ABSTRACT

CANETE BENITEZ, SANTIAGO NICOLAS. University Researchers and Public Communication: What Influences their Intention to Engage with Non-Experts? (Under the direction of Dr. Andrew R. Binder).

There have been many calls to the mobilization of scientists to engage meaningful interactions with non-experts, but research seeking to explain and predict participation in science communication is still developing. This project used an expanded version of the theory of planned behavior as a model to examine whether determined demographic, institutional and cognitive factors influence researchers' intention to participate in public engagement with science activities, such as giving public talks, writing popular science articles or talking to young students in schools. Data from a stratified random sample of researchers at North Carolina State University (n=404) were collected and subsequently analyzed through hierarchical multiple regression. Findings indicate that there are six significant independent predictors of scientists' intentions to engage with the public: past training, past participation, attitude, moral norm, managerial norm and role in a funded project. Based on these results, it is concluded that experience, liking, and accountability are the major factors influencing this type of behavior. Implications of these results for initiatives aiming at stimulating researchers' participation in public communication are discussed and overall recommendations are provided.

University Researchers and Public Communication: What Influences their Intention to Engage with Non-Experts?

by
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DEDICATION

To my mother Nancy

To my grandparents Rafael and Matilde (RIP)

For their example of life and unconditional love

BIOGRAPHY

I am an international student in the Master of Science in Communication program at North Carolina State University and my interests spin around the intersections of communication with science, technology, innovation, risk and society. I am originally from Asuncion, the capital of Paraguay, a 7-million people, landlocked country in the heart of South America. Before coming to the United States, I majored in Communication and Public Relations and worked in these areas for 5 years for the Catholic University Press Office (my undergrad institution) and for the National Council of Science and Technology. After this Master's program my goal is to find a way to collaborate, either through advanced degrees, teaching, research, and/or practice, with the implementation of projects related to my aforementioned areas of interest in my country and the Americas. Photography, Latin dancing, radio, cooking, helping others and basketball are important components of my health and well-being. My life motto is: "*Tal como tu actitud es tu destino*", which means "As your attitude is your destiny".

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Chapter 1: Introduction

The production of knowledge is increasing at its fastest rate ever and technological innovations are permeating almost every aspect of our lives. At the same time, the potential risks and benefits that science and technology bring about often represent a matter of concern and/or promising solutions to human problems. In this framework, a democratic society demands that citizens not only need more information about scientific and technological topics but also participation in decisions related to them. There is also a growing consensus among governments, funding agencies, multilateral and non-governmental organizations about the necessity of closing the gap between science and society. This does not only mean augmenting people's knowledge of scientific and technical concepts per se. More importantly, it entails finding ways of encouraging scientists and citizens alike to discuss the social and ethical implications of the advancements of our time in areas such as climate change, biotechnology, genetically modified food, nanotechnology, stem cell research, among others (Leshner, 2007; Nisbet & Scheufele, 2009).

To respond to this challenge, the participation of researchers –as the producers of new scientific and technological knowledge– in meaningful interactions with non-expert audiences, via direct and mediated channels, is fundamental. Talking to the media, speaking to students in schools, advising policy makers, writing popular articles and books, engaging non-specialists online, giving talks at public places are all activities that, for many, have become a necessity, a routine, a pleasurable task, or a pain in the neck. Either to promote general understanding of scientific knowledge, the appreciation of their own work, or even to raise funds in periods of scarce resources for research, scientists are called by public and private funders, as well as professional societies, to participate in public communication of science and technology (PCST) or simply public engagement (PE) activities. But, what do they get out of these activities? What

are the main barriers and motivations? What are the factors that influence a researcher's decision to go public and engage with society?

Providing answers to some of these questions have been part of the work of PCST scholars. On the one hand, public communication on the part of the scientists can help them get research funding, it may enhance their teaching skills, it can be fun and exciting, or it can even inform actual research. On the other hand, it can be challenging, because it requires additional skills, it encompasses the risk of public misunderstanding or it just takes time away from actual research. Although the last four decades have produced a great deal of perception studies analyzing public knowledge of and attitudes towards emerging science and technologies (Miller, 2004), less attention has been paid to the views and level of engagement of scientists in public communication activities (Andrews, Weaver, Hanley, Samantha, & Melton, 2005; Bauer & Jensen, 2011). This has changed in the last few years, but there is still a lack of comprehensive data about what influence researchers to go public. There have been a considerable number of descriptive surveys of scientists' engagement, some qualitative articles, and very few studies aiming at explanation and prediction.

The present study seeks to contribute to our understanding of the factors that lead scientists to plan and participate in communication activities with non-specialists. Based on previous work of PCST scholars, I used an expanded version of the theory of planned behavior (TPB; Ajzen, 1991) as a model to test the extent to what demographic, institutional and cognitive factors predict scientists' intention to participate in PE in the next 12 months.

Comprehending the views and attitudes of researchers as well as trying to identify significant predictors of their behavior regarding public communication can be meaningful for different audiences. For the general public there is an indirect benefit, given that an effective

participation of scientists in the public forum can contribute to an increased understanding of a great deal of complex topics involving science, technology, and risk issues, which in turn can lead to make better daily life decisions.

Results from the study though, are more directly beneficial at the level of universities, research organizations and funding agencies, which are the institutions the researchers belong to. For managers and public information officers at universities, empirical data and insights about scientists' engagement in public communication can help them do a better job encouraging their scientists to participate in communication activities. This involvement is a key component of strategies to promote and maintain institutional reputation, especially in a time of strong competition for students, professors, researchers, and funding. Museums, cultural and community centers, and K12 institutions can also benefit from knowledge related to effective ways to engage the research community. Knowing how the research community feels about public engagement and how they deal with it throughout the reality of their career, are aspects that can also contribute to successful communication interventions applying more strategic approaches to the calls for training and participation currently being made by scientific societies and funding agencies.

In addition, and equally important, results should also allow scientists themselves to reflect on their perceptions and actions concerning science communication. This might involve a constant evaluation of their own role as researchers, experts, policy advisors and participants of the public sphere in today's national and international techno-scientific scenario.

In Chapter 2, the literature review shows the context of science communication, and the calls for mobilization of scientists to reduce the gap between science and society. In addition, I present what we already know about scientists' engagement and describe the theoretical model

with its proposed expansions. First, I examine the goals and activities of public engagement. Second, I describe the components of a reasoned action approach to decision making such as the TPB, including additional aspects that might influence behavior. Third, I also review previous studies on researchers' involvement in public communication, which led me to expect certain results in my data, but also left some aspects unclear. Therefore, finally, I propose pertinent research questions and hypothesis.

Based on that review, I expected that attitudes towards PE, a sense of efficacy about performing PE, a sense of duty to do PE, perceiving colleagues participating in PE, perceiving support from supervisor, past participation in PE, past training in PE, and being funded by the National Science Foundation (NSF) will be predictors of a researcher intention to perform PE. Furthermore, I pose questions asking to what extent demographic (sex, status, field) and institutional factors (normative pressures, institutional incentives, institutional facilitators) are influencing a researcher's intention to participate in PE.

In Chapter 3, I describe my methods. A survey questionnaire design was utilized with a random sample of participants at North Carolina State University, a land-grant research-intensive university in the southeastern United States. I also explain the operationalization of variables and the data analysis procedure. Hierarchical multiple regression was used to test the hypothesis and answer research questions.

