literacy are communicated.

3.2 Models

In science communication, researchers usually deal with three major different models: the deficit model, the dialogue model and the participation model. (Hetland, 2014; Trench, 2008). Other denominations of these models are also found in the literature, namely, the diffusion model, the deliberation model and the negotiation model (Horst, 2008).

3.2.1 The deficit model

"Science is transmitted by experts to audiences perceived to be deficient in awareness and understanding" (Trench, 2008, p. 131). This model is also referred to as the diffusion model, the transmission model and the dissemination model where the focus lies on the mode of conveying scientific information.

Deficit was the term that evolved out of Snow's theory (1959, 1974, cited in Schiele, 2008) in the early sixties in order to describe the big gulf between scientists and non-scientists. The theory depicted, in the first place, the social contrast between two cultures, that of scientists and that of literary intellectuals, where the latter group was regarded as deficit in scientific knowledge. This theory was later applied to research into the gap between scientists and the public (Schiele, 2008). In the early days of science communication theory and research (Snow 1959, 1974, cited in Schiele, 2008, p. 96) physicists were the idealized representation of science. Furthermore, in those days, scientific knowledge referred to results from pure research or basic research without any utilitarian aspects.

Schiele (2008) looks back and evokes the time when a spirit of enlightenment urged scientists to acquaint the public with science which was realized by the means of exhibitions that could be seen in the Palais de la Découverte in Paris created in 1937 or Chicago's science museums. Another, earlier and somewhat more spectacular form of communication where the scientist himself was part of the performance, were live experiments. Faraday (1791-1867) communicated his findings about electricity and electricity fields to a an exclusive and interested public, enthralled by the miraculous effects of science. If the scientists themselves took the first step to disseminate science and continued in doing so for a longer period, their role as communicators between experts and laymen was taken over and professionalised by a core of specialized journalists during and after the war (Schiele, 2008). This could be explained by the newspapers' important role during a period where new wartime technology progress was transposed to civilian society in very optimistic words (Schiele, 2008). Through newspapers and other types of mass media, science could be disseminated from an exclusive group of experts (the scientist) to a great number of consumers (the public). The mass media communication model was seen as a powerful instrument to improve public understanding of science (Logan, 2001). At the top level of this top-down model we see the experts who had gained their knowledge by the scientific method. The facts were then disseminated to various public groups without this knowledge (Trench, 2008).

The mediators, mainly scientific journalists, had the responsibility to understand, explain and adjust complex concepts to an interested public with the goal to enlarge the audience. In this context it should be noted that mass media communication was theorised in the transmission model launched by

McQuail, 1994 (Trench, 2008).The same author also pointed out that mass media put an end to conversation: the audience was in the early years of communication research reduced to “receivers of messages at the end of the linear process of information transmission” (McQuail, 1997, cited in Trench 2008, p. 124). As pointed out earlier, disseminating information through the deficit model is built on the concept that knowledge emanates from scientists with or without a mediator and reaches the public in a one-way process, the greater the audience the better. The rise of the power of media and mass communication made it possible to reach a greater number of people. Although McQuail (1997, cited in Trench, 2008) initially described the audience from a rather narrow standpoint, this group was considerably enlarged and over the years, information was more adapted to audiences with different interests. In the same way the concept of communication developed into a more interactive process. According to Trench (2008), conversation between scientists and the public was lost in this communication model, in which a new group of professionals, the scientific journalists, took on the role as intermediaries.

The diffusion model originates in the traditional or positive tradition where scientific communication is a part of mass communication theory. Science in accordance with any other knowledge and information is seen upon as an accumulation and emanates from the source, in this case scientific and scholar institutions, and is spread to different publics. In McQuail’s (1994, cited in Horst, 2008) general communication theory from 1994, the transmission model prevails. The truth is transmitted or conveyed to people who need to be enlightened and educated, a process that, in the long run, will help individuals not only to lead a better life, but also to be more prepared to take part in political decision-making. This approach, as Horst (2008) points out, holds the strong belief that science is a contributing factor to social progress. If something goes wrong and controversies arise, the fault is to be found in the processes of diffusion; inaccuracy of the message itself, in the disseminating procedure or default of delivery (Horst, 2008).

The transmission model is just another name for the dominant model within public communication of science and technology (PCST) deficit model. The word ‘transmission’ focuses on the conveying of the message, whereas the word ‘deficit’ refers to the assumption that the ignorance of lay people on scientific matters is due to a lack of knowledge (Trench, 2008).

Schiele (2008) is interested in the conditions that made this model possible to appear and the reason why it is stigmatised today. He reminds us of the fact that science and society were originally kept apart from one another. Alchemy and astrology used a “scientific” language, hidden from the general public, which also gave the scientists of that time an aura of superiority and kept science beyond reach (Schiele, 2008). In the 17th century the Enlightenment was signalled by Fontanelle and his work *Entretiens sur la pluralité des mondes,* (*A Discovery of New Worlds*) published in 1686, which according to Schiele (2008) could be seen as the beginning of the public dissemination of sciences. With the development of the newspaper and magazine industry in the 19th century, science was often published as feature articles with a touch of “science wonders” in order to attract readers. The rise of mass media took science communication a step further in that three different categories were taken into account; the scientists, the general public and a mediator, whose role it was to consider the needs of the producer and the consumer (Schiele, 2008).

Weakness of the deficit model

Over the years, researchers in the PCST (public communication of science and technology) field have pointed out the weaknesses of the deficit model (Schiele, 2008; Trench, 2008). The major objection is related to the relationship between scientists and the public in which one part has the authority to speak, the scientist, while the other part just listens and learns. Moreover, the scientist gains his authority from, and make statements on behalf of a solid institution, whereas the receiver of the message is an individual without supportive surroundings. This kind of unilateral approach reflects an unequal social relationship which can be questioned in a democracy where the public is expected to participate in taking decisions (Lévy-Leblond, 1994, cited in Schiele, 2008 p. 102).

Furthermore, the top down model is based on a one-way dissemination of information to an audience which, especially during the first years of the mass communication era, was regarded as a body "of receivers of messages" without any individual characteristics or needs (Trench, 2008). As the designation of this model implies, the *deficit model*, there is a lack of information, a gap, which could be filled, preferably with even more information. This way of looking at information and communication is to some extent out of date or rather, according to researchers in the field, substituted by complementary models (Hetland, 2014; Horst, 2008; Trench, 2008). The deficit model remains, albeit new perspectives on science communication, the major option in communication with the public (Trench, 2008).

Yet another weakness of this model according to Schiele (2008) is that it considers knowledge for knowledge's own sake. Knowledge is thus produced separately from a wider context and cannot be questioned. In the course of time, this perception of knowledge production has become obsolete.

3.2.2 The dialogue model

"Science is communicated between scientists and their representatives and other groups, sometimes to find out how science could be more efficiently disseminated, sometimes for consultation on specific applications" (Trench, 2008, p. 131).

Critiques of received transmission models in communication theory had, according to Trench (2008), focused on dialogue and conversation since 1970. Influences came from the social theorist Habermas, but also from social and political theory, where Giddens developed the idea of a 'dialogical democracy' in which dialogue had "the capability to create active trust through an appreciation of the integrity of the other" (Giddens 1994, cited in Trench 2010 p. 123).

This model is also called the two-way model, which implies an exchange between scientists and the public, an element that is, generally, excluded in the one-way model, where the information in shape of factual truth is transmitted to the public. It should be noted that the public serves as a reference group for consulting which is seen as a big step towards democratic procedures. An example would be the risks of high-voltage power lines or radiation from cell phones. The dialogue enables the subject to be lifted to a science communication level, but the science itself is not a matter of discussion.

According to Horst (2008) who prefers to refer to this model as the deliberation model, which implies that science opens its door in order to legitimize its actions and decisions, the public should instead pass on information to science than vice versa. This is, above all, a way to avoid scepticism towards science in a context where different communication solutions and their cause of controversies are discussed (Horst 2008).

Van der Sanden & Meijman (2008) who chose to study the dialogue model in-depth refer to the wording of Bohm 1996:

Dialogue comes from the Greek word *dialogos*. Logos means "the word" or in our case we would think of the "meaning of the word". And dia means "through". It doesn't mean "two". … the picture or image that this derivation suggests is a stream of meaning flowing among and through us and between us … and this shared meaning is the "glue" or "cement" that holds people and societies together … In dialogue nobody is trying to win" (Bohm 1996:6, cited in Van der Sanden & Meijman 2008 p. 91).

Even though discussion and dialogue are often treated as synonyms, dialogue can be distinguished from discussion where the latter is characterised by argumentative statements for and against in order to win. As mentioned above the purpose of a dialogue is to create an arena where different facts and feelings can be shared (Van der Sanden & Meijman, 2008).

Table 1. Bohm's distinction between dialogue and discussion (In Van der Sanden & Meijman, 2008, p. 92).

Dialogue	**Discussion**
No theme	A theme
No goal	A goal
No agenda	An agenda
No direction	A direction
No fixed process	

From a non-specialist point of view, it is easy to see the difference between a one-way, often top-down communication process, and a two-way process where interaction built upon dialogue takes place. The dialogues arise between groups and individuals, within groups, via a mass medium or in a social network. Van der Sanden & Meijman (2008) describe this state of things as a vison where meaning and facts could be negotiated in an arena where target group and sender meet. This exchange develops into a negotiation during which lay people and scientists are expected to reach a mutual understanding. However, even though the dialogue seems to offer a balanced way of communicating, agenda setting is another major issue – who decides what topics should be treated?

According to Van der Sanden & Meijman (2008) dialogue is a powerful instrument in order to reach science communication goals that could be divided into public awareness, public engagement, public participation and public understanding of science. Van der Sanden & Meijman (2008) make a distinction between dialogues used for awareness and engagement on the one hand and public understanding on the other. The reason for this is that dialogues on awareness and engagement involve feelings and emotions, whereas dialogues on understanding deal with facts of sciences - dialogues with different goals. Van der Sanden & Meijman (2008) find that the science communication of today is less concerned with public understanding than with public awareness and engagement.

In the dialogue Bohm (1996, 2004, cited in Van der Sanden & Meijman, 2008) had in mind, there is neither goal nor agenda. Any subject can be raised in order to inform on facts, feelings, concepts or emotions. Dialoguing without defined themes is as Van der Sanden & Meijman (2008) underline both rare and difficult, especially in a mass media situation. Nevertheless, in France, in the wake of the rebelling *gilets jaunes (yellow vests)* there was an attempt to create a forum without an agenda where the president suggested meetings with representatives of the people and groups of laypeople. Certainly, these dialogues had a political goal and were supposed to cover political matters rather than scientific questions. However, the dividing line between these two is sometimes very fine. One of the questions that was approached in this context was the prohibition of glyphosate in agriculture - a controversial issue with political as well as scientific implications.

With reference to the subject mentioned above, it is interesting to note that Van der Sanden & Meijman (2008) are critical of the way in which dialogue has been used as a mantra to describe and initiate any topical debate that is held in order to deal with public awareness of science where questions about health, food safety and genetic manipulation have been, and still are targeted.

Trench (2008) is one of those who claims that there is no such thing as a fundamental shift of models. Instead he considers this model to be a refinement and not a replacement of a prevailing model. As Trench (2008) points out, one side is still in control and chooses the subjects to be taken up to discussion, even though the public side is encouraged to interact with science.

3.2.3 The participation model

"Communication about science takes place between diverse groups on the basis that all can contribute, and that all have a stake in the outcome of the deliberations and discussions" (Trench, 2008, p. 132). This model is built on the premise that people have gained a good level of scientific literacy.
The participation model is based on real exchange between the public and the scientist through conversation and negotiation. In contrast to the dialogue model there is no set agenda. Several groups in society, scientists included, contribute to development by shaping issues. According to Horst (2008) a major concept is acceptance of heterogeneity. Debates and discussions between groups and individuals lead to controversies which are regarded as normal features in this model (Horst, 2008).

3.2.4 Three models in use

Hetland (2014) is one researcher who applied these three models on research material. In the mid-seventies the responsibility to disseminate research findings lay with researchers but more particularly with journalists who were trained specifically for this task in order to reach out to the public. The result was, as Hetland (2014) learned from his study of the white papers that findings were published for dubious reasons; they had a good press value but failed in scientific value. In order to come to terms with this problem, it was advised to follow Ingelfinger's rule "to keep scientific findings out of media until peer-reviewed and published" (Hetland, 2014, p. 9). This rule was, as Hetland (2014) points out, applied by social sciences and humanities, but not by natural science and technology. One reason for this, according to Hetland (2014), was that the governmental reports in Norway emphasised the role of public relations and even saw scientific results as a "sales product" (Hetland, 2014, p. 10).

The channels chosen to disseminate scientific results have developed over the years. Journalists conveyed scientific news as they had access to specialised magazines, radio and television, but innovative projects were also launched. Some of these were a TV series for youths, *Newton*, and the Norwegian Science week inaugurated in 1995. Later, in 2002, an online newspaper dealing with Norwegian and international science was opened for feedback and discussion. Some of these examples; radio, television, internet are historical landmarks of attempts to disseminate research to different groups or to the general public. Today, as Hetland (2014) points out, the disseminating process has long since reached the internet, and the number of applications that deliver scientific findings and news are no longer possible to account for. Open days, science festivals, seminars, street theatre, workshops are other channels for disseminating of science.

In the same way as one-way communication is linked to the disseminating model, two-way communication is associated with the dialogue model. The importance of feedback was, according to Hetland (2014) mentioned in the white papers as early as in 1976. The advantages that were put forward were that both researchers and users would benefit from an exchange on scientific matters. Furthermore, there would be a greater acceptance for the results and the users would get a better understanding of a scientist's work. As a result, the Norwegian authorities recognized a need for new forums. Consequently, today Norwegian citizens can engage in workshops, lay people's conferences and citizens panels (Hetland 2014). This kind of communication which has been established in Denmark and Norway is also seen as a part of the democratic process. In a comparative study between Denmark, Norway and France, Nielsen et al. (2007) found that lay people in Norway were expected to contribute with their everyday knowledge and were appreciated for their social skills whereas lay people in France were regarded as "les naïfs"(the naïves) who needed some sort of training before being competent enough to participate in scientific debates.

According to Hetland (2014), user-orientated science communication built on dialogue has been the traditional way to communicate in the Nordic countries. Through this two-way communication between the user and the researcher, the user was empowered to act. Initially, in Norway, the agricultural field constituted the arena where lay people could engage. Different field experiments made it possible for a concerned public to participate and contribute to scientific research. Later, the participation model was applied and, in many ways, developed in other areas, mainly in those close to health and environment. Hetland (2014) refers to an interesting example where in 2008 the Norwegian Biodiversity Information Centre opened a digital reporting system to which people could contribute with their observations. Ten years later there are numerous institutions that through applications and websites offer lay people to contribute, discuss and share information. However democratic, engaging and far-reaching participatory citizen science is, the question now is how trustworthy the information from different sources is. As a solution to this problem a "third way", is according to Hetland (2014) launched – apomediation – a filtering process in 2.0 environment where supporting tools or persons guide and push users to accurate and relevant information.

3.3 Science Communication as social science

Merton is, as Knorr-Cetina (1991) phrases it, the founder of the sociology of science. When Merton published his first work in 1938 sociology of science was not recognised as a research field. The impact of his publications has been of great importance of the development in the research field and has inspired adepts as well as adversaries (Knorr-Cetina, 1991).

Society is, according to Merton (1973) to be considered as an assembly of different institutions that are subdued to and kept together by norms and values in order to function well. Like other institutions in society, science has its own norms and values. These "norms are expressed in the form of prescriptions, proscriptions, preferences and permissions. They are legitimised in terms of institutional values" (Merton, 1973, p. 269). These values are, according to Merton (1973) internalised by the scientist and his conscience throughout their socialisation and develop the ethos of science. Merton (1973) suggests that this ethos is built up from four sets of institutional imperatives. In Mertonian literature the acronym CUDOS is prevalent as a mnemonic (Arnaud, 2013, Berggren, 2016).The first one is *universalism* where requirements of objectivity and independence are set in the first place which means that only talent can be a ground for a successful career, thus excluding social attributes such as race, religion, class or personal qualities. *Communism* is the second imperative and deals with science as common propriety. According to Merton (1973) it is of great importance that scientific findings that are won by social collaboration should be assigned to society. In line with the thought of shared propriety, secrecy for personal or institutional reasons are banned, whereas communication and diffusion of results are imperative. In this context Merton (1973) also approaches the notion of ambivalence, which occurs when a scientist is confronted with incompatible values from two different equally strong domains. The third imperative is *disinterestedness* which postulates that a scientist should gain no personal benefits from its outcome. If personal credits could be obtained from scientific activity, the temptation of fraudulent behaviour would have to be considered. However, scientific method and scrutiny of fellow experts are procedures that ensure that the imperative of disinterestedness is applied. Science is thus looked upon as an accumulation of knowledge produced by scientists and tested by reliable peer experts. This does not render the fourth imperative of *organized scepticism* less important. Scepticism is a value within the science community as well as towards other social institutions. Science like any other domain in society will be confronted with contradictory norms and values, but science has no reason not to objectively analyse dogmas of church, economy or state (Merton, 1973).

In science communication literature, Merton's imperatives are often present explicitly or implicitly. Rödder (2012) clearly refers to the norm of humility when he discusses the ambivalence of visibility. In the first place there is the question of humility toward priority and originality. When a scientist gains recognition through an important work, he is between two incompatible values: "the value of originality, which leads scientists to want their priority to be recognized, and the value of humility, which leads them to insist on how little they have been able to accomplish"(Merton,1973, p. 305). In the second place, obtaining recognition of priority and originality puts the scientist in a situation where he is supposed to communicate with his peers and with a public outside the scientific sphere. The first situation is to some extent part of the institutional scientific norm through which every work is peer- reviewed by collegial expertise and would not appear to cause any uneasiness. Nevertheless, claiming or accepting priority is not always evident. Merton (1973) refers to the example of Darwin who, for humility reasons, urged him not to claim priority with respect to his colleague Lyell's work. It was the scientific community that claimed priority in the interest of science. When science communication is equal to communication outside the scientific institution the researcher is confronted with the humility norm as contradictory values from two domains. In the role of communicator, the scientist agrees to refrain from the value of modesty and he also takes on the responsibility to represent the entire research team. Attitudes towards colleagues that participate in public engagement have been studied by a number of researchers in the field of science communication (Besley, 2014; Jensen, 2011; Rödder, 2012).

Rödder (2012) chooses to see science as a separate social system which over the years has distinguished itself from other spheres in society. By using a technical jargon and addressing exclusively their peers, scientists have been able to close their community and thereby establish an ethic of their own. Moreover, the visibility, as Rödder (2012) puts it, of scientists and their work is not equivalent to that of other categories in society. Communication between scientists and society has experienced a great deal of tension. It is often pointed out that communication with the public requires media skills that need to be improved, as well as time to spare to these activities. Rödder (2012) explains these tensions by referring to the social unease the scientist feels when put in an ambivalent role. On the one hand, it is important to stay loyal to scientific values and criteria, on the other hand there are the requirements of mediatisation which seem incompatible with each other (Rödder, 2012).

Social constructivism

According to Jackson and Sorensen (2006) the sociologist Giddens presented the concept of structuration where he analysed the structures, rules and conditions that guide social actions. These structures are neither defined by natural laws nor are they permanent. Instead, structures are formed by human interaction where thoughts and ideas are the main foundations. Thus, reality is constituted by humans who live, reflect and act in a social context. This means that social norms change according to time and place and cannot be established once and for all in a set of rules that are objectively studied, which is argued by positivists and behaviouralists (Jackson and Sorensen, 2006). Furthermore, the material world we are analysing is rather a question of how we choose to interpret the meaning and the importance of this material. Consequently, from a social constructivist's point of view scientific knowledge is not an ever-increasing accumulation of research findings of the truth, but a product of an outcome of a process of constructions. According to Knorr-Cetina (1991) Merton's imperatives are fundamentally rebutted by the social constructivism for a number of reasons.

In the first place, social constructivism does not accept the idea of science ethos as according to this theory, there are no external laws that can define the behaviour of people in social institutions (Knorr-Cetina,1991). The imperative of universalism, which postulates that the only ground for scientific achievement should be talent, could be claimed to be an ideal but does not reflect reality where the evaluation of scientific work is highly influenced by gender and social status (Knorr-Cetina, 1991). Similar objections are made toward the imperative of disinterestedness. In the view of social constructivists, science is a social construct and for that reason the scientific community is not exempt from values that are highly esteemed in society – celebrity, originality and influence. In the same way, the imperative of communism could raise some questions. Merton's imperative certainly postulates that science should be shared among scientists and should be made public, but science is from that point of view regarded as a pure product of scientists. In a social context, prevailing structures decide on the interpretation of science, the purpose of science and not least on the methods of scrutiny of science. Science is not created in an elitist vacuum, but is a matter for every citizen to reflect on and participate in. From that point of view science communication will be given a new purpose as well a new direction. If the deficit model prevailed at a time when scientists produced and an ignorant public received, new models that focus on participating and dialogue reflect a society that includes the public in the scientific process.

Scientists and researchers are not tucked away in an ivory tower today. On the contrary, they are urged to enhance their visibility and communicate with a wider audience. As members of a society they are influenced by current ideologies and values. With the theories and the models in mind it should be easier to discern patterns in how and why scientists and researchers engage in communication activities with the public. The models also give valuable information about what to focus on when constructing the items of the survey. Even though the respondents are not aware of the different models in science communication, they are likely to adhere to them in some way when communicating with non-specialists.

4 Method

4. 1 Method and sampling

For this study I have chosen a questionnaire survey distributed to potential respondents via email and a web tool. In literature dealing with methods applied in social research, the advantages dominate the disadvantages for this kind of study (Bryman, 2016). The most crucial disadvantage is the possibility of low response rate which can jeopardise the result of the survey. It is, however, possible to reach out to a great number of respondents and get access to valuable and accurate data rapidly. The questions in this survey are mainly close ended which, on the one hand restrict the respondents to a limited set of answers, but on the other hand does not demand too much effort of the respondent which in turn may entail a higher response rate. In order to mitigate the possible negative impact of close ended questions, there is, when suitable, a possibility to add a comment on the comment line. The answers are analysed in the light of earlier studies and findings.

The sample in this study consists of a number of researchers and scientists who work or study at a national research institute in France. The sample did not use a random selection method. Instead, a few teams were selected and constitute thus a convenience sample. The reason for this is accessibility linked with administrative issues. To separate the targeted groups from other groups, as administration and maintenance staff in the mailing address book in order to obtain a random sample would have been a rather time-consuming task for this kind of survey. It is more efficient to dispatch the questionnaire via the administration team of each group where the mailing list is readily at hand. Thus, the convenience sampling does not allow a generalisation of the results, but the findings can be related to existing research in an area (Bryman, 2016).

This survey aims at answering a number of questions that are mainly of theoretical and hypothetical character. By asking these questions it should be, to some extent, possible to measure concepts and evaluate the validity of the inventory. In this study the concept of engagement is essential and for this reason the questions are focused on attitudes, opinions and acts that reflect the respondents' engagement. Attitudes and opinions are mainly approached in Likert scale responses where the respondent is asked to indicate a level of agreement, i.e., strongly agree to strongly disagree. Likert scales are useful when measuring latent constructs. In order to approach behaviour and attitudes linked to theoretical models the respondents were faced with closed-ended questions. The construct of the items is important: both questions and answers should be relevant to the concept. In order to asses such a relationship the measure of content or face validity may be applied. This could be obtained by consulting an expert in the field who can give the investigator useful information on this issue.

The concept of reliability refers to the constancy of a measure of a concept and its main concern is stability. Even though a survey of this kind reaches high validity, i.e., it measures what it is supposed to measure, the reliability is not satisfying or even desirable in the sense that it is meaningful that results obtained will not vary over time. A survey that deals with opinions and attitudes could be regarded as a snapshot and is expected to change in some direction over time. A second type of reliability, internal reliability, could be applied as a measurement in this survey. It is a way of measuring the constancy by relating scores from the different items. This reliability could be evaluated by using Cronbach's Alpha test where the correlations between items are calculated statistically. This test has not been used in this survey but is applicable in studies with Likert-type scales.

Why respondents at this institute?

Institut National de recherche en informatique et en automatique (INRIA) is a French national research institution in computing and automatization (robots) with headquarters and research centres in six different places in France: Bordeaux, Sofia Antipolis, Grenoble, Paris, Rennes, Nancy and Saclay. The main field of research is digital science which in turn is divided into five different themes, Digital health, Biology and Earth, and Applied mathematics, Computation and Simulation. As most universities, academic institutions and private research centres, the institute dispose of a communication department whose responsibility is to disseminate scientific findings to the public via different mediators or directly through web sites or brochures. In addition, this institute has made scientific mediation a priority. A Mediation Team disseminates researchers ongoing work and findings in different ways in order to reach out to a wider public. Consequently, the institute has a strategy for its communication which is incorporated in its organisation and its production of various documents and activities, some of which are organisation of festivals, participation in festivals, production of MOOCs (massive open online courses), open-day activities, radio productions and articles in in newspapers and on the web. Furthermore, this institute attracts people from several countries and different age groups with special skills. As mentioned above, there is an official policy document which gives examples of how the institute interacts with the public by different means and on various levels. For these reasons, researchers and scientists from this institute are relevant respondents in a study focusing on science communication and science outreach.

4. 2 Data collection

Data collection was mainly achieved through an electronic survey that was distributed via email and an online tool from within the French Institute. This questionnaire was sent to two different research teams embracing 70 potential respondents. In order to participate in the survey, the respondents who received the email were asked to click on a link. Once the questionnaire had been completed the answers were forwarded back to the investigator. The respondents are members of teams constituted of different staff categories: senior researchers, PhD students and engineers. Within these teams, various age groups as well as positions are represented. The younger part of the respondents is mainly engaged for a limited period of time, whereas the more advanced in age and seniors benefit from lifelong contracts as civil servants. This category of researchers at the institute are also engaged in teaching activities outside the institute.

Data was also collected from documents dealing with science communication published online by the institute and its researchers. The first document *Mediation scientifique en science numérique:une facette du metier de la recherche* (INRIA, 2019) is a document published online that describes engagement in science communication with the public. The second document, *Médiation scientifique en science numérique: une facette de nos métiers de la recherche*,(INRIA, 2019) from 2013 a technical report (working copy) presented online is more informal and can be regarded as an appeal from researchers to other researchers to engage in science communication, but also as a comment on the former document with the same title. Finally, data was collected from the institute's website where among other things, the engagement in yearly scientific festivals, during which an important part of their communication with the public takes place. Data from these information sources are used as supportive or comparative elements.

This questionnaire was designed in an online survey tool and consisted of thirty items half of which were statements where the respondents were asked to indicate their level of agreement or disagreement on a 5-point response scale. (appendix B; item 4, 5 ,6, 28). By using Likert-type scales it is possible to detect latent constructs such as attitudes, feelings and opinions which are relevant features to this survey where researchers' and scientists' engagement is at the heart of the study. This type of questions has been used in earlier studies that focus on similar target groups (Merton, 2008). The other half of the questions consists mainly of close ended questions. The intention with these questions is to relate to the models accounted for in the theory chapter (appendix B; item 18, 19, 29, 30). Three questions deal with the respondents' actual participation in communication activities. It seems important to include these questions in order to counterbalance questions of more theoretical and hypothetical character. Two questions were open ended and asked for a short factual answer (discipline and the activity that the respondent had participated in). The number of questions may seem to be high, but this does not automatically have a negative impact on the response rate. According to Bryman (2016) respondents may be more tolerant, if they take interest in the topic. The aim of the entire set of these questions was to get a better understanding of why and how scientists engage in communication activities with the public .In order to cover various aspects of this subject the questions refer to five different themes: scientific-political drivers, personal drivers, perception on their research field, real activities, perception of communication skill and choice of channels.

4.3 Methodological limitations

The survey administrated online runs the risk of finding its way into the junk mail, but also to drown in a great number of emails or just be postponed and forgotten about. In these days, when the respondent is just a click away, we are all overwhelmed with soliciting surveys of all kinds. This is a real problem as the motivation to answer surveys diminish with the augmentation of requests. Another aspect is time. Compared to studies where qualitative interviews frequently are used as a method to collect information, the self-administrated survey has its advantages. The latter method does not demand a lot of the respondent's time, a factor that seems to be crucial. The interview, on the contrary is considerably more demanding in this respect.

A short but persuasive introduction might be helpful, if no other compensation is at hand to urge the respondent to participate. The online survey generally excludes a more personal approach through which it is possible for the investigator to show his appreciation. This distance also entails a loss of control once the investigator has sent the questionnaire. There are, according to Bryman (2016) reduced possibilities to know who really answers the question and to what extent they are discussed between the respondents. The same thing applies to clarification of questions. Even though it is technically easily done, it is rather an exception than a rule.

A questionnaire is composed by a limited number of items and is for that reason a rather limited instrument. If the questions in this survey had been formulated otherwise, the information would not have been the same. With any set of items, and especially close ended questions, there is a risk of missing out issues that seem important to the respondent which can have an impact on the response rate. In this survey the majority of the questions are close ended. Compared to open ended questions they are easier to handle for the respondents as well as for the investigator. The answers received from multiple choice questions are ambiguous, in the first place because the alternatives are pre-formulated and leaves little freedom to the respondents. In the second place, it is impossible to know whether the respondent took his time and really considered the alternatives or just ticked any box.

Even though the institute where this survey was done is a French national institute with research centres in France, solely, the research environment is international which means that everybody with a few exceptions understands English, the language used in this survey.

Ethics

The respondents in this survey were informed about the purpose and the handling of the collected data and their anonymity. There was an initial presentation in the questionnaire which also informed the respondent that participation is on voluntary basis The mail with the link to the questionnaire was sent to a number of mailing lists, but there was no way to reveal the identity of the respondents or whether he or she filled out the questionnaire. The answers were automatically sent to the investigator and registered in the survey tool. Only the number of answers could be listed but no expeditors. Even if the anonymity from the investigators point of view could be assured, there was always the question of what was registered from our activity online. For this reason, a paper survey has its advantages.

5.Results and analysis

In the following chapter the research questions are presented and the results will be analysed in relation to findings from other studies and relevant literature.

In this survey the respondents were confronted with thirty different items. Apart from three initial questions about age, gender and research field, twenty questions were formulated as multiple-choice items. Out of these, eleven items were close ended questions with fixed answers using a Likert scale with the options: strongly agree, agree, disagree, strongly disagree and no opinion. In addition, there was also a possibility to add a comment or an alternative. The respondents were asked to tick another ten close ended questions also giving the option to comment. Furthermore, there were five items of close ended character where several alternatives were possible but imposed. Finally, the survey contained two open ended question were short factual answers were demanded. The questions above were asked with the objective to cover the themes that are expressed in the aim with this survey. It should be noted that the questions in this survey were formulated in the light of earlier research in this field. The results presented below are analysed and discussed in relation to these findings.

- What are the personal and social drivers that incite this group of researchers and scientists to engage in communication activities with the public?
- How does this group of researchers want to communicate their findings to a wider audience?
- To what extent do new channels and tools enhance communication outreach and alleviate tensions?

5.1 Engagement linked to the variables age, gender and discipline

What may motivate scientists to participate in communication activities with the public? This question is asked by a great number of researchers in the field with different approaches. From one point of view scientists' engagement could be understood as planned behaviour which means that future behaviour depends on attitudes to the behaviour and subjective norms (Poliakoff & Webb (2007). Engagement could also be explained by looking at different interior and exterior drivers that urge scientists to participate in communication with the public (Merton, 2008, Stocklmayer, 2001). Whatever the approach factual variables as age, discipline and gender constitute one part of the study. This information is then related to attitudes, normative beliefs, efficacy beliefs and actual participation in activities with the public.

The three initial questions in this survey deal with age, gender and discipline. This is a way of identifying the respondent without breaking the rule of assured anonymity. Age generally constitutes a valuable component in surveys in which attitudes and behaviour are studied. In the same way surveys in the field of science communication incorporate this variable as earlier findings related to below show. The respondents of this survey mainly belong to the age groups 25-34 and 35-44. In the former age group, we find PhD students and post PhD students. This group could be categorized as young, but also, as a rule, loosely linked to the institute as they are engaged on contracts that run for a period of three or four years. The latter group is constituted of researchers and scientists who are attached to the institute by permanent contracts and in the middle of a career. Moreover, the respondents are likely to represent several nations. Official figures from the institute declare 105 nationalities represented among researchers, PhD students and post doctorands in the region Grenoble Lyon.

Table 2. Respondents in this survey. Number, age and gender.

N=24	MEN	WOMEN
55+	0	1
45-54	3	0
35-44	4	2
25-34	8	3
UNDER 25	2	1

One way of measuring engagement is to find out to what extent scientists and researchers participate in communication activities with the public. The first figure illustrates the respondents' participation in communication activities in general. The second figure shows the respondents' participation in science festivals.