Next, in Chapter 4, I report the main findings along with the statistical data relevant for each of my hypothesis and questions. Finally, in the discussion and conclusion, Chapters 5 and 6, I present a detailed analysis of each finding, the limitations of the study, overall practical recommendations, opportunities for future inquiry, and my final thoughts in respect to the implications for the study of scientists' engagement.

Chapter 2: Literature Review

In a period that demands more information, dialogue and participatory democracy concerning current advancements in all areas of science and technology, an important gap has been described between science and society, based on public understanding of science studies (Miller, 2004). This research project stems from the necessity to comprehend one of the aspects that play a crucial role to overcome that gap: the factors that influence a researcher's involvement in public engagement activities. Therefore, I start the chapter providing a context to the discipline of science communication, explaining its goals, discussing the calls for mobilization, and describing the types of activities it entails. Next, I offer an overview of the elements that have been mentioned in the literature to affect researchers' participation, as well as present the theory of planned behavior with the proposed expansions as a valid theoretical model to analyze scientists' engagement. Finally, I also include my hypothesis, research questions, and a summarized rationale for the study.

Goals of Science Communication

Public communication of science and technology (PCST), also known as science communication or public engagement with science (PE), has been growing in recent years. It has become a research discipline and a field of practice seeking to increase scientific culture in society (Burns, O'Connor, & Stockmayer, 2003). Before advancing in the text, it is important at this point to define the scope of PCST for the present project.

Published studies in PCST usually refers to the natural, health and engineering sciences, as well as there is often a perceived superiority in epistemological status of these "hard sciences" over the sciences of the human and the social, especially in English speaking countries (Cassidy,

2008). Thus, frequently, if one makes allusions to science communication, PCST or PE, it is interpreted as the communication of physics, mathematics, engineering, chemistry, biology, genetics, etc. Cassidy refers, though, that in continental Europe these perceptions tend to include all forms of scholarly research. This view is in line with etymology and evolution of the term science (Middle-French origin) described in the Oxford English Dictionary as the "kind of organized knowledge or intellectual activity of which the various branches of learning are examples". In modern use, while French *science* has, like the English word, come to be the usual term for those branches of study that deal with a connected body of demonstrated truths or observed facts systematically classified and more or less comprehended by general laws, the French word continues to have rather broader application than the English word to knowledge as acquired by study, experience, or reflection (Science, 2014).

Cassidy also highlights that knowledge from the social sciences is very frequently covered by the media, relevant to audiences, and easy to understand, as well as that social scientists have key roles to play as experts and advisers on social, political, and personal issues. The author calls for more consistent research addressing also the issues involved in communicating expertise by those in the social sciences.

Similarly, my perspective on PCST/PE is integrative. Thus, in further references to PCST/PE and in my methodological approach, I will include not only those who would describe themselves as "scientists" or "engineers" but also scholars from other social and human disciplines (e.g. psychology, communication, anthropology, education, etc.), who also are interested and are actually participating in the dissemination of significant research results outside Academia.

The general motives for PCST can range from comprehending how science and technology affect people's lives, to promoting young people's interest in careers in these areas, to having a better understanding of the work of scientists. Other reasons are fostering public participation in decision making about science and technology issues, and a better engagement between scientists and policy makers. In addition, PCST can contribute in gaining public support to fund research and innovation. Communicating science also implies sometimes controversial interactions among different stakeholders, between experts and non-experts, each of whom has different knowledge and perceptions of science and risk (Cook, Pieri, & Robins, 2004; Mulder, Longnecker, & Davis, 2008).

In this respect, governments, universities, industry, organizations, and individuals are putting effort to stimulate science communication. But, what is science communication? In a simple and broad definition, it may include all types of interactions involving the communication of scientific topics to non-specialist audiences. According to Burns et al. (2003), who did a review of past definitions, other related terms such as public awareness of science, public understanding of science, scientific culture, and scientific literacy, have been often used interchangeably as synonyms. However, these terms have considerable distinctions and actually represent different dimensions of science communication, which deserve better characterizations but are out of the scope of this project. Nonetheless, Burns and colleagues tried to unify these aspects in a broader description of the PCST concept proposing what they called the "AEIOU" definition, which defines science communication as the use of appropriate skills, media, activities, and dialogue to produce one or more of the following responses in the public: awareness (including familiarity with new aspects of science), enjoyment (appreciating science as art or entertainment), interest (as a powerful inspirer or motivation to understanding and

scientific culture), opinions (as the forming, reforming or confirming attitudes towards science), and understanding (of science, its content, processes, and social factors). This definition of PE constitutes a great way to plan communications strategically by focusing on the potential outcomes expected in the publics (audience-centric).

However, in addition to that, the goals of science communication often originate in funding agencies plans or outreach initiatives from universities. According to Bauer and Jensen (2011) science communication has to be interpreted in a double way. On the one hand, as the conjunction of different components of public understanding of science (Burns et al., 2003), and, on the other hand, as the mobilization of scientists to engage a variety of publics with science.

Mobilization of Scientists

As influential reports on public understanding of science express (see AAAS, 1989; Royal Society, 1985), there was a call –which is still valid today– to mobilize the scientific community to go outside their laboratories and classrooms to talk to the mass media and directly to people about their research (Davies, 2008).

In addition to the recommendation of interacting with society, other governmental and institutional reports (e.g. House of Lords, 2000) also encouraged the science community to overcome the 1-way/top-down approach (the so-called deficit model[1]) to science communication, and apply a more dialogical style to public engagement (PE). It is out of the scope of this project to deeply examine different models through which the process of science communication has been explained. However, any project aiming to analyze public engagement with science would

[1] The belief that just by injecting information in a knowledge-deficient public, they will develop positive attitudes towards science and technology.

be incomplete without at least mentioning the central ideas of the dominant models: deficit model, dialogic model, and engagement model. An overview of the models is given in Von Roten's (2011) explanation: "At first, the growing levels of negative public attitudes were attributed to a deficit of knowledge, and scientists were encouraged to inform the public [deficit model]. Then, negative attitudes were related to a crisis of trust toward scientists and scientific institutions; therefore scientists were encouraged to develop dialogue on scientific facts and processes [dialogic model]. Finally, the public's fundamental questions about scientific innovation and its demands for openness, open mindedness, reflexivity, and transparency in science imply that scientists must engage with society in the early phase of scientific development [engagement model]" (p.54).

Moreover, several authors (Besley & Tanner, 2011; Dickson, 2010; Von Rotten, 2011) agree that scientists and engineers have the mission to communicate the results of their research to society. They also agree that the scientific community would benefit from training in the diverse dimensions of communication, in addition to traditional academic scheme.

As a response to these challenges, a new sector whose specialty is to engage the public with science has developed: visible scientists, science communicators, science journalists, popular science writers, museum curators and interpreters, press officers and public relations professionals, and other mediators (Bauer & Jensen, 2011; Burns et al. 2003). In this sense, new terms such as 'civic scientist' were also coined to describe those researchers active in public engagement and who recognize themselves as part of the whole society rather than just belonging to the scientific community (Lane, 1999 as cited by Matthews, Kalfoglou, & Hudson, 2005). Furthermore, in the last decade, funding agencies started requiring grant applicants to

establish plans on how they will communicate societal impacts and research results beyond the academic community (e.g. U.S. National Science Foundation - Broader Impact Criteria).