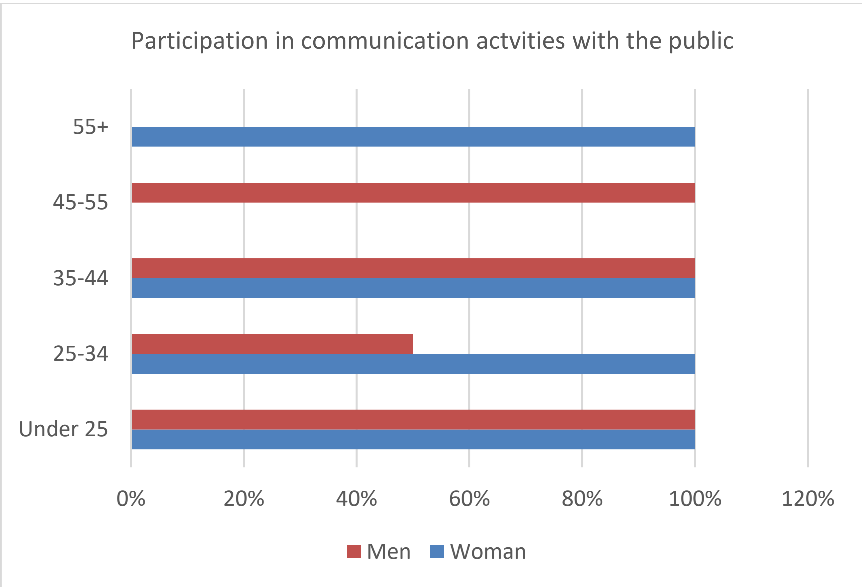

Fig.1 Respondents who have participated in communication activities according to age group and gender.

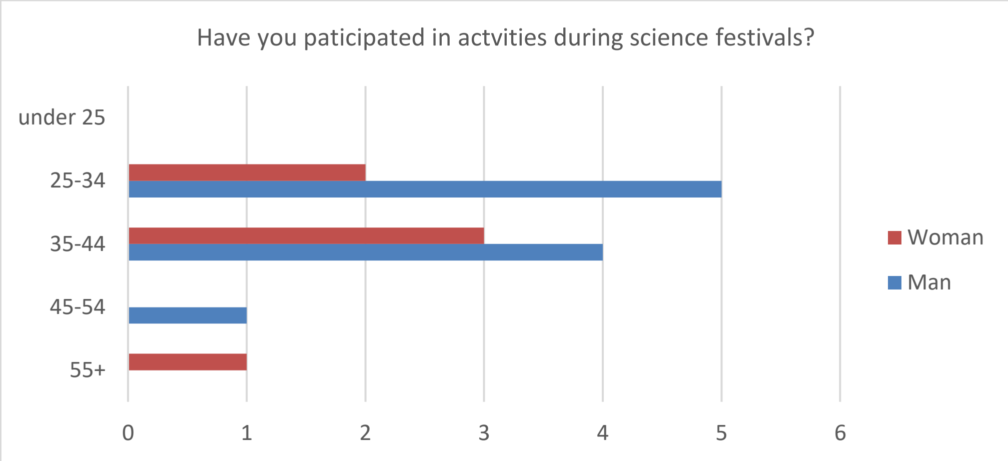

Fig.2 Number of respondents who have participated in science festivals.

The respondents who chose to participate in this survey were mainly men which may very well reflect the gender split at the institute. It is not possible to give the exact percentage as PhD students come and go, but an instant picture would show that about 20% of the researchers and scientists are women. Of the respondents in this survey 70% are men and 30% women. It should be taken into account that the research areas covered in this survey are focused on mathematics and computing science, two research domains which traditionally attract more men than women.

Figure 1 illustrates the repartition of men and women in each age group and the degree of participation. The figure shows that 50% of the men in the age group 25-30 have not participated in any communication activity with the public. The reasons for this absence can only be suggested. This age group is usually in a phase when preparing a future career is important. In line with Rödder's (2012) findings, communication activities are not recognized within the scientific sphere and therefore not a priority to scientists with a career goal in mind. Figure 2 shows that the age group under 25 has not been engaged in activities during festivals and open days. They have, however been active in discussions on social media and presentations of their work outside the institute. Overall, the respondents show engagement. 83 % of the respondents participate, thus, in some kind of communication activity.

Earlier studies show that demographical variables as age and gender are linked to communication activity and behaviour. (Bentley & Kyvik, 2011; Besley, Oh, & Nisbet, 2013; Crettaz von Roten, 2011; Kreimer, Levin, & Jensen, 2011; Kyvik, 2005; The Royal Society, 2006, cited in Besley et al., 2018). A majority of these suggests that older scientists are more likely to engage with the public than younger scientists. One explanation which is put forward by Rödder (2012) is that scientists with a long career are more often contacted for this kind of activity as they hold more important positions. France was in this respect an exception as junior scientists answered more favourable to engagement in science communication activities (Jensen 2011). In the same way studies have shown that young scientists are more active when online actions and events are involved (Besley, 2018).

Several researchers who studied engagement linked to gender found that men were more likely to engage, but there again Jensen (2011) who studied French scientists came up with a deviating result, as women showed more interest in engaging activities.

Research field

In this study the respondents were asked to specify their field of research. The question was not compulsory. As the research areas are restricted to Applied mathematics and Data science it is only possible to say something about the relationship between these disciplines and researcher's tendency to participate in communication with the public. 17 out of 24 respondents in this survey work in the Data science field but, there is nothing that indicates that there is a difference in approach regarding communications activities in the two research fields Data science and Applied mathematics. There is reason to believe that the activity in the Data science field is higher because of the extended outreach to groups of schoolchildren and teachers in which programming workshops, for example Scratch, take place on a regular basis. On the other hand, the discipline Applied mathematics holds subdisciplines like robotics and virtualisation, two areas that attract interest from a diverse audience during open days, for example. Generally, it could be argued that Data science and Applied mathematics are two disciplines that have "wind in their sails". Both disciplines belong to cutting-edge technology that attracts investors as well as sharp brains, and a thrilled audience. Big companies such as Airbus, EDF, Nokia and Total find it interesting to work in partnership with research team from this institute. These circumstances are likely to facilitate communication and enhance engagement.

According to earlier research, there is some evidence that scientists from certain disciplines tend to participate more in communication activities than others. Jensen (2011) who, in the first place investigated six major different disciplines and then forty subdisciplines, found that there was a difference between the disciplines regarding communication activities. While 84,8 % of social scientists were active at least once, only half of the biologists and chemists reported their presence in any communication activity. Among the highest scores within Social Sciences we find Sociology, rules and regulations; Society and cultures; Politics, power and organization. On the other hand, chemists showed more engagement for actions in schools than social scientists. Another interesting result from this study showed that biologists who dealt with subjects that generate public debate, for example GMO, were much more active in communication activities than other subdisciplines of biology. According to Jensen (2011), this could be interpreted as a pressure from the public upon scientists to engage in wider public discussions in a situation where more scientific information is not regarded as a satisfying answer to questions. A similar tendency is registered in health topics (National Science Board, 2016). From Jensen's comprehensive study we learn that the engineering departments where Information science and technology is found, show an activity percentage around 55 which is somewhat lower than Physics, 61% and somewhat higher than Chemistry, 46 % (Jensen, 2011).

5. 2 Personal, social and political drivers

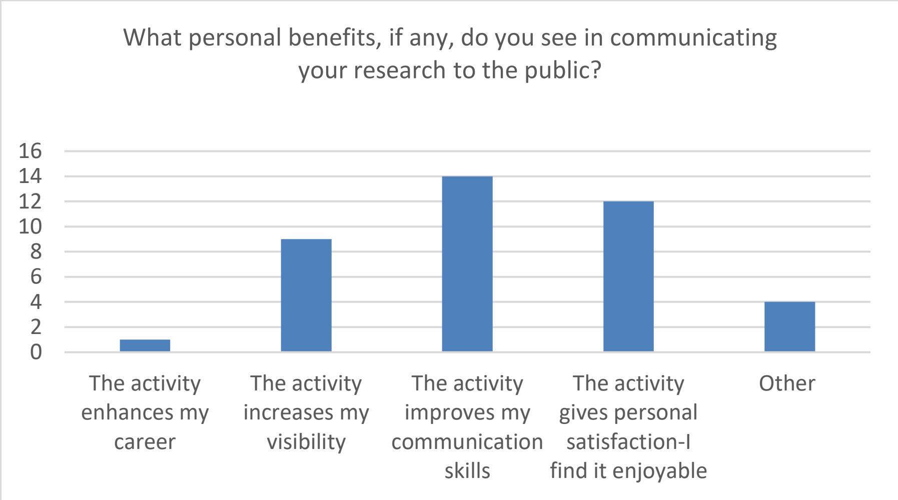

Fig. 3 Perceived benefits in communication with the public

The respondents see a number of personal benefits in communicating with the public. In this close-ended question four different suggestions were given with the possibility to tick all of them and add a personal alternative. The alternative "The activity improves my communication skills" is the strongest personal driver among these respondents. Personal satisfaction is also an important personal driver. Wanting to improve one's communication skills indicates that the respondents fear insufficiency on this matter. Combined with the second most chosen alternative which deals with personal satisfaction, the interpretation could be made that the researcher wants to do this job which he or she finds enjoyable in the best way. It is, undoubtedly, a sociable activity, and different from the daily routine. This factor may contribute to a feeling of personal satisfaction. The comment which is made under the alternative "other" suggests that the respondent sees communication activities as a part of his job and is eager to do this well in order to get satisfaction.

"I see it as a part of my work to increase knowledge about my research field."

The benefits described as enhancement of career and more visibility are closely linked and therefore difficult to separate. The notion of visibility is a phenomenon that is of great importance not only for researchers but for a wider audience in general. Social media and online tools make it possible for each one of us to make our voice heard and show our face with the intention of creating our own social career. In the same way the researchers publish their findings with the purpose to be read and disseminated. In the first place, researchers are likely to enhance visibility within their discipline among their peers, but visibility in contexts outside this sphere is also of great importance. Today, visibility is necessary to raise funding for personal or institutional purposes, but visibility can also function as goodwill for a specific research area which in turn attracts new students as well as funding. Finally, an improved visibility enhances the possibility to reach career positions with more influence and funding.

A successful researcher is not always a communicator. That is why obtaining improved communication skills is a personal driver. What techniques and channels to use can be learned from handbooks, colleagues, workshops and by practicing. In fact, the researcher enters into a different domain where professional communicators and journalists dwell. By taking on the communicating himself the researcher has more control of the process and *what* is said but is not always comfortable with *how* to say it. Furthermore, today researchers are supposed to communicate their findings, either with the help of a mediator or directly to a wider audience which stresses the importance of improved communication skill (European Commission, 2013).

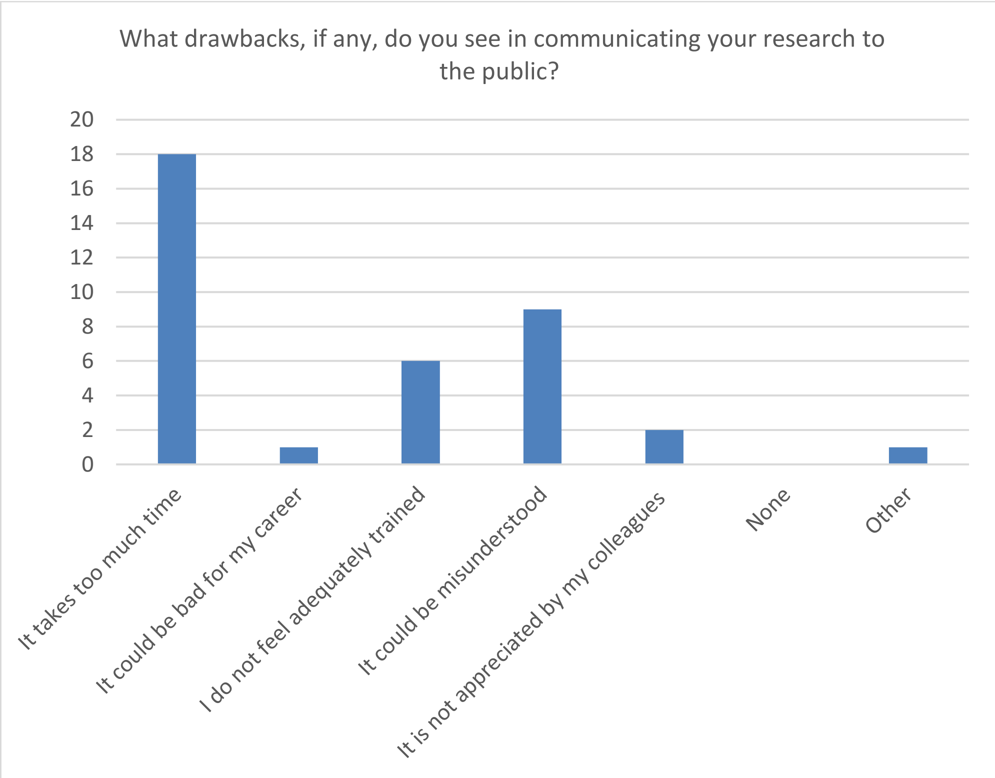

Fig.4 Perceived drawbacks in communication with the public

The respondents were given the possibility to tick several alternatives which means that the chart above shows the total of one of each of all alternatives that were ticked. Figure 4 illustrates that the respondents are most concerned with the time factor. The respondent also fears that there is a risk of being misunderstood.

As mentioned above, scientists have the responsibility to share findings with a wider audience, and consequently new tasks are added to the researcher's agenda. It takes time to write books, prepare lectures, arrange workshops or participate in debates. It is understood that newly added missions take time that could be used otherwise and is for this reason regarded as a drawback. Yet another drawback, which is highlighted in the respondents' answers, is the possibility of being misunderstood. This issue could be due to the researcher's lack of communicating skills or the audience's level of knowledge. In the only comment given under the option " other" "People understand but are not applying what they learnt most of their time" it is suggested that even though information or knowledge has been communicated, there is no guarantee that people who have been confronted with new knowledge will change their way of thinking or behaviour. Therefore, communicating is not enough. The height of the bar *I do not feel adequately trained/equipped* suggests that further training in communication skills is needed.

According to Merton (2008) personal drivers that are in involved in scientists' communication with the public stems from a mixture of altruism and individual benefits. Engagement with the public can be seen as a personal challenge but also be a means of recruiting new students. Merton (2008) who asked the question "Why get involved in science communication? to researchers in the biotechnology field, were able to discern six different reasons.

- Sharing- responsibility to share with the public for funding reasons
- Recruitment- influence students to take up science
- Science and society-a better informed society makes better decisions
- Pragmatic- fulfil requirements attached to funding
- Personal satisfaction-an enjoyable and morale-boosting activity
- Career- possibility of career progression

In fact, some of these drivers could be looked upon as personal as well as socio-political, but as Merton (2008) points out, the individual scientist is also a part of society. The responsibility to live up to requirements from funding is, thus, both political and personal. On the one hand, the state and its citizens want a return on an investment and on the other hand the scientist is eager to perform in order to obtain funding for further research.

The belief that science can contribute to a better society is not, however, conditioned by any exterior obligation – the scientist is free to adhere to this idea or not. In the same way, no one from outside is able to impose personal satisfaction. Whether a scientist experiences this feeling could be a question of personality (social and outgoing), but also a question of how well the scientist controls the techniques of communication. For this reason, user control, where linguistic as well as presentation techniques and tools become important factors that contribute to personal satisfaction.

In 1990 Csikszentmihalyi described a state of mind which he called flow. In this condition where "people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at a great cost, for the sheer sake of doing it" (Csikszentmihalyi, 1990, cited in Obrien & al., 2008, p. 4). Csikszentmihalyi mainly referred to witnesses experienced by skilled professionals as medical surgeons or craftsmen. Focused attention, feedback, control, activity orientation and intrinsic motivation are, however, some of the attributes that the flow theory shares with engagement. 'Taking position' which will be discussed in detail below, is based on a personal conviction that leads to a deep and dynamic engagement.

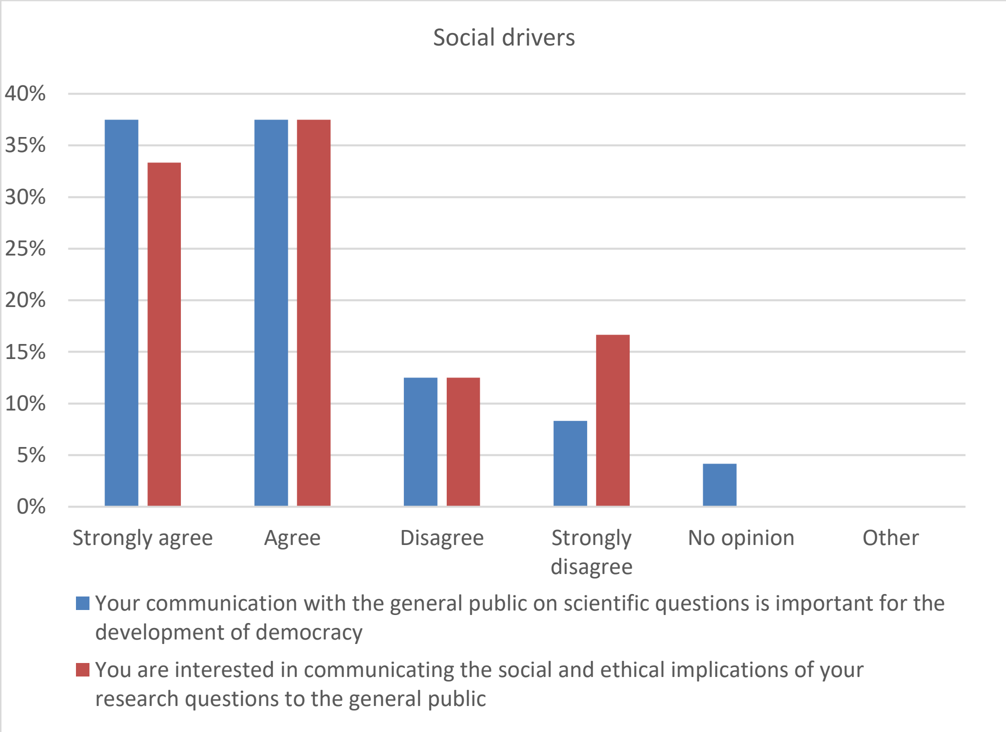

Fig.5 Perceived social benefits in science communication

Beyond skill, while the hypothesis has not been widely tested, the belief that engagement will have a positive effect on the real world—response efficacy (similar to external efficacy in political contexts)—may also drive engagement (Besley, 2014, p 10).

The attitude to science communication's importance for developing democracy is a social driver. 76% of the respondents strongly agree or agree with this statement.71 % of the respondents are interested in social and ethical issues linked to their research which also could be referred to as social drivers (Merton, 2008). The figures of chart above reveals respondents who think that communication with the public on scientific question is important for the development of democracy are also interested in communicating ethical and social implications in their research field to the general public. The result implies that researchers and scientists share the standpoint that facts are always part of a social and moral context. For this reason, they find it legitimate to approach questions about funding of their research as well as potential consequences of exploiting their findings.

Governmental and institutional policies promote science communication as a good thing and the activity is therefore considered to be of great importance. Science communication is currently, by this means, a question on a political level. Consequently today, most universities and institutes inscribe their communication goals in the official strategic plan in order to meet political requirements. These requirements are based on assumptions that well-developed science communication is beneficial for both parts, the scientists and the public, and also greatly contributes to the development of society on many levels. These ideas equally find support in research. Stocklmayer et al. (2012) identify and discuss five possible benefits of science communication:

- economic
- utilitarian
- social
- cultural
- democratic

From an economic point of view, science can be considered as beneficial as it contributes to making a country more competitive on an international market. New products and methods enhance economic growth. In that respect, science and its implications are looked upon as a product that creates money value. Science is also implied when innovations find their way to individuals where they can be of help in daily life. The social benefits can be observed in health care where science has proved its efficiency. Similarly, science is transmitted through the educational system in the hope of better equipping new generations. As Merton (2008) points out, science is a part of humankind and cannot be separated from our cultural activities. Moreover, even though Stocklmayer et al. (2012) have identified different sectors within which benefits have been found, it could be claimed that the dividing lines between these areas is not always obvious. The democratic benefits will be the outcome of well-informed and interested citizens who are able to make decisions based on scientific facts. All things considered, the thought is that science contributes to a better society for people to live and act in.

The French institute where this survey was done has approached these aspects in a document published online: *Mediation scientifique en science numérique:une facette du métier de la recherche.*(Institut de recherhe en informatique et en automatique) In the introductory part of this document we find the question: Why scientific mediation? The arguments found in Stocklmayer et al. (2012) are all present in this document.

- ✓ Economic argument: Show the importance and the need of public investments. Show how the money is invested.

- ✓ Utilitarian argument: Show how different economic sectors are linked to computing. Its importance for new job opportunities. Show the importance of mastering new technology.

- ✓ Social argument: Diminish the gap between computing literate and non-computing literate.

- ✓ Cultural argument: Acquire a scientific culture in order to better understand the bases.

- ✓ Democratic argument: Educate people and encourage them to participate and engage in the development of the usage of new technologies.

In order to make these arguments more concrete and manageable, some of them are transformed into questions.

In what way does computing science contribute to equal chances in life?
(Comment la connaissance de la science informatique contribue-t-elle à l'égalité des chances ?)

How can scientific mediation in computing change the use of computing tools or the tools themselves? (Comment la médiation scientifique en informatique peut-elle changer les usages des outils informatiques voire les outils eux-mêmes ?)

*Médiation scientifique en science numérique: une facette du métier de la recherche.(*Institut national de recherche en informatique et en automatique*)*

As mentioned above, it is difficult to draw a dividing line between personal drivers and social drivers. What is more, we have seen that is possible to make a difference between political, social, economic, utilitarian, cultural and democratic drivers (Stocklmayer et al. 2012). Even though it is obvious that each one of these could be studied separately, it could be argued that the beneficial outcome of these drivers contributes to the development of democracy and its values.

Scientists are often accused of hiding in their ivory tower, reluctant to communicate with the rest of the world. To counterbalance the exclusivity of this group, scientists are urged to extend their working field and exchange their intellectual ground with society in line with expectations from the public. This closer relationship is, however, according to Neveu (2003) not without implications on the scientist's independency. The scholar communication scrutinizes scientific work according to internal norms and rules that constitute a guarantee for objectivity which, under ideal circumstances, is free from bias not only from internal institutional hierarchy, but also from external influences. In this context it is possible to refer to Merton's institutional values where independency and objectivity play an important role in a scientific society separated/detached from the rest of society. Neveu (2003) remarks that objectivity and independency can be difficult to defend and maintain in a situation where the border between the scientist and the public becomes less distinct. Involvement in social and political questions may lead to the loss of institutional and intellectual independence. In opposition to this, it could be argued that a complete independency is impossible in any situation. Private as well as public institutions give their guidelines and demand some kind of return.

5.3 Engaged – taking a stand

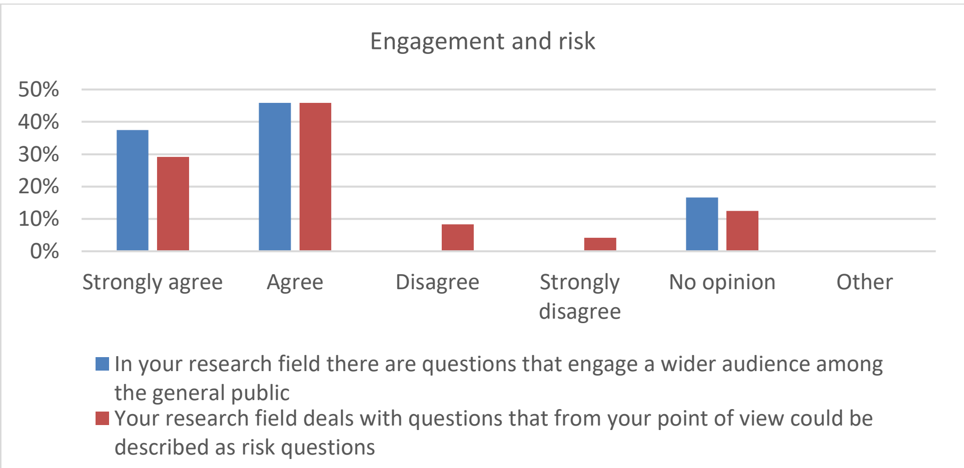

Fig. 6 Respondents' attitude to the general public's engagement. Perception of the research field as a risk domain.

The chart reveals that 84% of the respondents think that their research field engages a wider public. 75% of the respondents agree that their research field deals with questions that could be described as risk questions. As mentioned earlier, the respondents do research in Data science and Applied mathematics. In these domains we find data privacy, developing of algorithms, questions of Big data, robotics, self-monitored cars, artificial intelligence and many more. The development in these fields both fascinates and scares. As edge-cutting research fields, the implications of this research are not a highway into the future. A number of questions are raised in order to ask: Is this a future we aspire for? The respondents are aware of the risk factor and as chart number 5 shows, they are also interested in communicating social and ethical implications to a wider public.

Being an engaged scientist may also be a question of intervening and taking position in social and political matters. This is a controversial question. Neveu (2003) maintains that scientists, as intellectuals, have an obligation to go public with their research even if the findings are morally, ethically, socially or politically incorrect. Neveu (2003) discusses these questions from a sociologist's point of view. In social sciences, research can be performed in the light of social and political ideologies. On some occasions the researchers purposely take a stand, but in the opposite case the researcher runs the risk of being categorised in some political or ideological fold and expected to defend adherent values. As Fleury-Vilatte & Walter (2002) point out, researchers who deal with politically and ethically delicate areas such as, former Yugoslavia or Sohua might find it more difficult to find a balance between objectivity and delicacy. Subjects that are more likely to engage than others may often lead to controversies. With this perspective in mind, Heinich (2002, cited in Fleury-Vilatte & Walter, 2002, p. 127) suggests that researchers best use their intellectual capacities when they are able to hold a position of what she calls 'neutral engagement', in order to work for compromises and consensus when different ideas and values are liable to develop into conflicts. In addition to this, it can be noted that during a period of time, especially in the sixties, seventies and eighties an engaged scientist was, with a few exceptions, equal to radical in the sense left wing with the ambition to bring about change on the ground.

From the public's point of view, there are certain fields of research that attract much attention and engage more than others. Van der Sanden & Meijman (2008) discuss the issue of awareness in science which includes feelings and emotions like fear, insecurity and confidence related to scientific issues. Some of the topics are climate change, use of pesticides, vaccination and GMO. Today, topical subjects reach high visibility when enhanced by the debate in social media. Not so long ago, but before blogs, FB and Twitter were tools within everybody's reach, people engaged in matters like nuclear weapons, Chernobyl, asbestos and HIV. According to researchers (Kahan, 2017) the public become more easily involved with research when risk is involved. (Grunig, 1974, cited in Borchelt, 2001, p. 178) described the public as passive and uninterested in science, unless there was risk involved. Over the years the feature of risk has developed into a distinct research field with its own publications. The *Journal of Risk* established in 1998 covers different aspect of risk analysis; communication and decision making.

The fact that people show more interest in scientific questions nourishes media, which in turn solicits scientists to be more present in the public room. There are also scientists who choose to engage out of personal reasons.
In this context it should be mentioned that engagement often engenders controversy and that full access to information does not necessarily lead to a better understanding of different points of view.

Never have human societies *known so much* about mitigating the dangers they face but *agreed so little* about what they collectively know. Because this disjunction features the persistence of divisive conflict in the face of compelling scientific evidence, we can refer to it as the "science communication paradox" (Kahan, 2015, p.1).

According to Kahan (2015) it is possible to distinguish two different hypotheses that would explain this paradox. The first, the public irrationality thesis, is linked to scientific literacy – the public is not scientifically literate, does not know facts, to the same degree as scientists. Whereas scientists use analytic reasoning drawn from empirical studies, the public gives more importance to unconscious emotions and appraise danger (Kahan 2015). A second hypothesis is that the cultural cognition thesis could explain the science communication paradox. This occurs when positions of facts are a result from wanting to identify with a group or a network that shares your moral values, social norms and political point of views (Kahan, 2015). According to Kahan (2015) the assessment of a scientist's degree of expertise is made out of the values of the group. A scientist who presents facts in line with the group's ideal is more likely to classify as an expert than someone who derives from these norms (Kahan, 2015). Kahan (2015) illustrates this in a figure called biased perception of scientific expertise. What is more, Kahan and his research colleagues also show that those members in each group who had a high level of scientific literacy are those whose perception of risk diverge the most (Kahan et al., 2012). Individuals with high score in the reasoning part of the scientific literacy test use their capacity to make a selection of the facts that supports the values of their own cultural group (expert consensus). Kahan (2015) suggests that there is a way to tackle this phenomenon. Studies have shown that a different approach through which identity is disentangled from knowledge, can help citizens to use scientific knowledge to address practical needs. In a situation where people do not feel obliged to choose sides, they are, as Kahan (2015) puts it, ready to act out of what they know and from what they are. "Individuals spend most of their time with people who share their basic outlooks, and thus get most of their information from them" (Kahan, 2015, p. 5).

In a recently published article Kahan (2017) investigates the correlation between scientific literacy and global warming beliefs and risk perception. In order to measure what Kahan (2017) calls scientific intelligence, he uses different kinds of questions most of which have been formulated by the NSB (National Science Board). The number of right answers in this context is supposed to be an indicator of science intelligence. In this case, Kahan and Kahan et al. (2017, 2012) finds no significant correlation between science intelligence and risk perception linked to global warming. Thus, scientific literacy, as it is defined here, plays a minor role in comparison to people's apprehension of cultural and political belonging. Kahan's study was made in the USA and according to the author the result says more about *who the people were* than how much they know about science. Consequently, trying to

convince people by disseminating more information would have very little effect. The US general public's perception of risk in global warming is due to other factors than scientific knowledge.
Examples of risk areas that are referred to in Kahan's article are: artificial food colouring, global warming, nanotechnology, private gun possession, fracking, genetically modified food, radio waves from cell phones, use of artificial sweeteners in diet soft drinks, residential exposure to a magnetic field of high voltage power lines (Kahan, 2015, p. 5).

In defence of science

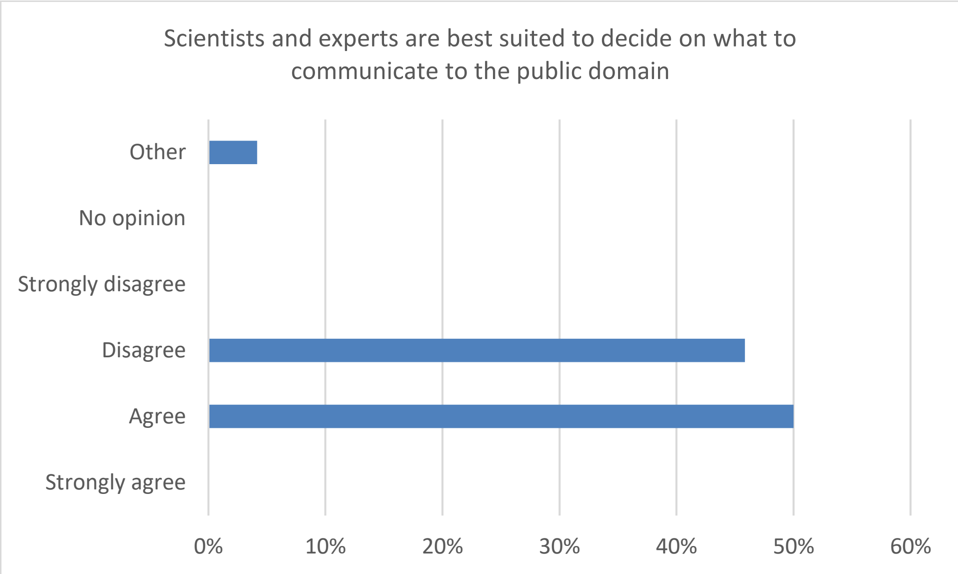

Fig. 7 Respondents' attitude to their own suitability to choose what to communicate to the public

The chart above shows that scientists and researchers in this survey are divided on this matter. 50% of the respondents agree with the statement that scientists and experts are best suited to decide on what to communicate to the public domain whereas 46% disagree. The result suggests by very little, 4% (one person), that the researcher is the best suited to decide what to communicate on. Well known representatives of science, as shown below, argue that the initiative has to be taken by scientists themselves. The reason for this is that data has to be correctly interpreted and only scientifically trained people are capable of making the distinction between findings obtained by scientific methods and non-scientific opinions. The former defined as truth and the latter defined as belief. Deciding on what to communicate is an efficient means of control. Nevertheless, the respondents in this survey take on a more modest attitude. There is a possibility that the answers suggest that the scientist is an expert in his domain but is willing to let other groups in society decide on what to communicate. There are other opinions, such as the citation here below indicates. Scientists and researchers are urged to leave their laboratories and offices with the aim of defending science itself.

> The enlightenment is under threat. So is reason. So is truth. So is science, especially in the Schools of America. I am one of those scientists who feels that it is no longer enough just to get on and do science. We have to devote a significant portion of our time and resources to defending it from deliberate attack from organized ignorance. We even have to go out on the attack ourselves, for the sake of reason and sanity (Richard Dawkins Foundation for Reason and Science 2007, cited in Trench, 2010 p. 122).

When this appeal for scientific truth was launched with the support of one of the most well-established scientists, Richard Dawkins, the debate on fake news had not yet started. At this time, “The crusade”, as Trench (2008) puts it, was aimed at pseudo-scientific movements that had won an increasing popularity among individual citizens as well as among professionals. The targets were mainly the alternative medicine sector such as homeopathy and activities promoted by fundamentalist religious movements (Trench, 2008). There were, according to Trench (2008), several scientists who felt indignation over the fact that individuals with authority, but without scientific training or understanding, were allowed to influence the public with their junk science.

This kind of engagement appears when the entire establishment of scientists feels a moral duty to protect the public and science from non-scientific beliefs and ignorance. The above citation was published more than a decade ago, but the potential threat from unreliable sources seems to be still prevalent. A topical issue where scientists have seen reasons to react against ignorance deals with the issue in which benefits of vaccinations were called into question. The fact that *Marches for Science* were organised in many places in 2017 is another example that science seems to need its defenders. In the United States this was primarily a protest against President Trump’s environment policy, but in France the scientists also claimed to defend science from ideologies.