The achievement of a society in which people can critically appreciate the of value science and technology to make informed personal and public decisions has a lot to do with the existence of good science communication, which in turn largely depends on the views, attitudes, and involvement of scientists –as the natural explainers of science– in public engagement (PE) activities. Burns et al. (2003) offer an overview of formal and informal PE activities. As formal activities they include: science education such as workshops, lab sessions and other learning activities, colleges and universities, accredited courses and training programs, academic conferences and seminars, as well as production of science textbooks and distance education material. Informal activities comprise science museums and centers; media programs or coverage on film, television, print or radio; community or Internet forums and networks; computer based activities in CD, DVD, and similar; science shows and theatre; open days at universities and research organizations; popular science books and magazines; community or school-based involvement in collecting research data (i.e., citizen science); and science competitions, events and festivals. This study focuses on the latter group, because it includes interactions with non-expert publics, which is in line with the calls for scientists' mobilization outside Academia made by public and private organizations.

In a recent article, Bauer and Jensen (2011) describe PE as a dialogue between science and various publics, and more specifically as a "wide range of activities such as lecturing in public or in schools, giving interviews to journalists for newspapers, radio or television, writing popular science books, writing the odd article for newspapers or magazines oneself, taking part in public debates, volunteering as an expert for a consensus conference or a *café scientifique*, col-

laborating with non-governmental organizations and associations as advisors or activists" (p.4). Nevertheless, the dynamics of new digital media, channels, type of content, strategies and approaches are constantly redefining the range of PE activities.

How are scientists perceiving and responding to these calls to communicate their research outside academia and engage society? Peters (2008) indicates that, as experts, scientists often play the roles of policy advisor and public communicator. He suggests that participating in public engagement can be rewarding for some researchers, but others may be reluctant to enter to the 'tumultuous' public sphere. Every researcher might have their own perception of public engagement and different factors might influence their views and their willingness to participate in public communication activities. As a result, it has become increasingly necessary to understand the factors that contribute to participation in these activities.

Factors Influencing Researchers' Participation in PE

According to Miller (2004) in the last four decades there have been several studies, mainly from survey data, analyzing public understanding of science, as well as the public perception of specific emerging science and technology topics. However, there have been fewer research projects examining views and level of engagement in communication activities among scientists, which was acknowledged in previous studies (see Mathews et al. 2005, Bauer & Jensen, 2011, Ecklund, James, & Lincoln, 2012).

Despite increasing calls for participation and initial studies, there is still a lack of comprehensive data about what influences scientists' attitudes towards PCST and their actual levels of participation in PCST activities (Davies, 2008; Bauer & Jensen, 2011). How do they perceive the communication of science? What do they get out of it? What factors motivates them

and what factors prevent them from engaging? These are just a few questions asked by PCST scholars, especially in the last decade. According to Besley, Ho, and Nisbet (2012), if the goal is to increase and improve public communication activities of scientists, more research is necessary on how individual and organizational-level factors shape the views and behaviors of scientists. In this respect, I will review what we know about these factors so far.

In a special edition of the journal *Public Understanding of Science*, Bauer and Jensen (2011) summarized some aspects of what has been studied on the mobilization of scientists for public engagement. Citing a 2004 National Science Foundation (NSF) survey, they indicate that 42% of American scientists said they were not involved in any public outreach activity; hence, 58% were involved in at least one. Similarly, Dunwoody, Brossard, and Dudo (2009) explained that 68% of American stem cell and epidemiology researchers have reported interactions with the media in the past year. In addition, a Royal Society (2006) survey indicates that 75% of English scientists have participated in at least one science communication activity, reporting different degrees of involvement in different types of activities. This Royal Society data shows an 18% increase in participation from a similar sample of British researchers studied by Wellcome Trust (2000). Also, Denmark university scientists, surveyed by Nielsen, Kjaer, & Dahlgaard (2007), reported a 70% level of participation in online science communication and that nearly 50% have interacted with the news media. In the case of Argentina, 75% of CONICET (National Council of Science) researchers mentioned having participated in PE as an occasional activity (Kreimer, Levin, & Jensen, 2011). These results might represent a positive situation for the actual participation of scientists in PE, but as it has been mentioned, many of them just participate in one PE activity and occasionally.

Despite these pretty good numbers for general participation, Alan Leshner (2007), CEO of the American Association for Advancement of Science (AAAS), indicates that researchers, especially those younger, are enthusiastic to engage with non-experts, but they have "tremendous pressure to stick to the bench, secure hard-to-get research grants, and publish rapidly and repeatedly in high-quality journals", suggesting positive attitudes but low levels of participation. This is in line with past research (see Bauer & Jensen, 2011, for a summary) that found that senior researchers participate in PE more than juniors. Moreover, Leshner says that a lot of novel scientists may feel that public engagement is not positive for their careers because part of the scientific community might still look down to those involved in public communication. This perception is also known as the Carl Sagan effect (named after the famous U.S. astronomer and former host of Cosmos TV science series), the belief that researchers who spend time and effort communicating science to the public must not be good scientists, so that engaging with the public may affect their reputation (see also Ecklund et al., 2012).

Nevertheless, according to Dickson (2010), in the past decade, judging from public comments of prominent scientists, there are increasing positive attitudes towards science communication and increasing willingness to participate in public engagement among the research community. A couple of descriptive survey studies (e.g. Wellcome Trust, 2000; Martín-Sempere, Garzón-Garcia, & Rey-Rocha, 2008; Royal Society, 2006; Mizumachi et al., 2011) provide evidence to this claim of a current shift towards positive views and also participation in public engagement, which give us a good perspective on the approximate level of mobilization of the scientific community.

In the present study I am interested in knowing how different factors influence a scientist's participation in public engagement activities in order to advance towards explanation

and prediction. At the present time I have identified three empirical articles aiming at prediction of researchers' participation in public engagement (see Poliakoff & Webb, 2007; Besley et al., 2012; Dudo, 2012), two of which used theoretical frameworks to test the relationships between different factors and participation in PE. In the following sections I will describe the theoretical framework used in this study: an expanded version of the theory of planned behavior. As a theoretical framework proposes key variables to explain certain phenomena, for this study the augmented TPB will constitute the basis for my hypothesis, research questions, and choice of research methods, as well as will help me to make better sense of data, statistics, and the inferences drawn from them.

The Theory of Planned Behavior

The theory of planned behavior (TPB; Ajzen, 1991) is one of the most utilized and most supported models to predict human behavior. Hundreds of studies have been conducted applying and refining the framework to predict different types of behaviors (Poliakoff & Webb, 2007). TPB focuses on theoretical constructs concerned with individual motivational factors as determinants of the likelihood or intention to perform a specific behavior. The theory asserts that the strongest determinant of behavior is *behavioral intention*, which is a person's decision about how to behave. Usually, this intention is measured by items such as "I intend to do…" or "How likely it is that you will perform…", indicating the strength of the intention in an ordinal scale (e.g. likely-unlikely) (Montano & Kasprzyk, 2008).