5.4 Engaged - objectives and models

Science communication is about science, but there are different ways of interpreting *science* within *science* as discussed below. In daily speech we talk about conveying findings which are facts that have been approved by a scientific method. It is also possible to include reasoning as well as reflection. Is there a body of knowledge to communicate? Is there still a need for books such as *All you need to know about*…?

If science is defined as facts then this is what science communication should be about, but if science is a method rather than facts, the methodology should have priority. When the National Science Board tested the scientific level among the American public in 2016, the respondents had to choose between true or false for 9 statements some of which were: *Electrons are smaller than atoms. Antibiotics kill viruses. Laser works on sound waves. It takes the earth one year to travel around the sun.* (National Science board 2016). National Science Board has been assessing Americans knowledge about S &T since 1979. According to National Science Board (2016) the scores obtained from these factual questions represent a reasonable indicator of basic science knowledge. The questions are completed with further sections with the headings: understanding scientific terms and concepts, reasoning and understanding scientific process, pseudoscience, perceived knowledge importance of science. Furthermore, there is a comparison with scores from nine other countries.
If science is a question of scientific method the focus should be on theory building, hypothesis, falsification theory, inductive and deductive methods. Another approach is to consider different aspects of the concept ‘science’ throughout history.

From facts to scientific literacy

Science communication and outreach is a question that deals with values closely linked to the development of a democracy. The final objective is that "people are *aware* of, *interested* and *involved* in, form *opinions* about, and seek to *understand* science" (Burns et al., 2003, p. 190). This means that the public has obtained a certain level of scientific knowledge, which could be measured, according to National Science Board (2016). This knowledge is mainly acquired through the educational system. It is important that the public feel that they are concerned by scientific questions and that their engagement has an impact on their living conditions.

Scientists and researchers choose to engage in activities that enhance all aspects of science for different reasons. As shown above, researchers in this survey do think that communication with the general public on scientific questions is important for the development of a democracy and 71 % are interested in social and ethical implications linked to their research area.

When Horst (2008) discusses the implications of science communication she underlines the fact that from an early stage there was the assumption that science would not only improve physical living conditions, but also contribute to the individual's ability to make political decisions. Moreover, the attitude to and confidence in science would grow. Seen from this angle it is easy to understand why science is looked upon as an important factor to reach social progress. In this context researchers introduce the term 'scientific literacy' which could, according to Durant (1993, cited in Horst, 2008) be interpreted in different ways: to know a lot of scientific facts, to know how scientific research works or to know how science works in society.

In 2003 Burns et al. (2003) presented what they at the time described as a contemporary definition. Science communication that strives for science literacy is represented as a mountain-climbing analogy. In short, a tool kit of skills (for climbing) the media (ladders), activities (the act of climbing) and finally the dialogue(encouragement) is needed to enable the process of communication. At the foot of the mountain we find public awareness of science, a bit further up public understanding of science and up at the top science literacy. All this is surrounded by a cloud of scientific culture. To clarify the analogy further it could be mentioned that science communicators or mediators may be thought of as mountain guides who help with tools and advice. Moreover, the ladders not only facilitate mounting, but also make it possible for people of different scientific literacy levels to meet half-way in order to learn something new from other levels. In fact, Burns et al. (2003) suggest that many scientists have acknowledged the benefits of sharing their knowledge to a non-specialist public and thereby not only develop their communication techniques but also get useful perspectives from outside. The same situation applies when scientists communicate with their peers.

Choice of model

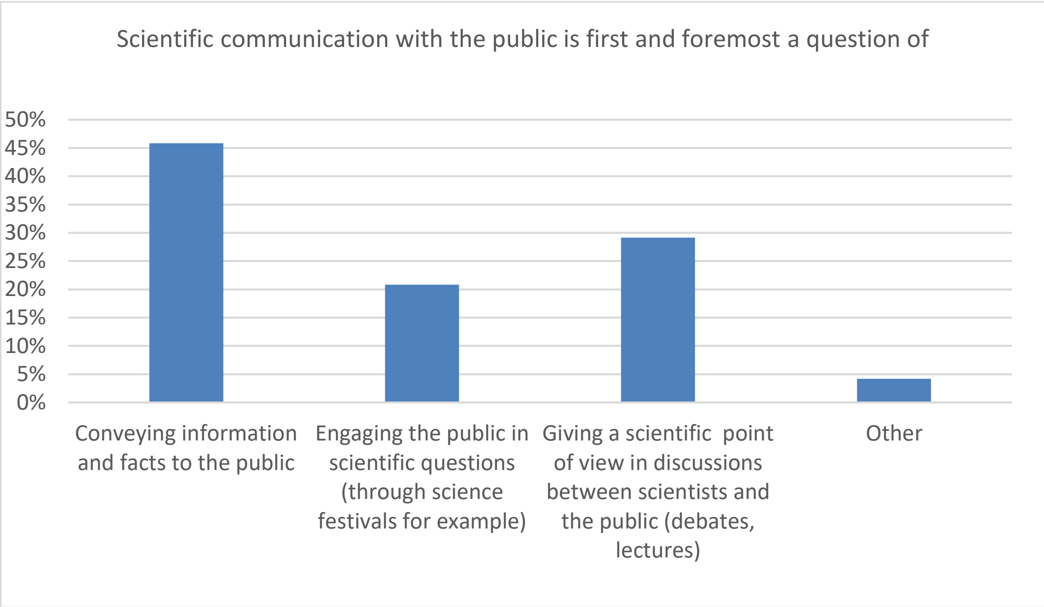

Fig.8 Respondents' perception of communication

According to the respondents' answers, scientific communication is first and foremost a question of conveying, (46%) and secondly, giving a scientific point of view, (29%). This question was asked with the aim of getting some information about how their communication could be related to the three models that have been described earlier. Communication is, thus, by these respondents a question of transmitting findings and facts to the public. The answer could be interpreted in two ways: The researcher fulfils an obligation by communicating the findings which is the result of many years of hard work to the public. It is also possible that the respondents refer to the need of filling the 'information gap' that distances the scientist from the non-specialist. Respondents who answer that communication is first and foremost a question of giving a scientific view in debates are more orientated towards the dialogue model.

Trench (2008) points out that over the years, three major communication models have developed within the science communication field. Trench (2008) suggests that they represent one-way, two-way and three-way models. Conveying information is linked to the deficit model which has been criticised of being a top-down model, only good for filling the information gap. The dialogue and participation models involve a higher degree of interaction between scientists and non-specialists, and for this reason, these models are more in line with a democratic development. According to Trench and Junker (2001, cited in Trench 2008), the deficit model is still dominant in the science sector. However, these three models seem to develop and to co-exist rather than excluding each other (Trench, 2008).

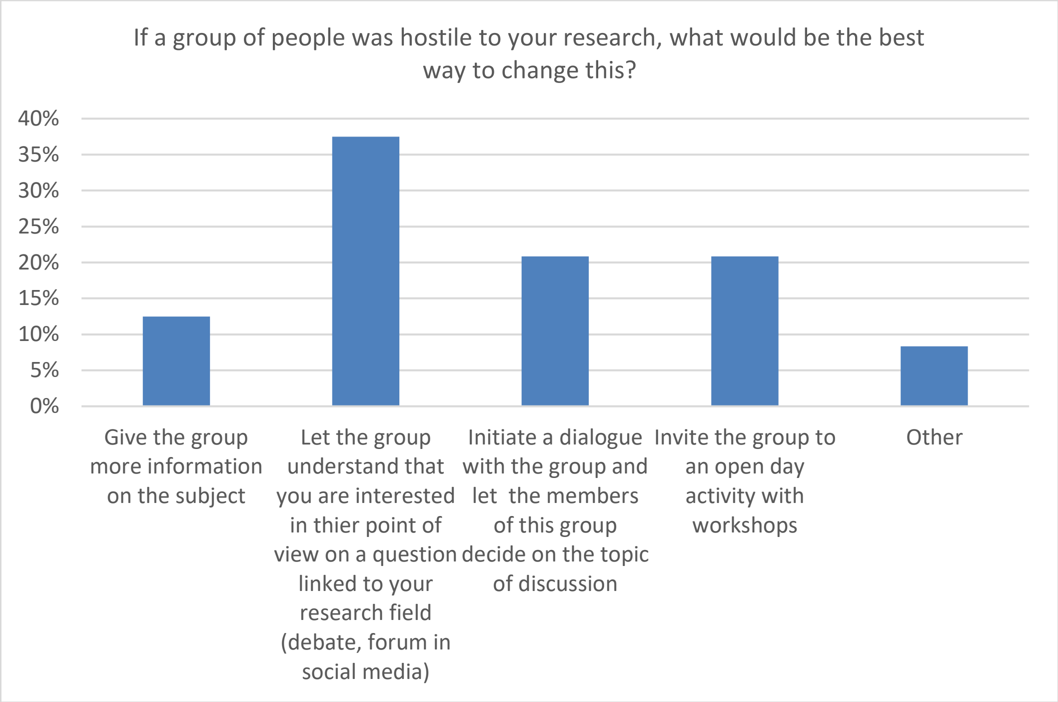

Fig.9 Scientists' communication approach to hostile groups

The chart above shows that 38% of the respondents are interested in discussing questions and listen to arguments from a group that are hostile to their research. Initiating a dialogue or inviting to an open day activity is found as an appropriate approach by 21% of the respondents. The fact that the alternative which suggests more information on the subject only attracts 13% suggests that a majority of the respondents does not think that hostility is a sign of ignorance which could be remedied by giving more information. The assumption that " if only people were better informed, they would see that the scientific understanding of the world is the most correct one" is discussed by Horst (2008, p. 261).

It goes without saying that communication with an interested and attentive audience is preferable to an inattentive audience. In most situations referred to in this study, such as lectures, workshops or debates, people attend because they take an interest in scientific matters. If the objective is to reach remote target groups that usually do not feel concerned about scientific issues, then different strategies which involve a reflection on the choice of communication model have to be taken into account. The approach will depend on the scientist's communication skills, but also on the scientist's attitude towards the audience.

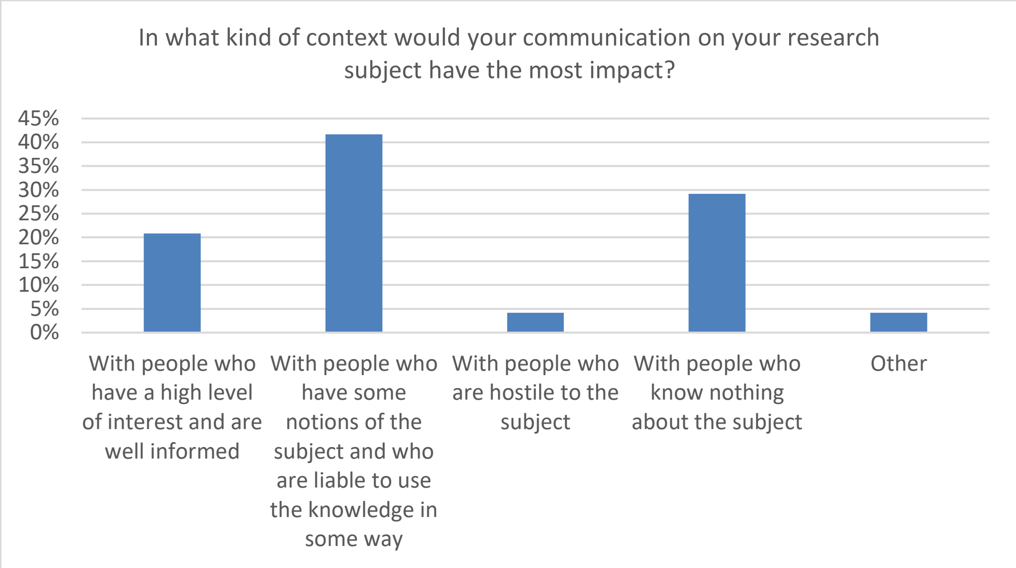

Fig.10 Respondents' communication impact related to different groups

Yet another important factor is that scientists are more likely to engage when the public take an interest in their research field (Rainie et al., 2015). Science communication literature refers to the attentive public (people with a high level of interest in a given issue and a sense of being well informed about that issue), the interested public (people who are aware of the subject and may use the gained knowledge), and the residual public (people who are neither attentive nor interested, therefore only a remote target group) (Miller and Pardo, 2003, cited in Van der Sanden, 2008).

The results from the survey at the French institute suggest that the scientists think that their communication is most efficient in a situation when the audience has some notions of the subject and are likely to use it in some way.

In the same way Besley et al. (2018) found that scientists who have a positive attitude to their audience are more likely to engage with it. In order to illustrate this, Trench (2008) presents a model in which he relates communication models, deficit, dialogue and participation to science's orientation to public.

In the table below Trench's (2008) original model that shows the relationship between communication model and science's orientation to the public is simplified. (the original model contains further parameters than accounted for below (Trench, 2008, p. 131). In this model it is suggested that the deficit model is used when the public is regarded as hostile or ignorant. An example of this would be the appeal made by the Richard Dawkins Foundation, which is mentioned above, in which there is an urge to 'science' to defend truth from organized ignorance (Trench, 2008). In this context the battle was targeting the alternative medicine sector, but since then other battles in the name of scientism (the belief that science is the superior knowledge system and can provide all the questions worth asking) have been fought (Trench, 2008).

Table 3. Communication model related to publics

COMMUNICATION MODEL IN PCST	SCIENCE'S ORIENTATION TO PUBLICS
DEFICIT	They are hostile They are ignorant They can be persuaded
DIALOGUE	We see their diverse needs We find out their views They talk back on the issue
PARTICIPATION	They and we shape the issue They and we set the agenda They and we negotiate meaning

Model from Trench (2008, p 131).

In the dialogue model the notion of *the public* is extended to a multitude of 'publics', each with their specific needs. The representatives of science show a sincere interest in their points of view and expect dialogues with the audiences.

In the participation model science and audiences are regarded as equal partners and are expected to set the agenda and decide on the issue in order to negotiate the meaning. This model finds its equivalence in the form of government called participatory democracy which "seeks to promote a form of self-determination or self-rule in which individuals actively make the decisions that determine how they are to be governed. It gives citizens a central role in the making of particular decisions through, for example, public discussion, negotiation, and voting" (Bevir, 2009, p.145).

5.5 Mediation - norms and conflicts

Several arguments have been put forward in order to enhance scientists' engagement in communication with the public. Dissemination of scientific knowledge is promoted by governmental and institutional policies with the objective of making people better democratic citizens (Horst, 2008). Furthermore, researchers in the science communication field suggest that a more efficient science communication is beneficial for society, as well as for the individual scientist (Stocklmayer, 2012). In short, science communication with the public is a good thing. Nevertheless, it is not possible to ignore some conflict areas. According to Rödder (2012) these are found in the "medialization of science" (Rödder, 2012, p. 156). Rödder (2012) discusses these conflicts in the light of normative expectations from institutions that contradict one another. Established norms and ethics in the scientific sphere are confronted with media visibility. Mediation of science is also linked to other questions such as linguistic issues, the scientist's attitude to mediation and presentation skills which will be discussed below.

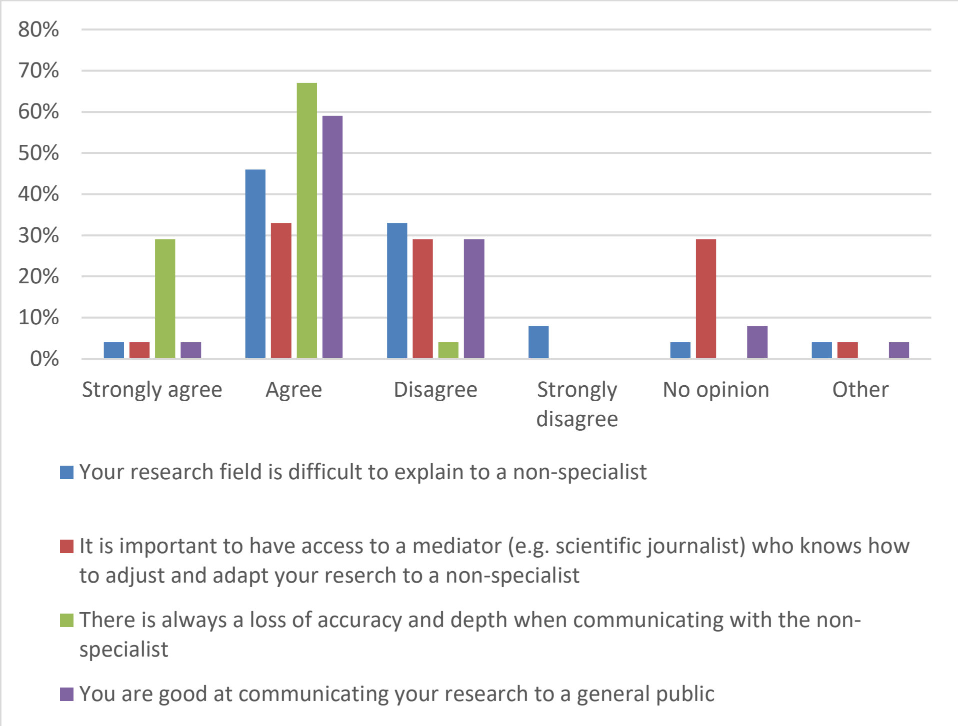

Fig.11. Respondents' attitude to their own field, their communication skills, access to a mediator and apprehensions involved in communication with the public.