According to TPB there are three direct determinants of people's behavioral intention: their *attitude* towards performing the behavior, the *subjective norm* associated with that behavior and the *perceived behavioral control* (control over the behavior). First, attitude is a result of the

individual's affective evaluation (positive/negative) of engaging in specific behaviors, and evaluations of individual beliefs about outcomes or attributes of performing the behavior (behavioral beliefs). Common measures are semantic differential scales (bad-good; unpleasant-pleasant). Second, subjective norm is determined by the normative beliefs, which refers to whether referent groups or significant others would approve or disapprove one's action. Finally, perceived behavioral control is a function of control beliefs about whether one has the resources and abilities to perform a behavior or, in other words, a person's perception of the ease or difficulty of a specific behavioral performance. Perceived behavioral control is similar to the concept of self-efficacy, introduced in Bandura's (1986) Social Cognitive Theory.

To summarize, TPB assumes a causal relationship between behavioral beliefs, normative beliefs, and control beliefs to behavioral intention and behavior via attitudes, subjective norms, and perceived behavioral control. Other variables, including demographic and environmental elements, are believed to be mediated through the three main constructs and do not independently contribute to explain the likelihood of performing a behavior (Montano & Kasprzyk, 2008; Poliakoff and Webb, 2007).

Applying the TPB framework to this study's topic of interest, it can be asserted that scientists' intention to participate in public engagement activities will be determined by their attitudes (positive or negative evaluations about taking part in PE activities), subjective norms (the belief that their colleagues or those they appreciate will approve or disapprove their participation), and perceived behavioral control (the belief of how easy/difficult the behavior is, or the projected sense of control over successfully taking part in PE activities).

Expansion of the Model

The TPB model has been previously applied to scientists' public engagement by Poliakoff and Webb (2007), as the first attempt to use a theoretical framework to predict researchers PE. Besides the TPB constructs (behavioral intention, attitude, subjective norm, perceived behavioral control), Poliakoff and Webb used an augmented version of the theory adding measurements for descriptive norms (e.g., Of the 5 colleagues you know best, how many take part in public engagement activities?), moral norms (e.g., I have a duty as a scientist to take part in public engagement activities), fear (e.g., I would fear repercussions if I took part in a public engagement activity), environmental constraints (e.g., I would participate in public engagement activities if there was money to support participation), and past behavior (participation in the last year). Regarding the three main TPB predictor variables, they found that only attitude and perceived behavioral control were significant predictors of intention to participate in PE in the final model. Subjective norm was not significant.

In another study, using secondary data of surveys in the U.S. and U.K., Besley et al. (2012) found that perceived importance of public engagement (an indirect measure of attitude) and internal efficacy (similar to perceived behavioral control) were positively correlated with willingness to engage and participation in PE. Similarly, Dudo (2012) found that attitudes towards PE and communication self-efficacy (similar to perceived behavioral control) were found predictors of participation; while negative extrinsic rewards (e.g. critical reactions reaction from peers, which is similar to subjective norm) was not a significant predictor.

Based on these recent studies, attitude and perceived behavioral control seems to have been consistent predictors of willingness to engage and actual participation. However, subjective norms, such as colleagues' disapproval or negative reactions, was not directly linked to a

researcher's involvement in PE as an important determinant (Dudo, 2012; Poliakoff & Webb, 2007), despite mentions of it as one of the reasons for not participation, especially in qualitative studies (Gascoigne & Metcalfe, 1997; Matthews et al., 2005; Ecklund et al., 2012; Qi, Xuan, & Fujun, 2013). This leads me to formulate my first two hypotheses, related to the TPB constructs.

H1: Attitude towards public engagement and perceived behavioral control will be positively related to intention to participate in PE.

H2: Perceived behavioral control will be positively related with intention to participate in PE.

The additional constructs (namely descriptive norm, moral norm, fear, environmental constraints, past behavior) included in Poliakoff and Webb (2007) were suggested in prior research to increase the prediction of specific behaviors. I will focus on descriptive norms, moral norms, and past behavior, for which I found more data related to scientists' engagement. Fishbein (2007, as cited in Montano & Kasprzyk, 2008) indicates that subjective norm, or the perception of what others think about one performing the behavior, may not completely explain the normative influence on behavior. In addition, descriptive norm, defined as the perception that referent groups are actually doing the behavior, was suggested to complement or to be an important part of the normative influence, especially because it captures the strong social identity in certain cultures. The scientific community can be considered a social group with very specific values as well as high social identity and control. It has a set of "formal and informal rules that govern status and support the value system" (McCain & Segal, 1969, p.113). With increasing specialization, these rules may also vary among sub-disciplines. Nonetheless, in general, the

perception of whether or not other scientists (e.g., colleagues, role models) are actually performing PE can be a determinant of behavioral intention and actual participation. Indeed, in Poliakoff and Webb (2007), descriptive norm was a significant independent predictor of intention (β=.20, p<.01), and its addition to the TPB constructs was attributed to cause an increase in the variance explained in the final regression model (from R^2 =.70 to R^2 =.73). Therefore, another hypothesis emerges.

H3: Descriptive norms will be positively related with intention to participate in PE.

Another additional measurement for TPB was suggested in the literature. Various studies (see Goddin, Conner & Sheeran, 2005; Rivis, Sheeran, & Armitage, 2009; Chan & Bishop, 2013) showed that *moral norm*, defined as a person's perception of the moral correctness or incorrectness of a given behavior, predicts intentions and behavior over and above the TPB constructs. In fact, a scientist's moral obligation to perform PE was measured in several descriptive studies.

One the one hand, the majority of scientists seems to perceive this moral obligation. Wellcome Trust (2000) indicates that 71% of British scientists agree that is their duty to communicate their research to policy makers and the non-specialist public. Nielsen et al. (2007) and Von Roten (2011) got similar results, in Denmark and Switzerland, with 41% and 80%, respectively, of agreement that communicating science and its implications to society is a duty of all researchers. Kreimer et al. (2011) found similar results with Argentinean researchers, for whom a sense of duty is the top reason to engage with the public. In one qualitative study in the United States, researchers interviewed were also in line with this vision of PE as a responsibility

of all scientists (Matthews et al., 2005). On the other hand, some studies suggest that outreach and engagement are not inherent to the role as scientists (Ecklund et al., 2012) or are outside the scope or their work (Mizumachi et al., 2011).

But, is this perceived duty to communicate influencing intention and participation? In Poliakoff and Webb (2007) moral norm was moderately correlated with intention ($r=.30$, $p<0.001$) but was not a significant predictor of participation in the final model. However, seeing science communication as someone else's job was associated with negative views and lower levels of participation (Besley et al., 2012), and Dunwoody et al. (2009) found that extrinsic rewards did not predict scientists' media activity, suggesting that appealing to moral and ethical values may be a better catalyzer of public engagement behavior. Therefore, based on theory and empirical research, it is suggested that moral norm will be associated with intention to participate, which lead my next hypothesis.

H4: Sense of duty to perform PE (moral norm) among researchers will be positively related with intention to participate in PE

Ajzen (2002) also recommend the inclusion of a measure of past behavior to improve the prediction of later behavior, especially when people have not developed a clear plan of action. Nonetheless, Ajzen refers that an association between prior and later behavior adds little to understanding a behavior's determinant; it just shows that a behavior is stable over time (potentially the same factors that determined behavior in the past continues to affect it in the present). Sommer (2011) also highlights that past behavior might directly influence human

information processing (intention formation) and actual behavior, as well as suggests to integrate past behavior as an independent construct of the TPB.