This figure shows that 50%, (46% agree, 4% strongly agree) of the respondents consider that their own research field is difficult to explain to a non-specialist. 41% disagree or strongly disagree to this item.

37% of the respondents think that is important to have access to a mediator while 29% express little need for a mediator. The same percentage of respondents has no opinion on this question.

96% of the respondents agree to the item "There is always a loss of accuracy and depth when communicating with the non-specialist."

58% think they are good at communication their research while 29% do not agree to this item.

The result shows that the respondents are divided on the question: "Scientists and experts in a field are best suited to decide on what to communicate to the public domain." Nevertheless, the respondents fully agree that there is a loss in accuracy and depth when communicating with a non-specialist. Half of the respondents consider their subject difficult to explain but the same number of respondents does not think that access to a mediator would help them. Quite a few expressed no opinion on this question which may suggest that they have no experience in contacts with mediators.

As mentioned above, the respondents seem to be divided on the question whether scientists and experts are the best suited to decide on what to communicate to a wider public. 50% agree and 46% disagree while only 37% think it is a good thing to have access to a mediator. Leaving the communication task to mediator may well be a necessity which, according to earlier research, can give rise to controversies.

Communication with the public could take place through a direct exchange between an audience and the scientists, but since the glorious days of mass communication, the mediator, often a journalist specialized in a specific scientific area, plays an important role. These ‘communicators’ hold the intermediary position between the scientists who should develop their communication skills and the public who should improve their scientific literacy (Jacobi, 1999). However, as Weigold (2001) points out, there are controversies between scientists and journalists for different reasons.

> The scientists’ primary responsibilities are to disseminate information, educate the public, be scientifically accurate, not lose face before colleagues, get some public credit for years of research, repay the tax payers who supported the research, and break out of the ivory tower for the sheer fun of it. The journalist’s goals are to get the news, inform, entertain, not lose face before his or her colleagues, fill space and time, and not be repetitive. Sometimes these divergent agendas work to mutual benefit, but at other times they lead to conflict (Tarvis 1986, cited in Weigold, 2001 p. 181).

From the scientist’s point of view objectivity and scientific method which include falsifiability and replicability of hypotheses, are crucial questions. The journalist, however, has more subjective reasons in mind when dealing with a scientific subject. The controversy is due to contradictory imperatives from two different spheres. In order to obtain a high media coverage, the journalist is encouraged to choose not only the most spectacular point of view, but also items that are considered as “news”, whereas the scientist is eager to give a complete and nuanced description of findings for an educational purpose. The way media covers scientific news involves emphasis on brevity and simplicity whereas scientists are more concerned with objectivity and accurate background information (Weigold, 2001). In a situation where media is in control, the scientist runs the risk of being captured in a trap where he or she is asked to be the judge of true or false, which is against the values of cautiousness and information balance (Neveu, 2003). Similar ideas are presented in Weigold’s text (2001) where Shortland & Gregory (1991 cited in Weigold p. 173) refer to scientists reluctancy of going public for various reasons: scientific findings are best shared in peer-reviewed publications, scientists should stay humble, broadcast media is trivial, lack of time, media career could interfere negatively with a scientific career, be excited by the wrong side of the store, journalists may distort.

Despite some possible drawbacks linked to mediation of scientific findings and going public, as discussed above, science is in many ways promoted by media. Media is a powerful means of communication, especially in an audio-visual context where a selection of sound and images turns science into a real experience. The popularity of channels like National Geographic and Discovery Channel is a fact. Similarly, popularised magazines targeting a wider public contribute to a better understanding of science. Over the years, authors such as Hawking (physics, 1998) Sagan (astronomy, 1980) Wright (evolution, 1994) have had a tremendous success which in turn may lead to an enhanced interest for science and its methods.

5.6 Language matters

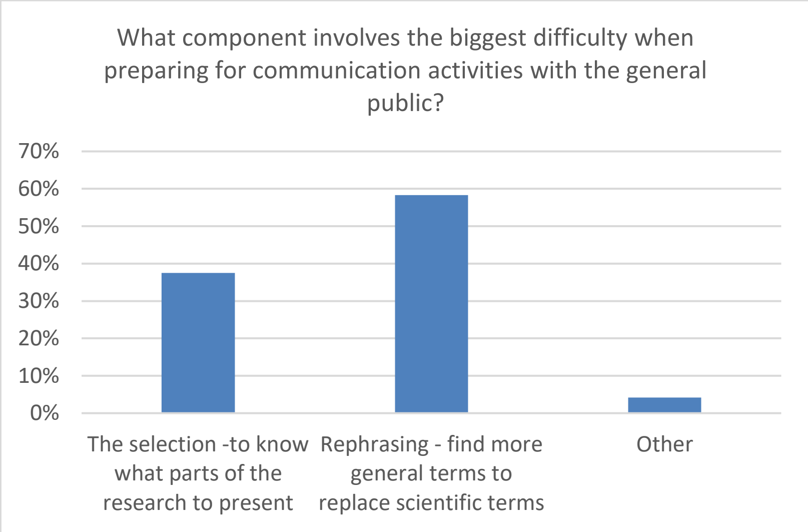

Fig. 12 Perceived difficulties linked to communication techniques

The fact that language usage is problematic have been evoked by several researchers (Jacobi, 1999; Merton, 2008; Weigold, 2001). Even though scientists in general cannot be expected to be fully aware of linguistic nuances and presentation techniques, they are aware of the delicacy of these issues. The respondents in this study considered that finding general terms to replace scientific terms was a bigger difficulty than knowing what parts to select. According to Weigold (2001), language is one of the biggest obstacles in science communication. Scientific terms have a very specific meaning and cannot be fully explained in a communication situation with a non-specialist public. This is why, the language has to be adapted to the receiver of the message in some way. While Weigold (2001, p. 173) uses strong terms such as 'change of code' and 'translation', Jacobi (1999) in his book *La Communication Scientifique. Discours, figures, modèles*, prefers to refer to different techniques, such as transforming, reconstructing and reformulating

On the one extreme, a researcher could be asked to concentrate her findings in a 90 seconds exposition in public, on the other, the scientist is expected to be humble and express her findings with cautiousness in a precise language. The scientist who engage in communication with the public is, at least to some extent, expected to reconciliate these demands.

When Jensen (2011) studied 7,000 French scientists and their communication activities with the public during a period of six years, he chose the term *popularization of science*. According to Jensen (2011) and Hilgartner (1999) there is no clear-cut frontier between scientific and popular literature, but rather a continuous gradation from pure technical production for initiated specialists to popularized production targeting a wider public. The same idea is found in Jacobi (1999) who points out that the scientific discourse is neither homogenic to its nature, nor necessarily conceived as specialized when the reader is confronted with a text of this type. It is in fact the reader's reaction to, and his or her familiarity with a scientific discourse that draws the limits (Jacobi 1999, p. 131). Jacobi (1999) suggests three different pillars in the scientific discourse. The first is found in scientists' communication with peers in accordance with an accepted standard which is introduction, material, methods, results, discussion and conclusion. Another characteristic of a scientist's approach is precaution in generalisation of the obtained results along with the usage of a specialised terminology (Jacobi, 1999). The second pillar is constituted by the didactic style, which is found in books aimed for students and pupils. A certain terminology is kept (or even the main goal), but the degree of generalisation has increased, and results are presented as facts. Finally, in the third pillar we find what could be described as informal scientific education. This scientific discourse is present in all kind of media, press, tv, and social network available for anybody who takes an interest in a scientific subject. Although Jacobi (1999) refers to this schematic table on the scientific discourse, and emphasises that there is a constant exchange between these categories.

Table 4. Scientific discourses and their production context (Jacobi,1999, p. 149).

SUPPORT	READERS	ORIENTATION	GOAL
SCIENTIFIC PUBLICATION	Researchers, specialists	Esoteric	Produce knowledge
SCHOOLBOOKS	Students	Pedagogic dogmatic	To teach/learn about science
MASS MEDIA	From specialist to beginner	Discourse de media	To popularize science

As professionals, scientists develop their skills in the scientific discourse in exchanges with their peers. Once the scientist chooses to engage in communication activities with media or the public, other linguistic and presentation skills are required. In order to show what kind of changes that the scientist would have to consider, Jacobi (1999) indicates five different verbs.

Choose. If the knowledge is conveyed by a mediator, it is his or her responsibility to decide what subject to highlight. The choice depends on its topicality, but it is also likely to depend on degree of novelty, expected reader impact or the subject's availability. In cases when the scientist decides to act the subject is given. In both cases, some information has to be omitted while other parts of the content need further explanation. According to Jacobi (1999) this type of discourse has a tendency to be longer and has few 'sous entendus'(less of shared knowledge) involved.

Transform. Next step involves transformation of the scientific information. Prudence and scepticism which are significant traits of a scientific discourse has, to some extent, to be abandoned in favour of a more affirmative and generalised discourse. At this stage, the scientist must accept the fact that the discourse is no longer that of a scientific publication but transformed into another category of discourse (Jacobi, 1991).

Change. A scientific discourse is objective and devoid of personal presence. When the aim is to reach out to a wider public a more personal approach is required. This could be obtained by relating to the scientist in an interview accompanied with personal background. This kind of setting brings the researcher nearer the public, and it often creates an appealing aura of mystery around research findings (Jacobi, 1999).

Reconstruct. The structure linked to the experimental model which has used a scientific discourse makes place for narrative in which the researcher is no longer anonymous but rather the hero of a tale. The researcher is somebody who has reached a goal by resolving a number of obstacles.

Rephrasing. One of the most important communication tools is the rephrasing of scientific language into a language that could easily be understood by the public. There are, as Jacobi (1999) points out, several strategies. One of the most efficient and therefore widely used strategies is paraphrasing, that is, exemplification or approximation to a key term (Jacobi,1999). An example of this strategy is when a medical term like *staphylococcus aureus* is approached by using a non-scientific term like *microbe* that could be understood by a larger public but is regarded as vague and inappropriate in the eye of a researcher (Jacobi, 1999).

These techniques are important but can be learned or handed over to a mediator. A more delicate question is the attitude towards this manipulation of linguistic matters. As Rödder (2012) points out in a study conducted among a successful team of researchers, going public involves ambiguity. Norms and ethics in the scientific sphere are of great importance in contact with the non-specialists. In the eye of the scientist, popularization is thus equal to concessions to values such as objectivity and humility. Objectivity is expressed by the use of a strictly defined terminology, which cannot be exchanged into familiar vocabulary without losing its scientific and exact meaning. The arguments against going public are based on the fear of deviating from the norm of objectivity. A scientific term that has been transformed is no longer trustworthy in a true scientific context. Moreover, the popularisation of scientific language runs the risk of being regarded as a simplification, not only of the terminology, but of all the effort involved and to science itself.
In order to reach out, communicating is also a question of knowing how to present and adjust a material to mediators and different groups of people. Absence of these skills may lead to misinterpretation of the subject. However, Weigold (2001) refers to a study made by Hartz and Chappell (1997, cited in Weigold) where over 80% of the scientist say they are willing to learn how to communicate better.

5.7 Policy and practise

As science communication is encouraged on different levels in society it is of great importance that there is a support from the hierarchy.

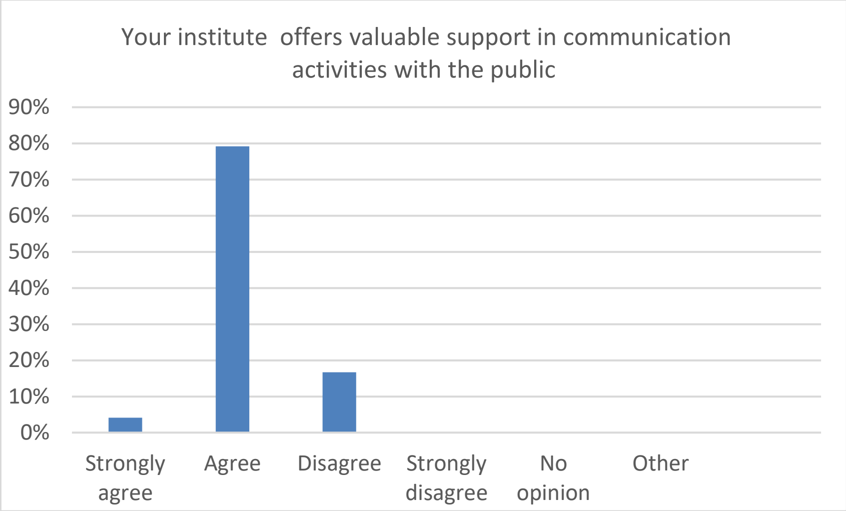

Fig. 13 Respondents' attitude to support obtained from the institute.

The figure illustrates that a majority of the respondents, 83%, think that they receive valuable support from their institute while 17% disagree on this point.

At the institute where this survey was conducted there is a clear official policy to enhance science communication and outreach. This support is at the scientist's disposal from professional staff at the communication department at the institute or organised by co-working partners during workshops. In the document entitled *Médiation scientifuque en sciences numérique*(INRIA) the importance of adapting and adjusting language to the public is emphasised. One of the techniques mentioned is the use of metaphors, which in this context means to use terms and expressions that are familiar to the public rather than scientific jargon.

As mentioned above there is an official policy to support scientists in the communication with the public. This means that universities and institutes encourage their researchers and scientists to participate in outreach activities, and that the scientists are offered moral, financial and methodological support. At the institute where this survey was conducted, the researchers consider that the support they receive is valuable. It is possible that an official policy has led to fewer ambiguities and norm conflicts. Rödder (2012) refers to scientists who are reluctant to going public evoking the mistrust from the scientific hierarchy and peers. Active institutional support is a way of enhancing the legitimacy of science outreach. Scientists are, in fact, both expected and encouraged to participate in various kinds of activities targeting a wider audience.

Tendencies- festivals

In order to enhance communication between a general public and scientists, events such as science festivals and open days are organised by the institute. Scientists and researchers are invited and expected to communicate their knowledge during these events, which are consequently regarded as important communication channels. Social media and other tools are equally channels that are expected to improve communication with a wider public.

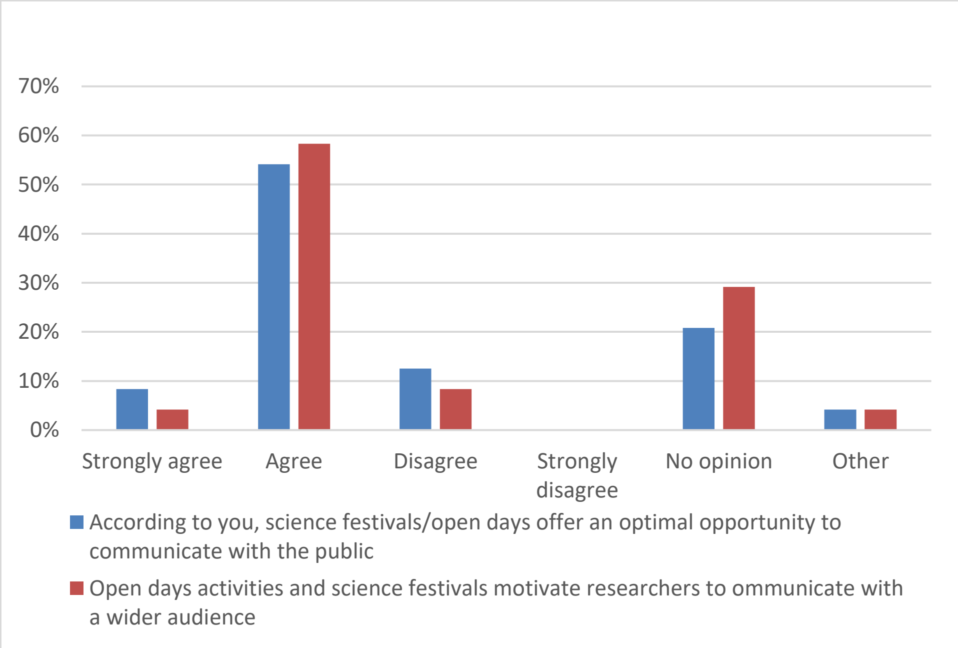

Fig. 14 Respondents' attitudes to festivals and open days activities

According to the figures above, 62% of the respondents strongly agree or agree to the statement that science festivals and open days, offer an optimal opportunity to communicate with the public. One respondent left the comment that the word 'optimal' was rather strong.

Table 5. How the respondents describe science festivals

A good opportunity to reach out to people who are interested in your research field	**14**
A good opportunity to reach out to people who normally take no interest in scientific issues	8
More festival than science	1
A good opportunity to enhance interest in your research field in general	2
A motivator in communication with the public	3
Time-consuming event	2
An opportunity to fill the information gap between the researcher and the non-specialist	9
An opportunity to establish a dialogue with the non-specialist	6
Other	

The reasons for dealing with festivals as a special feature in science communication and outreach are several. Festivals are often a product of a number of official actors who contribute with administration, buildings and human resources. Apart from public funding from universities and institutes, industries and private donators contribute with money and other support. Researchers and scientists play the major role as they are expected to use the arena for communication activities targeting a wider audience. A panoply of activities enhances a direct exchange between scientists and the public. The festive circumstances and a relaxed atmosphere are supposed to attract an audience that does not usually attend to scientific activities.

Scientists and researchers at the French institute where this study was made are solicited for their participation in a great number of activities such as open days and science festivals. To mention a few, an annual regional festival is organised during a week in October with, among other activities, a comprehensive program (forty pages) destined at school children and students. The same groups are targeted in workshops that are offered on a regular basis. The public is invited to participate in a number of activities whose objective is to share, discover, learn and stimulate. Scientists and researchers at the institute are equally invited to external festivals, e.g., the artificial intelligence festival to hold lectures or animate workshops. There is, therefore reason to believe that communication activities linked to festivals and open days constitute a major part of the scientist's communications with the public.

Every domain in society seems to organize their festival with themes linked to food, beverages art or music, and science is not an exception. The Edinburgh international science festival which started in 1988 is probably the oldest in Europe. Similar weeklong meetings during which scientists tried to reach out to a broad public with the latest findings in science were organized by the British Association for Advancement in Science in the beginning of the 19 th century (Gregor & Miller, 1998, cited in Nolin et al., 2003).

Science events of different dimensions are organised worldwide. A survey performed in 2008/2009 by Bultitude et al. (2011) included no less than 94 different web sites linked to scientific events.

The gathering of people that is manifested in festivals offer an excellent opportunity to reach out to interested visitors with a specific theme. In order to do so, science must reach the society and its citizens. For egalitarian and democratic reasons, society embraces 'everybody'. Organizers of scientific festivals and weeks are eager to underline the fact that the event is open to an audience consisting of 'everybody'. Nevertheless, there are a number of activities that have more specified target groups in mind. Among these are schoolchildren, teachers, journalists, politicians, scientists and other professionals. 'Everybody' can, in this context, be seen as a separate group with its special programme which is explicitly announced on the organisers website, (programme for everybody). On the other hand, according to Bultitude et al. (2011) everybody is a part of the general public consisting of families and (school)children. In addition to this it could be mentioned that no less than 72% of the investigated science festivals in the study made by Bultitude et al. (2011) actually discerned the group 'career scientists' as one of their audiences.

In order to discern the scientific festival Bultitude et al. (2011) identified the following characteristics:

- The main focus is a 'celebration' of science, technology, engineering and related aspects
- The intention is to engage non-specialists with the scientific content.
- The event is time-limited and recurring, usually on an annual or biannual frequency.
- There is a common theme and/or branding to component activities.
  (Bultitude et al.,2011, p. 3)

The authors clarify that the term *science* is to be interpreted as the German concept *Wissenschaft*, which includes Social Sciences, Art and Humanities as well as medical disciplines.
While the third characteristic is focused on the organisational aspects of the event (how and when), the second gives an answer to why it is organised. The first and the fourth characteristics deal with the content of the festival that is expected to engage scientists as well as a wider public.

Even though festivals and open day events offer a good opportunity for scientists and different publics to exchange perspectives and knowledge there are other ways of communicating which are not covered during these events. In this item the respondents were asked to tick 3 alternatives in order to indicate their preference for communication activities.

Table 6 The communication activities the respondents would prefer to engage in

Debate/conference with non-specialists	**14**
Articles in papers, newsletters or online	16
Radio/podcast	8
Workshops for school children	10
Workshops for other groups than school children/students	5
MOOC	5
Books for the general public	5
Exhibitions	3
Open days activities	7
Other	

83% of the respondents have engaged in activities such as festivals and open days. It could be claimed that these events, which are organized on the initiative of the institution together with local and regional partners, are more spectacular in their nature compared to other activities. When the respondents were asked what activity they would rather engage in, writing articles in papers and online got the highest score. This activity is to a large extent practised online where several forums are accessible for publishing and exchange. In addition, the scientist himself or herself choses what to communicate and to whom which gives the scientist more control and autonomy. Furthermore, it is a way of communication that scientists are more familiar with as it is practiced in their exchanges with their peers.

Social media and other tools for enhanced openness

Many of the communication activities enumerated above involve a physical presence from the scientist and the non-specialist. Online activities, however, are not concerned with this restraint. In this context, advantages such as unlimited accessibility, interactivity and information abundancy are often mentioned. The possibility to communicate seems to be without limits.

Scientists as well as other professionals know how to take advantage of this possibility, but they are also aware of drawbacks linked to communication online.

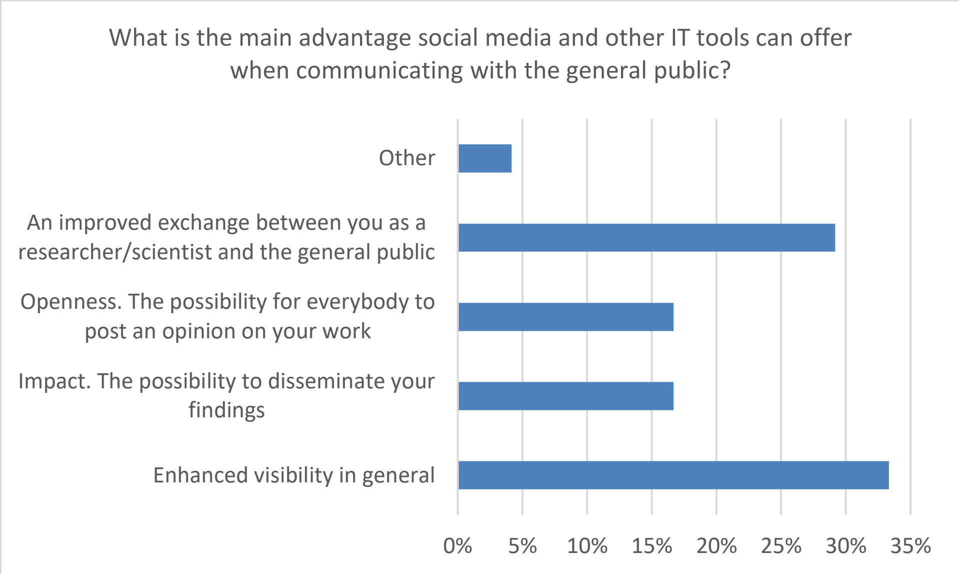

Fig. 15 Advantages that social media and other IT tools can offer in communication with the general public.

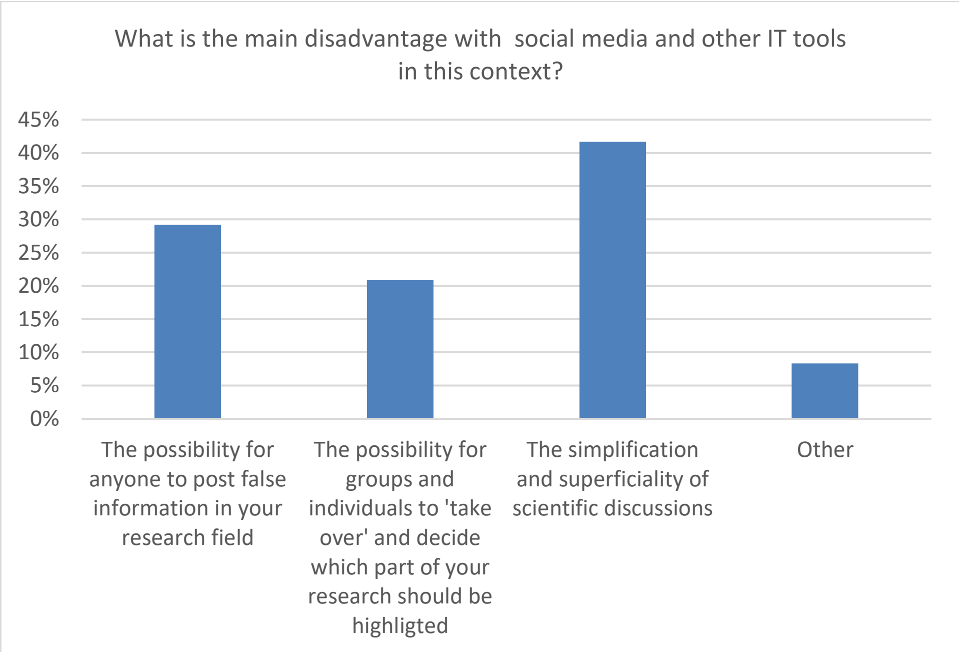

Fig. 16 Disadvantages that social media and other IT tools may entail in communication with the general public

When Weigold (2001) in the beginning of the twenty-first century ponders over the impact of the World Wide Web on science communication he sees four major beneficial changes: Firstly, he underlines the possibility for scientists and audience to communicate directly without meditation of news organisations. Secondly, he points out that space and time will no longer restrict the communication which in turn allows for more complex and sophisticated information. Thirdly, he sees how “the Web combines the information richness of print with the demonstration power of broadcast in a seamless, accessible, interactive fashion." Finally, he envisages how a multitude of voices/interlocutors exchange information "the Web is a two-way communications medium, allowing one-to-one, one-to-many, many-to-one and many-to-many interactions" (Weigold, 2001, p. 176).

However, new communication channels such as social media and other IT tools offer advantages as well as disadvantages. 34% of the respondents regarded enhanced visibility in general to be the main advantage. 41% of these respondents saw the simplification and superficiality as the main disadvantage. According to the answers above, social media is primarily seen a means of enhancing visibility. The respondents may refer to personal, scientific or institutional visibility, or to all three of these, as the expression "in general" is a part of the question. It is also possible that the alternative "enhanced visibility in general" is just summing up the other alternatives. Scientists see new communication channels as a means to improve the exchange with the general public. The word 'improve' suggests a more serious and constructive exchange with a public which is already initiated in a scientific question.

Traditionally, the media had an important educative and agenda setting role that in some cases was harnessed by power elites for propagandistic purposes. Today, especially new social media have come into the picture, often introducing epistemic uncertainty in the relation between experts and laymen creating relations toward scientific knowledge in new ways (Bragesjö et al.,2012).

Social media creates wide open arenas where everybody can intervene. This phenomenon is perceived as a possibility as well as a threat. The respondents in this survey fear most of all, in this context, the simplification and the superficiality of scientific discussions. With the scientific values such as objectivity and accurateness in mind, scientists have reason to fear a deteriorated relationship with the public.

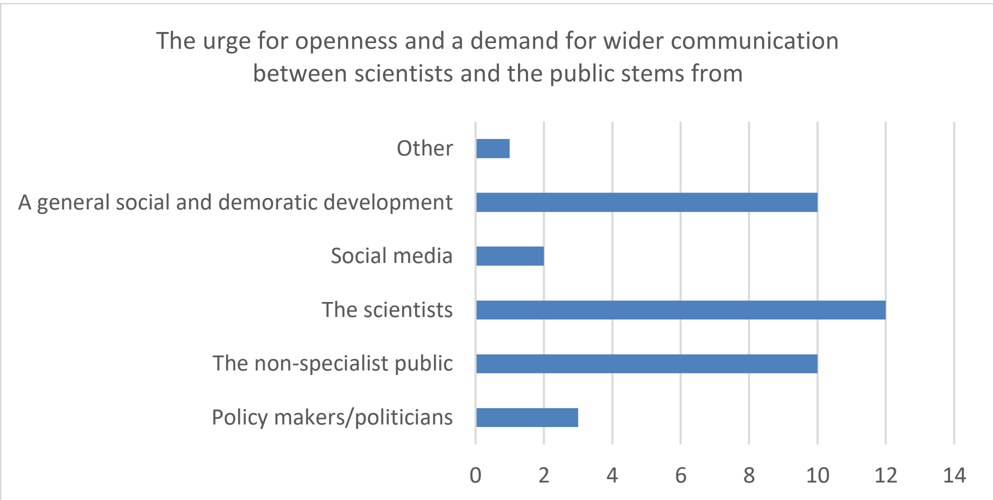

Fig.17 Urge for openness-possible initiators.

Why is openness a central concept in scientific communication and what is open and for what purpose? Openness could be looked upon from different point of views. Scientists and scholars are at present involved in discussions with editors, national and international institutions on how scientific publications and data could be shared and made accessible, not only to other scholars, but also to a wider public. An initiative was taken by a group of physicists in the early 1990's to publish scientific findings in a repository with free access. The Budapest Open Access Initiative in 2001 took the issue to an international level and also treated the question of open access to findings published in scientific journals, often locked away by expensive subscription fees, only targeted at a very limited group of initiated researchers (Chowdhury, 2014). From the scientists' point of view a wider openness would enhance the possibilities, on the one hand to reach out and, on the other hand to better benefit from their peers' publications. From a social-political point of view openness is one of the major features of a well-functioning democracy. A citizen in a democracy has rights and responsibilities. In order to fulfil a citizenship, the citizen needs information, knowledge and facts which are produced and provided for by national and international institutes, or universities. In the same way, the citizen is expected to acquire this information in order to be able to participate in and contribute to the development of the society. One of the main arguments for a greater openness to scientific information is that the citizen financially contributes to research and consequently should have free access to it. Furthermore, new technology devices have contributed to a wider accessibility; a connected pc, pad or a telephone renders access to information and knowledge instantly regardless of distance. The internet is a part of mediation and provides for tools that contribute not only to openness and engagement, but also to disseminating, participation and dialogue.

Finally, it could be mentioned that when Trench (2008) discusses the development of communication models, he underlines the tendency of openness. " as a general observation, we might say that communication processes become more open-ended and more open to values as well as facts in the transmission from deficit model to dialogue and participation" (Trench, 2008, p. 132).

6.Discussion

The aim of this survey was to answer the following questions:

- What are the personal and social drivers that incite this group of researchers and scientists to engage in communication activities with the public?
- How does this group of scientists want to communicate their findings to a wider audience?
- To what extent do new channels and online tools enhance communication outreach and alleviate tensions?

In order to answer these questions an online survey was sent to seventy active researchers and scientists at a French national institute. This institute employs more than 500 researchers and scientists in the Grenoble -Lyon region, and their research is organized in teams, where also administration staff is included. Among these, three teams were selected for this survey. This selection was based on a convenience sample, mainly for administration reasons. The response rate was, however, low after the first posting, and a reminder was sent two weeks later. In all, 24 questionnaires were collected and analysed in the relation to the aim of this thesis and earlier studies in the field. Finally, the response rate was low, 34%. This is, in general, regarded as an unacceptable response rate, especially for a study with randomly selected samples (Bryman, 2016). The current study is, however, based on a convenience sample where, according to Bryman (2016), a low response rate could be considered as less significant The reason for the low response rate in this case could be that the annual science festival had just come to an end and that there was little engagement left for an online survey on science outreach. In addition, this survey was just another email in the box and easy to postpone or neglect in a situation when more urgent matters await. Part of the explanation could also lie in the high awareness of data privacy at the institute. Despite the low response rate in this case, the online questionnaire has the potential to collect useful information from many informants, in general. The convenience sampling method, which was used in this survey, resulted in answers from a group of respondents that seem to correspond to age split as well as gender split known from the actual situation at the institute. Even though most of the questions were closed, which gives the respondent little opportunity to elaborate the answer, the information obtained was satisfying. The questionnaire provided a line for a comment which was eventually used by very few respondents. It should be noted that phrasing and choice of vocabulary is of great importance in online survey questionnaires where there is little possibility to clarify .

A number of researchers in science communication have studied the question “Why do scientists engage in communication activities with the public?” (Merton, 2008; Poliakoff & Webb, 2007; Rödder, 2012). Merton (2008) tries to explain scientists’ engagement in terms of personal and social drivers. In line with the results obtained by Merton’s (2008) comprehensive investigation on science communication environment, the results from the survey performed at the French institute show that “improving communication skills” is regarded as a major personal benefit. It is worth noting that the scientists see to the technique rather than to an immediate result. e.g. “it enhances my career”. The main personal benefit is thus to develop the techniques that are likely to improve communication with the public. Personal compensation is ranked second.

As well as advantages there are disadvantages linked to engagement in communication activities with the public. In 2008, Merton found that time was a major drawback in this context. Ten years later the time factor is still crucial according to the results in the study at the French institute. Unfortunately, this perceived lack of time is shared by other professions as new tasks are added on top of one another without reducing the total workload. In recent years, the pressure on the scientists to fulfil their missions as communicators has increased. At the same time a greater visibility and presence within the research field is demanded for funding reasons.

75% of the respondents in this survey consider that their research field deals with risk questions. As Kahan (2017) points out, these questions vary over time. Even though people are still concerned with matters on data privacy and robots’ take-over, it seems that disciplines dealing with these issues are less involved in controversial debates these days. The digitalisation of our society is as prosperous as vital and those who are not quick enough to leave the analogue world are deplored. However, if 75% of the respondents think they deal with risk questions, they have without doubt been confronted with dubious minds. As the results from this survey show, the respondents are interested in communicating on social and ethical implications of their findings. This social drive is important for their engagement.