Thus, the extent to which a scientist has been part of public communication activities in the past would also be a strong factor in predicting intention and future participation. Wellcome Trust (2000) results show that researchers who have experience in communicating with non-specialists are more likely to engage with the public. Also, in Besley et al. (2012), a weak correlation was found between engagement activity in the past year and willingness to engage. More importantly, past behavior, measured as participation in PE in the past 12 months, was in fact the stronger predictor of intention to participate in PE in Poliakoff and Webb (2007).

H5: Past participation in PE will be positively related with intention to participate in PE

Another important common barrier mentioned by scientists is a lack of encouragement and support from the institutional management, heads of departments, and supervisors regarding their participation in public communication (Gascoigne & Metcalfe, 1997; Royal Society, 2006; Andrews et al., 2005; Kreimer, et al., 2011; Qi et. Al., 2013). Indeed, managerial support was one of the predictors of participation in Besley et al. (2012). Similar to a subjective norm, but specifically referred to how supportive supervisors or other superiors are regarding PE, this perception seems to function as a norm influencing behavior. I would describe this perceived norm as managerial norm, and state my next hypothesis.

H6: Perceived support from direct superior or supervisor (managerial norm) regarding participation in PE will be positively related with researchers' intention to participate in PE

Other potential factors. Recent behavioral models can also shed light in predicting researchers' PE activity. For example, the Integrative Model of Behavioral Prediction (IMBP; Fishbein, 2000; Fishbein, 2008) adds other important factors to explain behaviors. IMBP basically has the same main constructs of TPB and behavioral intention remains the most important determinant of actual behavior. However, IMBP states that two other components affect behavior: (1) knowledge and skills to perform the behavior, and (2) environmental constraints.

In this framework, sometimes the problem might be not motivation, but a person's competence or skills, and the environmental barriers or facilitators. Thus, according to IMBP, a scientist's participation in PE is most likely to happen if the researcher has a strong intention to do it, has the knowledge and skill to do so (i.e., communication skills), and there is no serious environmental constraints preventing participation (i.e., rules, rewards, incentives). Now, I will review past research regarding these two additional variables: skills and environmental factors.

Skills. Measurements of actual communication abilities and skills of scientists may be challenging and have not been found in the present literature review. However, some studies have measured perceived skills and level of training, which can be indirect indicators of skills. For instance, perception of lack of skills is one of the top reasons mentioned by British scientists for not participating in PE (Wellcome Trust, 2000; Poliakoff & Webb, 2007). Also, findings from

a few qualitative studies that analyzed different subpopulations of American researchers, show that poor communication skills or inability to communicate with non-scientists were also indicated as an important barriers impeding involvement in public communication (Matthews et al., 2005; Ecklund et al., 2012).

In respect to training, data from Wellcome Trust (2000) and Royal Society (2006) show that 90% and 73% of British scientists reported not having been trained to communicate with the media or non-experts, respectively, which was linked to a lower confidence and participation in PE. In fact, having been trained in communication was related with higher levels of participation in PE in the aforementioned studies, and was one of the predictors of participation in Dunwoody et al. (2009) and Dudo (2012), studies that examined biomedical scientists' engagement. Thus, skills and competences to interact with a broader audience are expected to be an outcome of general communication training -or more specifically of science communication training- which may in turn influence intention, and participation. In the absence of a clear measure of skills, past training may influence a researcher's intention.

H7: Past training in PE will be positively related with intention to participate in PE

Environmental factors. Reasoned action models of behavior such as TPB and IMBP also recognize the powerful influences of environment on behavior. According to IMBP, the lesser the environmental constraints, the more likely is the behavior to be performed, which is in line with some of the constructs of Social Cognitive Theory such as incentive motivation and facilitation (Bandura, 1986; Montano & Kasprzyk, 2008). For example, the use of rewards and punishments can be used to modify behavior (incentives). Similarly, facilitation strategies such as providing

tools and resources to make individual and social change easier can be implemented by actors and institutions of the social system (Montano & Kasprzyk, 2008).

In the case of public engagement with science, universities, research institutes and government agencies are the organizations that, along with researchers and the public, shape the process of science communication. They provide scientists the environment, affiliation, funding, and practice for research activities and public engagement. Thus, a big part of the environmental influence on researchers' PE might reside on the institutional factors. But what is the organizational status of PE at research institutions? Is it PE part of the organizational culture or a matter of marginal importance?

Neresini and Bucchi (2011), in an exploratory study of 40 European research institutions, found that despite outreach and engagement being the third mission of universities, as well as an increasing pressure in the form of policy reports and requirements to communicate with society as part of the grant evaluation process, there is still a failure by research institutions to incorporate PE to their practices and organizational cultures. For instance, this means that PE is not yet effectively recognized as part of the evaluation process (e.g., tenure, promotion) or appropriately rewarded (e.g., allocating time, providing funds to participate). A variety of incentives in the form rewards and normative pressures were suggested in Wellcome Trust (2000) to improve scientists' involvement in public communication, such as encouragement from funding authorities and research institutions to spend time in PE, grants for engagements activities, financial support from institutions, inclusion communicators at institutions to speak with media and other publics, and requiring plans to disseminate results to society as part of research proposals.

Investigating the extent to which public engagement has been incorporated to the organizational culture of American research institutions would be an entirely independent topic of study. Nevertheless it could be worthy to analyze if researchers perceive institutional incentives (e.g., allocating time for PE, rewarding participation in PE) and normative pressures (e.g., PE in mission statement of the institution or academic unit, requirement from funding agencies to do PE) within their organizational cultures; and more importantly, if these incentives and normative pressures influence a researcher intention to participate in PE.

In general, prior data tells us that researchers perceive that the social system of science (i.e. organizational culture) is not supportive of public engagement. Lack of acknowledgment, reward or recognition of a scientist's PE effort within the scientific culture was a common shared belief that hindered researchers' participation in PE, mentioned in qualitative and quantitative studies of scientists' engagement (Dunwoody & Ryan, 1985; Gascoigne & Metcalfe, 1997; Watermeyer, 2005; Poliakoff & Webb, 2007; Matthews et al., 2005; Ecklund et al., 2012). Thus, the following research questions emerge.

RQ1: Do perceived institutional incentives, such as allocating time for PE and rewarding participation in PE, influence a researcher's intention to participate in PE?

RQ2: Does the perception of a normative pressure, such as the presence of PE in the mission statement of the institution or academic unit, influence a researcher's intention to participate in PE?

Furthermore, in respect to normative pressures, requiring the communication of research results to society has become a policy implemented by government agencies in several countries as part of the grant evaluation process. One of the best codified examples comes from the U.S. National Science Foundation (NSF), agency that from 2002 has determined the mandatory inclusion of the Broader Impacts (BI) criteria along with the Intellectual Merit (IM) review criteria, for every proposal seeking research funding (BI began in 1997 but was not mandatory then). BI basically consists of explaining how the proposed research project may benefit society. NSF's goal with BI was that potential benefits were achieved not only through research itself, but through complementary activities aiming to increasing diversity and quality of STEM research at any level, as well as to enhance public scientific literacy and public engagement with science and technology, among others. Currently, BI and IM criteria are given equal weight in the assessment of proposal merits, and while fulfilling the IM requirement has not represented a major problem, failing to address BI results in not passing the NSF compliance check, with the proposal being returned without review (NSF, 2013). Other U.S. funding agencies do not have clear requirements regarding outreach and engagement activities in their guidelines for grant applications. In addition to requirements from agencies, other funding institutions at the state and local government level, as well as from the private sector, may have diverse type of policies, expectations and organizational cultures that stimulate or not PE.