Theories in the field of science communication stipulates different communication models (Hetland, 2014; Horst, 2008; Trench, 2008). The main three are: the deficit model, the dialogue model and the participation model. There has been a discussion whether these models represent un evolution in time, or whether one model is a refinement of the other. Another question is whether one model is supposed to be out of date when others appear, or if they can coexist. Trench (2008) hesitates to use the word hierarchy but speaks rather of the development of openness. The participation model can thus be regarded as more open to values and facts than the deficit model (Trench, 2008). There is reason to believe that the respondents in this survey have some notions of communication models and know how to adapt these according to their audience. One of the respondents referred, for example, to the expression "filling the gap" which is closely linked to the deficit model in which the public is seen as deficit in knowledge. Even though a majority of the respondents perceive communication with the public as a question of conveying information and facts to the public, there is also, among the respondents, a tendency to see communication as a dialogue. When official policies ask scientists to communicate, the stress is on conveying information, knowledge and findings. By conveying knowledge scientists and researchers fulfil their obligations. The results from this survey show that scientists go beyond their responsibilities and adapt their communication model to the audience. The following survey items could be given as examples: When the respondents were asked how to approach a group that were hostile to their subject, they preferred to take interest in their point of view and start from there, rather than give more information(Figure 9). In the same way, the respondents regarded that their communication would have the most impact in a context where the non-specialists had some knowledge of the subject and which they were likely to use in some way. These findings can be related to Hetland's (2014) outline of the participation model which is described as the most user-orientated model. This communication model is employed in a context where a certain level of skills and knowledge is necessary and: "The aim is to empower the users to act" (Hetland, 2014, p. 12). In the option "other" to item 29 one respondent commented:

"If they know nothing, I can teach; if they know some, I can fill the gaps; if they are hostile, I can convince; if they know a lot, I can debate."

Science festivals are, as mentioned above, a phenomenon that increases in popularity. Activities focus on workshops, hands-on where the experience of science, sometimes spectacular, is predominant, but debates and lectures are also a part of the offer. The ambition of the organisers is to attract all kinds of publics, in a festive environment. Even though the festivals are open to everybody, the respondents in this study perceive them mainly as a good opportunity to reach out to people who are interested in their research. This is most likely to happen in a situation where people have to sign up for participation in workshops and debates using an online form in advance.

Festivals are initiated on an institutional level and there is a possibility that the engagement in activities during these events are conceived as more of a professional duty than a free choice. 62% of the respondents see festivals and open day events as a good motivator for communicating with the public, which is a sign of recognition. When the respondents were asked about their preference of activity, they choose articles in papers, newsletters, paper or online in the first place. This may indicate that there is a preference for activities that scientists initiate and control themselves. Furthermore, writing articles and exchange online is an activity that is closer to their professional communication with their peers.

It could have been expected that new channels and online tools which enhance visibility would alleviated tensions present in science communication, but as Rödder (2012) points out, norm conflicts that put the scientist in a state of ambivalence are still present, mainly due to expectations linked to two different roles, the professional "scientific" role and the "media visible" role. Rödder (2012) argues that "medialization of science" Rödder (2012, p. 156) tends to increase tensions between what scientist themselves valorise and what is expected from them on an institutional level. According to Rödder (2012) knowledge production and recognition by the way of scientific contribution is the scientist's core work, whereas visibility outside this context is of less importance to the scientist. The obligation to engage in events such as science festivals and other kinds of science outreach is neither a part of what the scientist perceives as core work, nor a basis for recognition. According to the results from the study at the French institute, time restraints and lack of presentation skills give rise to tensions; communication with the public is seen as taking too much time (from work that is more important). These tensions are, as Rödder (2012) points out, known, but are not the main sources of tensions. A more important issue is that "media prominence needs to be established as eligible for recognition" (Rödder, 2102).

The main advantage that social media and other IT tools can offer in communication with the public is according to the respondents' answers an enhanced visibility in general. An improved exchange between scientists and the public was rated lower. This suggests that social media and other IT tools could play an important role in science communication with the public, but also that social media is used for other purposes in the first place. There is a possibility that earlier experiences in communication with groups or individuals on social media have led to distrust. 42% of the respondents regarded that the main disadvantage in this context was that of the fear of superficiality and inaccuracy in discussions. This is an inconvenience that comes along with social media and increased openness, an issue that is a challenge to all of us. It is thus possible that the use of new communication channels and online tools alleviate tensions considering openness and transparency, but it is also possible that the visibility that these channels offer create new tensions.

7 Conclusion

The setting of this thesis is science communication and science outreach. Scientists and researchers play an important role in this context as they, in their daily work, produce knowledge at institutes and universities. According to policies on national and European level the outcome of researchers work and knowledge should to a wider extent reach the public domain. The main reason for this is socioeconomic; universities are funded by taxpayers and those who have contributed should have the right to see the results of their contributions. The reasons are also socio-political. The latter reason is grounded on the assumption that a scientifically literate public takes more interest in political questions in general, which in turn leads to social and political progress in a democracy. It was, however, scientists who took the initiative to free access to repositories with the aim of enhancing scientific communication not only between peers, but also between scientists and non-specialists.

In order to live up to these ambitions, scientists are expected to communicate their findings to a wider public. The question is why and how researchers and scientists engage in communication activities with the public. Merton (2008) has shown that personal as well as social drivers are involved. The most important personal driver for the respondents in this survey was that participation in communication activities could improve their communication skills but also give them personal satisfaction. Most of the respondents agreed that scientific communication is important for the development of a democracy and they also showed interest in communicating on social and ethical issues linked to their subjects. Being engaged as a scientist is, at times, equal to dealing with and even taking a stand on delicate matters.75% of the respondents agree that within the research fields Data science and Applied mathematics there are questions that could be categorized as risk issues. The negative aspect of this is that controversies are likely to appear. The positive aspect is that the research field attracts attention and create visibility.

The question is what science communication is about, how it is perceived as a method and also how the scientist sees his or her relationship with the public. Scientists are expected to share their findings consisting of new data, scientific connections and new methodology with a wider public. This transfer of knowledge is highly dependent on scientists' engagement in the communication process. 46%, of the respondents in this study perceive their communication as an act of conveying facts and information to the public. This approach is in line with a theoretical model in science communication, which is referred to as the deficit model. This model focuses on facts being conveyed, transmitted or disseminated to an ignorant public, or a public in need of more knowledge. An expression which is widely used in this context is 'filling the gap'. Most of the respondents would, however, not try to fill this gap with additional information if they were confronted with a group of people with a hostile attitude to a scientific issue. Instead, they would approach such an attitude by letting the group understand that they take an interest in their point of view and from there continue the discussion on the subject.

When scientists go public or popularise their work they are confronted with conflicts, some of them are ethical, others are linguistic. Even though 58% of the respondents think they are good at communicating their findings, there are occasions when access to a mediator could be of help. The conflict arises when the professional scientist and the professional mediator have different objectives. The values of media visibility and scientific visibility do not coincide. With this in mind, the results of this survey show that 96 % of the respondents fear a loss of accuracy and depth when communicating with a non-specialist. Furthermore, the respondents show an awareness of linguistic matters. When selection (what part to present) is opposed to rephrasing (find more general terms to replace scientific terms) the respondents find that the latter is more difficult than the former.

All of the respondents have participated in communication activities of some kind with the public. Not everybody has been present at big events like open days and science festivals which are either organised on a regular basis by the institute where the respondents work, or at locations in France and abroad where researchers in Data science and Applied mathematics engage in communication activities with the public. Similar events have been more frequent in recent years. The success is due to the occasions where scientists and the public meet in communication activities in a relaxed atmosphere. The respondents at the French institute think the events offer a good opportunity to exchange with non-specialists who are interested in their research. Moreover, the scientists think that the events can provide motivation for further communication with the public. The respondents in this survey, however, have a preference for activities that are not covered in these kinds of events, namely writing articles and newsletter online or on paper.

From the respondents' point of view, social media and other IT tools are considered to be useful, in offering a better visibility in general. The respondents also found that use of these tools improves communication between scientists and the public. There is, however, a fear among the respondents that wide open doors into scientific debates lead to negative consequences such as loss of objectivity and accurateness.

Tensions, conflicts and controversies are still present in science communication activities with the public. As mentioned above, the results from this survey show that lack of time and presentation skills are factors that create unease among scientists. The scientists consider that they get valuable support from the institute which reduces tensions between official policies and scientists. Engagement in communication activities, such as festivals and events, organised by the institute encourage non-specialists to take interest in scientific questions with the aim of reducing the gap and thereby tensions between scientists and the public. The use of social media in communication with the public offers real possibilities in this respect, but these communication tools also give rise to new tensions between the scientist and the non-specialist.

In conclusion, this study shows that scientists and researchers engage in communication activities with the public for personal and social reasons. Developing their own communication skills is an important incitement. In the same way, social benefits such as contributing to the development of democratic values and initiating discussions on ethical and social issues encourage engagement. Conveying information and facts is regarded as the main feature in communication but the there is also an awareness of the necessity to adapt the way of communicating according to the public. Social media is not primarily seen a means of communication with the public but rather a way to enhance visibility in general. A reason for this is a fear of simplification of facts and debates. Respondents in this study receive valuable support from the institute where they work and consider science festivals to be good motivators for communication with a wider public.

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Appendix A. Tables and Figures

Appendix B Questionnaire Science communication/science outreach

You have received this survey because you are a researcher/scientist who probably communicates to people who are non-specialists. As a student on the master's program in Librarian and Information Science I am interested in knowing more about your engagement in communication with a non-specialist public. The results will be used in my thesis. The answers are anonymous and will be sent to Google forms where I can collect them. The results will only be used for this purpose.

This survey will take less than ten minutes to complete. Most of it consists of multiple-choice questions but there is always a possibility to use the option "other" for a comment. Your participation is of course on voluntary basis but nevertheless most welcome and very valuable to me. Thank you!
Evy Sekund
* Required

1. 1. Your age *

   Mark only one oval.

   - 55+
   - 45-54
   - 35-44
   - 25-34
   - Under 25

2. 2. Gender *

   Mark only one oval.

   - Woman
   - Man
   - Other: ______

3. 3. Your field of study/research. Example: Applied mathematics

   ______

4. 4. Your research field is difficult to explain to a non-specialist. *

   Mark only one oval.

   - Strongly agree
   - Agree
   - Disagree
   - Strongly disagree
   - No opinion
   - Other: ______

5. 5. It is important to have access to a mediator (e.g. scientific journalist) who knows how to adjust and adapt your research to a non-specialist. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- No opinion
- Other: ______________________________

6. 6. You are good at communicating your research to the general public. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- No opinion
- Other: ______________________________

7. 7. What component involves the biggest difficulty when preparing for communication activities with the general public? *

Mark only one oval.

- The selection – to know what parts of the research to present
- Rephrasing – find more general terms to replace scientific terms
- Other: ______________________________

8. 8. There is always a loss of accuracy and depth when communicating with the non-specialist. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- No opinion
- Other: ______________________________

9. 9. In your research field there are questions that engage a wider audience among the general public. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- No opinion
- Other: ____________

10. 10. You are interested in communicating the social and ethical implications of your research to the general public. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- No opinion
- Other: ____________

11. 11. Your communication with the general public on scientific questions is important for the development of a democracy. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly Disagree
- No opinion
- Other: ____________

12. 12. Your research field deals with questions that from your point of view could be described as risk questions. *

Mark only one oval.

- Strongly agree
- Agree
- Disagree
- Strongly disagree
- No opinion
- Other: ____________

13. 13. What personal benefits, if any, do you see in communicating your research to the public? *

Check all that apply.

- [ ] The activity enhances my career
- [ ] The activity increases my visibility
- [ ] The activity improves my communication skills
- [ ] The activity gives personal satisfaction - I find the activity enjoyable

Other: [ ] ____________________

14. 14. What drawbacks, if any, do you see in communicating your research to the public? *

Check all that apply.

- [ ] It takes too much time
- [ ] It could be bad for my career
- [ ] I do not feel adequately trained /equipped
- [ ] It could be misunderstood
- [ ] It is not appreciated by my research colleagues.
- [ ] None

Other: [ ] ____________________

15. 15. Your institution offers access to valuable support in communication activities with the general public. *

Mark only one oval.

- ( ) Strongly agree
- ( ) Agree
- ( ) Disagree
- ( ) Strongly disagree
- ( ) Other: ____________________

16. 16. Scientists and experts in a field are best suited to decide on what to communicate to the public domain. *

Mark only one oval.

- ( ) Strongly agree
- ( ) Agree
- ( ) Disagree
- ( ) Strongly disagree
- ( ) Other: ____________________

17. 17. Which of the following popularization activities would you rather engage in? (Please tick 3) *

Check all that apply.

- [ ] Conference/debate with non-specialists
- [ ] Articles in papers, newsletters or online
- [ ] Radio/Podcast
- [ ] Workshops for school children/students
- [ ] Workshops for other groups than school children/students
- [ ] MOOC
- [ ] Books for the general public
- [ ] Exhibitions
- [ ] Open days activities

Other: [ ] ______________________

18. 18. Scientific communication with the public is first and foremost a question of *

Mark only one oval.

- ( ) Conveying information and facts to the public
- ( ) Engaging the public in scientific questions (through scientific festivals for example)
- ( ) Giving a scientific point of view in discussions between scientists and the public (debates, lectures)
- ( ) Other: ______________________

19. 19. What is the main advantage social media and other IT tools can offer when communicating with non-specialists. *

Mark only one oval.

- ( ) Enhanced visibility in general
- ( ) Impact. The possibility to disseminate your findings
- ( ) Openness. The possibility for everybody to post an opinion on your work
- ( ) An improved exchange between you as a researcher/scientist and the general public
- ( ) Other: ______________________

20. 20. What is the main disadvantage with social media and other IT tools in this context? *

Mark only one oval.

- ( ) The possibility for anyone to post false information in your research field
- ( ) The possibility for groups and individuals to ‘take over’ and decide which part of your research work should be highlighted.
- ( ) The simplification and superficiality of scientific discussions
- ( ) Other: ______________________

21. 21. Have you participated in activities during science festivals/open days? *

Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) I have not had the opportunity
- ( ) Other: ____________________

22. 22. According to you, science festivals/open days offer an optimal opportunity to communicate with the public. *

Mark only one oval.

- ( ) Strongly agree
- ( ) Agree
- ( ) Disagree
- ( ) Strongly disagree
- ( ) No opinion
- ( ) Other: ____________________

23. 23. How would you describe science festivals? (please tick 2 alternatives) *

Check all that apply.

- [ ] A good opportunity to reach out to people who are interested in your research field.
- [ ] A good opportunity to reach out to people who normally take no interest in scientific issues.
- [ ] More festival than science.
- [ ] A good opportunity to enhance interest in your research field in general
- [ ] A motivator in communication with the public
- [ ] Time-consuming event
- [ ] An opportunity to fill the information gap between the researcher and the non-specialist
- [ ] An opportunity to establish a dialogue with the non-specialist

Other: [ ] ____________________

24. 24. Open days activities and science festivals motivate researchers to communicate with a wider audience. *

Mark only one oval.

- ( ) Strongly agree
- ( ) Agree
- ( ) Disagree
- ( ) Strongly disagree
- ( ) No opinion
- ( ) Other: ____________________

25. 25. The urge for openness and a demand for wider communication between scientists and the public stems from *

Check all that apply.

- [ ] Policy makers /politicians
- [ ] The non-specialist public
- [ ] The scientists
- [ ] Social media
- [ ] A general social and democratic development

Other: [ ] ______________________

26. 26. How much time do you spend on communication activities with the public each year (estimation)? *

Mark only one oval.

- ( ) Less than one day
- ( ) One day
- ( ) A couple of days
- ( ) A week
- ( ) More than a week
- ( ) Other: ______________________

27. 27. What activity have you engaged in during the last year.

____

28. 28. How satisfied are you with your participation/engagement in communication activities with the public? *

Mark only one oval.

- ( ) Very satisfied
- ( ) Satisfied
- ( ) Dissatisfied
- ( ) Very dissatisfied
- ( ) Neither satisfied nor dissatisfied
- ( ) Other: ______________________

29. 29. In what kind of context would your communication on your research subject have the most impact? *

Mark only one oval.

- ( ) With people who have a high level of interest and who are well informed
- ( ) With people who have some notions of the subject and who are liable to use the knowledge in some way
- ( ) With people who are hostile to the subject
- ( ) With people who know nothing about the subject
- ( ) Other: ______________________

30. 30. If a group of people was hostile to your research, what would be the best way to change this ? *

Mark only one oval.

- Give the group more information on the subject (a lecture or a newsletter)
- Let the group understand that you are interested in their point of view on a question linked to your research field (debate, forum in social media)
- Initiate a dialogue with the group and let the members of the group decide on the topic of discussion.
- Invite the group to an open day activity with workshops
- Other: ____________________