Thus, it is expected that the source of funding, whether this comes from the university, industry, or a specific government agency might influence views and intention to participate in public engagement. Specifically, those researchers funded by NSF, that has a specific requirement for PE, are expected to have a higher participation in PE.

H8: Being funded by NSF will be positively associated with a researcher's intention to participate in PE

Furthermore, independently of the source of funding, it might be interesting to analyze the extent to which the role in a funded project is associated with involvement in PE activities. For example if the responsibility of being a PI (principal investigator) or Co-PI, versus not being in such a manager or leadership position and just collaborate in funded projects, has an effect in forming intentions and participating in PE. On the one hand, a PI or Co-PI, as the formal leader, might feel more obligated to be the public face of the project, to be interviewed by the media or to be the one who gives the public presentations. On the other hand, he or she may feel freed of those responsibilities and have their research assistants fulfill the broader impacts and engagement requirements or opportunities.

RQ3: Does the role in a funded project (being a PI or Co-PI) influence a researcher intention to participate in PE?

Another example from Neresini and Bucchi (2011) to illustrate the weak presence of PE in the organizational culture is that several researchers interviewed in the study are unaware of the existence of a Public Relations or Communication office that deals with PE, or they know there is be one, but they do not know where it is located or who are in charge. This is an aspect to pay special attention, because even in the hypothetical presence of these institutional infrastructure to PE (PR/Press office), a communication challenge seems to emerge within scientific institutions. Multiple studies report that researchers lack information about outreach

and engagement opportunities, as well as are unaware of the procedures and institutional infrastructure available regarding public communication (Andrews et al., 2005; Sturzenegger-Varvayanis, Eosco, Ball, Lee, Halpern, & Lewenstein, 2008; Matthews et al. 2005; Ecklund et al., 2012; Loaiza, 2012; Qi et al., 2013).

For instance, in respect to facilitating procedures, Dudo (2012) found that decision autonomy influences participation in PE. The autonomy a scientist has to talk directly to the media or the public (e.g. not need approval of supervisor or academic unit) was one of the predictors of actual engagement. What Neresini and Bucchi (2011) suggest is that, if institutions and policy actors want to take seriously the challenge of public communication of science, we need organizational frames that support PE through the implementation of infrastructure and facilitating procedures, which might help to create intentions to participate in PE, as well as translate that intention into actual communication with society. Therefore, another question is whether researchers perceive these institutional facilitators (e.g., communication infrastructure and procedures regarding communication) and if that affects their PE participation.

RQ4: Do awareness of infrastructure for PE (PR/Communication Office) influence a researcher's intention to participate in PE

RQ5: Do perceived decision autonomy regarding PE influence a researcher's intention to participate in PE?

Although an overall negative perception of institutional support, there are cases indicating potential partial changes in organizational cultures regarding PE. Sturzenegger-

Varvayanis et al. (2008) found that 57% of scientists at an American research-intensive university considered their institution and colleagues supportive of public engagement. However, the same respondents still believe that barriers to PE are external rather than on scientists themselves. Similarly, Loaiza (2012) who interviewed 112 researchers at 5 nanotechnology and material science European research centers, found that respondents perceived their institutions fairly supportive of PE, though this support is mostly moral or without funds or professional recognition. The author concludes that the level of scientists' participation in PE varies in accordance with the degree of their individual necessity and the level of support available, which basically consists of three factors: external initiatives, institutional structures and funds.

Demographics. In the reasoned action models such as TPB and IMBP, demographic variables, as well as personality and media exposure, are denominated background variables, which are believed to influence behavior indirectly. They are mediated by the three more proximal influencers of behavioral intention: attitude, perceived norms, and self-efficacy.

In prior research of scientists' engagement, despite correlations, demographic variables such as sex, status (seniority) and field of research have been shown as minor predictors of attitudes and participation in PE. However, previous empirical studies have found that mid-career and senior scientists tend to be more active in PE than juniors (Gascoigne & Metcalfe, 1997; Royal Society, 2006; Dunwoody et al., 2009; Bauer & Jensen, 2011; Besley et al., 2012; Dudo 2012; Kreimer et al., 2011). Similarly, Von Roten (2011) studied Swiss scientists at a single university and also found that being older and in a higher hierarchical and permanent position (e.g. professors, heads of research, senior research fellows) increases the level of engagement.

In the same vein, a researcher's status seems to have a relationship with the motivation to perform PE. Martín-Sempere et al. (2008) surveyed Spanish researchers at a science fair (n=167) and reported that senior scientists were highly motivated by a sense of duty, while juniors were more motivated by enjoyment and personal satisfaction. Regarding the type of activity usually done, Kreimer et al. (2011) found that seniors carry out the most 'prestigious' PE activities such as TV or News Media, and juniors participate more in open lab days and interacting with schools.

In respect to sex, despite male and female researchers having similar positive attitude levels towards PE (Besley et al., 2012), PE activities are done significantly less frequently by women (Von Roten, 2011; Besley et al., 2012; Kreimer et al., 2011), which according to Von Roten, is mostly explained by a low level of media contact (i.e. journalists contact more men researchers than women).

Regarding disciplinary field a couple of studies indicate that social scientists are more active in public communication than their peers of other fields (Kreimer et al., 2011; Bentley & Kyvik, 2012) and they are the ones that perceive fewer constraints to participate in science communication (Dunwoody & Ryan, 1985). Furthermore, Besley et al. (2012) found that chemists and physics (natural sciences) tend to be less involved in PE, and engineers are less likely to perceive its importance. Also, results from Royal Society (2006) show that clinical and non-bioscience researchers are more likely to undertake public engagement. In sum, regarding status and sex there are slightly more consistent findings than the results relating disciplinary field and participation. However, considering these data, I still prefer to propose a research question regarding demographic variables.

RQ6: Does a researcher's sex, status and field predict intention to participate in PE?

Rationale for this Study

The last decade saw a growing interest in understanding the views of scientists regarding public communication and their level of participation in engagement activities. Nevertheless, even though initial studies laid the foundation for research in the area and some of them advanced towards predictive models (Dudo, 2012; Besley et al., 2012; Poliakoff & Webb, 2007), the topic is far from being totally understood. Diverse types of limitations were mentioned by these authors (i.e. lack of theoretically motivated research, small samples, sample of specific disciplinary fields, incomplete measures). The present study seeks to explore whether the constructs of the Theory of Planned Behavior and new additional constructs (perceived norms, institutional factors) are able to predict researchers' intention to participate in public engagement with science and technology in the next 12 months. Based on theory and prior research, it is predicted that attitude, perceived behavioral control, descriptive norm, moral norm, managerial norm, perceived normative pressures, perceived incentives, perceived facilitation strategies, past behavior and past training will be determinants of intention to participate in PE.

Chapter 3: Methodology

Participants and Data Collection

The present research project utilized a questionnaire design and collected data via an online survey of researchers working at North Carolina State University (NCSU) in Raleigh, United States. NCSU is large land-grant public university with intense teaching and research activities, as well as high level of interactions with Industry. It is located in a region known as the Research Triangle due to the presence of three major research universities such as NCSU, University of North Carolina at Chapel Hill, and Duke University in Durham, as well as the Research Triangle Technology Park and several other techno scientific companies. This makes the region one of the prominent knowledge production and innovation poles in the country.

Using the NCSU online Campus Directory search engine, the most updated publicly available database of faculty and staff, several search strings were used to collect data of professors (all ranks), research assistants (master's and PhD students) and postdocs currently working at every department/unit listed by the university. Thus, the sample included researchers from all disciplines, from engineering and technologies, to humanities and social sciences. Information indicating researchers' name, status, department and email were collected from the online database. The final sample frame consisted of 4998 researchers (3201 professors, 1471 research assistants, 326 postdocs). A simple stratified random sample was drawn, resulting in a sample of 1785 researchers (1142 professors, 527 research assistants, 116 postdocs).

A NCSU Institutional Review Board (IRB) exemption was obtained prior to data collection. As part of the informed consent it was made clear to participants that the study was not part of any initiative to promote their participation in communication activities and that the data would be treated in the strictest confidentiality as well as reported in aggregated form. The

possibility of entering a drawing to win one of five Amazon gift cards was used as an incentive for participation.

Dillman, Smyth, & Christian's (2007) procedures were followed to implement the online survey. Data was collected between November and December 2013; the questionnaire stayed online for five weeks. Using Qualtrics online software provided by NCSU as the data collection platform, an initial invitation email was sent to selected scientists explaining the project, asking for their voluntary participation and providing the link to the survey. Two subsequent reminders on weeks 2 and 4 were also sent aiming to increase the response rate.

The following explanation was used at the beginning of the survey to define the nature of the study: "As you know, researchers from different disciplines, ranging from life sciences, to engineering, to humanities and social sciences, engage at some point in interactions with non-experts outside their fields and academic circles. For the purposes of the present study we define this process of communicating with non-specialist audiences about your research or area of expertise as public communication or public engagement. This includes all activities performed outside academia that are related to your research, whether it focuses on science, technology and engineering, or the social sciences, arts, and humanities".

Data collection[2] yielded 404 valid responses, which gives a minimum response rate RR1= 22.6% (AAPOR, 2011). The stratified response rate was 20% for professors (n_1=224), 25% for research assistants (n_2=131), and 42% for postdocs (n_3=49). All career stages were adequately represented: 55% of the final sample were professors, 32% were research assistants, and 12% were postdoctoral fellows. Comparisons with the actual proportion of researchers at

[2] A final data report, including descriptive statistics for all measured variables is available upon request from the author at the email sncanete@ncsu.edu.

different career stages for the entire population of at NC State (52.6% professors, 40.2% research assistants, 7.1% postdocs) show a very slight overrepresentation of postdocs and slight underrepresentation of research assistants. Regarding sex, 64.2% of respondents were male and 35.8% were female, which is consistent with the actual distribution of researchers at the university (61% male, 39% female). (NCSU, 2012).

Measurements

Questionnaire measures were taken of the theoretical constructs presented in the literature review. Items were adapted from previous research on attitudes and participation of scientists in public engagement (Poliakoff & Webb, 2007; Von Rotten, 2011; Royal Society, 2006; Dudo, 2012) as well as from published guides on the behavioral theories (Montano & Kasprzyk, 2008).

Demographics. *Sex* was measured as a dichotomous variable with male coded as "0" and female coded as "1" (35.8%).

Status (seniority) was a categorical variable measured using 8 categories coded from "1" to "8": Master's student, PhD Student, Post Doc, Non-tenure track faculty/Adjunct professor, Assistant professor, Associate professor without tenure, Associate professor tenured, Professor. For the purposes of statistical analysis, these categories were grouped[3] into three dummy

[3] I did not want to increase even more the number of independent variables in the regression model, so the grouping for the status variable was done according to three well known and easily understood academic ranks: research assistants (grad students), postdocs, and professors. Besides that, the means on the dependent variable for the subgroups included in each category were similar. Here I list the means of behavioral intention by status: Master's student (M=4.76), PhD Student (M=4.45), Post Doc (M=4.90), Non-tenure track faculty/Adjunct professor (M=4.63), Assistant professor (M=5.20), Associate professor without tenure (M=5.78), Associate professor tenured (M=4.74), Professor (M=4.99)

variables: research assistants (32%), postdocs (12%), and professors (56%), each of them coded as 1=Yes, and 0=No.

Field was measured using the Organization for Economic Cooperation and Development (OECD) revised classification of fields of science and technology (FOS) in the Frascati Manual (OECD, 2007), which are six major fields coded from "1" to "6" (Mathematics & Natural Sciences 25.1%, Engineering & Technology 23.8%, Medical & Health Sciences 7.2%, Agricultural Sciences 18.7%, Social Sciences 18.7%, Humanities 6.4%). Each of these categories was converted into a dummy variable (1=Yes, 0=No) for data analysis.

Behavioral intention. This is the dependent variable and was measured with one item: *"Thinking of communicating your research to non-specialists… In the next 12 months, how likely is that you will participate in a public engagement activity?"* (1= very unlikely, 7=very likely) (M=4.82, SD=1.77).

Attitude. Attitude towards public engagement was measured using the following prompt "*I'm interested in knowing how do you personally feel about taking part in public engagement activities. Would you say these activities are…*", followed by six 7-point semantic differential scales: bad-good, unenjoyable-enjoyable, pointless-worthwhile, unpleasant-pleasant, foolish-wise, harmful-beneficial (Cronbach's $\alpha = 0.89$).

Subjective Norm. Subjective norm *(colleagues' negative reactions)* was measured with one item: *"Talking to the public will negatively affect my image in front of my colleagues"* (1= strongly disagree, 7=strongly agree) (M=2.35, SD=1.26) (recoded).

Perceived behavioral control. This construct was measured with one 7-point semantic differential item: *"Would you say that public engagement activities are...."* (1=difficult- 7=easy) (M=4.31, SD=1.44).

Descriptive norm. This construct was measured with one item: *"Thinking about the colleagues you respect the most, how frequently would you say they take part in PE"*, ranging from 1 to 7 (Never, Rarely, Occasionally, Sometimes, Frequently, Quite Often, Very Often) (M=4.02, SD=1.36).

Moral norm. This construct was measured with one item*: "Every researcher has the duty to communicate with the non-specialist public"* (1=strongly disagree, 7=strongly agree) (M=4.81, SD=1.52)

Managerial norm. The perceived support from direct supervisor was measured with the following item*: "Thinking about the degree of support you receive from your Department Head, Dean, Director, or other supervisor regarding your participation in public engagement activities. Would you say he or she is…"* (1=Strongly opposed, 7=Strongly supportive) (M=5.31, SD=1.12).

Past participation. Previous participation in PE was measured using the stem *"Now thinking about your actual participation in the same public communication activities, in the past 12 months have you…",* followed by 14 types of public engagement activities. (e.g. Given a public talk or participated in a science cafe, written for popular audiences, drafted a press release, talked to children and teenagers in schools). Responses were in an ordinal scale ranging from 1 to 5 (Never, Once, 2 or 3 times, 4 or 5 times, 6 or more times). An index was created with the average participation in each of the 14 PE activities (Cronbach's $\alpha = 0.854$)

Past training. Prior training in PE was measured with a single item: *"How many times in your career have you have participated in training courses or workshops about communicating to public audiences?"*. Responses were in an ordinal scale ranging from 1 to 5 (Never, Once, 2 or 3 times, 4 or 5 times, 6 or more times) (M=1.92, SD=1.16).

Normative pressure - Role as a PI or Co-PI. This variable was initially measured with this categorical item *"In the past 12 months, have you received research funding? Select all that apply"*, with 3 response options ranging from "1" to "3" (1=I have received research funding as a Principal Investigator or Co-Principal Investigator 44.1%; 2=I have contributed to funded research where I was not the Principal Investigator or Co-Principal Investigator 46.5%; 3=I have not received funding 23.3%). Then I created a dummy variable (1=received funding as a PI or Co-PI, 0=else) for statistical analysis.

Normative pressure - Funded by NSF. To measure this item, a question was shown to those who marked having being funded in the last year. It was measured with a categorical (select all that apply) item: *"In the past 12 months, have you received research funding from any of the following sources?*". Responses ranged from "1" to "8" (University sources 28.5%; Foundations , Nonprofits, and/or Professional Associations 17.3%; Industry 20.8%; State and/or local government funds 13%; Federal-National Science Foundation-NSF 25.%; Federal-National Institutes of Health (NIH) 6.4%; Federal-Other 27%; Other 4.5%). A dummy variable was created for statistical analysis (1=funded by NSF, 0=not funded by NSF).

Normative pressure – PE in Mission Statement. This is the researcher's perception of the presence of public engagement in their institutions' mission statement. The variable was measured with the following item: *"Does your college/institute mention PE in its mission statement?"*. The response options ranged from "1" to "3" (Yes 47.5% - No 3% - I don't know 49.5%). A dichotomous variable was created for data analysis (1=Yes, mention PE in mission statement / 0=No, I don't know).

Institutional Incentives - Allocating time for PE. This is the perception of researchers regarding their institutions *allocating time* for public engagement. It was measured with this

item: "*Does your college/institute…"* followed by the specific option: *"allocate time for PE"*. The response options range from "1" to "3" (Yes=29%, No=18.2%, I don't know=52.9%) A dummy variable was created for statistical analysis (1=Yes, 0=No, I don't know).

Institutional Incentives - Rewarding PE. This is the perception of researchers regarding their institutions *rewarding participation* in public engagement. It was measured with this item: *"Does your college/institute…"* followed by the specific option: *"reward participation in PE"*. The response options range from "1" to "3" (Yes=19.8%, No=22.3%, I don't know=58%). A dummy variable was created for statistical analysis (1=Yes, 0=No, I don't know).

Institutional facilitators - Presence of PR/Press Office. This variable was measured with the following item "*Does your college/institute…",* followed by the specific option: *"have a communication, PR or press office"*. The response options range from "1" to "3" (Yes 65.5% - No 2.5% - I don't know 32%). A dichotomous variable was created for data analysis: *Have a PR-Press Office* (1=Yes, 0=No, I don't know).

Institutional facilitators – Approval to talk to Media. This variable was measured with the following item *"Does your college/institute…",* followed by the specific option: *"require approval before you talk to the media"*. The response options range from "1" to "3" (Yes 8.5% - No 31.8% - I don't know 59.7%). A dichotomous variable was created for data analysis: *Requiring approval to talk to media* (1=Yes, 0=No, I don't know).

Analytical Approach

Initial data processing was done using SPSS v.22, but missing data appeared as a potential issue. Missing data points ranged from 4.5% to 13.5% for the different variables in the dataset. In order to handle missing data better, dataset was exported to and processed with Mplus

v.7, a statistical package that features Full Information Maximum Likelihood (FIML) handling of missing data. FIML is an appropriate, modern method of missing data handling that enables Mplus to make use of all available data points, even for cases with some missing responses (Muthén, 1998).

In order to test my hypotheses and answer my research questions, I used a hierarchical multiple regression procedure, in which the independent variables were entered in blocks according to their assumed causal order. Sex and status were entered in the first block, followed by field in the second. In the third block, past participation in PE and past training in PE were included. Institutional factors (normative pressures, institutional facilitators, institutional incentives) were entered in the fourth block. In the fifth block, the constructs of the Theory of Planned Behavior (attitude, subjective norm, perceived behavioral control) were included. Finally, in the sixth block, other perceived norms (descriptive norm, moral norm, and managerial norm) were entered.

Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, and homoscedasticity. Additionally, the inter-correlations amongst the predictor variables were examined and all correlations were weak to moderate indicating that multicollinearity was unlikely to be a problem. Most of the predictor variables were statistically correlated with intention to participate in PE which indicates that the data was suitably correlated with the dependent variable for examination through multiple linear regression to be reliably undertaken. The correlations between the predictor variables and the dependent variable were all weak to moderately strong, ranging from $r = .06$, $p < .001$ to $r = .50$, $p < .001$.

Chapter 4: Results

Before presenting the main regression results, I will offer a general perspective on the univariate statistics for the independent and dependent variables, along with some comparisons by demographics. In addition, I will present the bivariate results, in terms of significant correlations between the predictors and criterion variable.

Regarding the dependent variable it is noticeable that researchers reported having moderate intentions to participate in PE over the next 12 months (M=4.82) which is slightly superior to Poliakoff and Webb (2007) (M=4.33), the only other comparable study. In respect to some demographics aspects and the dependent variable, female researchers reported a slightly higher intention (M=4.94) than their male counterparts (M=4.78), as well as professors (M=4.95) and postdocs (4.90) showed higher intentions than research assistants (4.54). Similarly, those in the Agricultural Sciences and in Social Sciences expressed higher intentions to participate in PE (Ms =5.29, 5.14) than those in the remainder fields (Ms=4.33 to 4.87).

Furthermore, researchers expressed a positive attitude towards participating in PE activities (M=5.59) and thought that participation in PE does not generate a negative image or disapproval from colleagues (subjective norm, M=5.65). Moreover, researchers perceived their direct superiors or supervisors as somewhat supportive of their participation in PE (managerial norm, M=5.31). Behavioral control, descriptive norm and moral norm were all around the midpoint (Ms = 4.40, 4.02, 4.81). Past training in PE (M=1.92) and level of participation in the last year (M=1.51) were low.

Despite a low mean in participation in PE in the last year (M=1.51, in a 5-point scale where 1=Never and 5= Six or more times), 87% of researchers reported having participated in at least 1 of 14 listed PE activities in the last 12 months prior to the study (see Table1). From this

perspective it can be considered a good rate of participation, but if we look at the intensity of this participation (how many times in the past year), the mean for participants (M=1.51) suggests that researchers have participated just one time in the majority of the reported activities. Men were slightly more active (M=1.54) than women (M=1.49). Similarly, professors participated more (M=1.66) than postdocs and research assistants (Ms=1.32, 1.34), and again those in the Agricultural Sciences and in Social Sciences reported higher participation in the past year (Ms =1.69, 1.65) than those in other fields of science and technology (Ms=1.40 to 1.45).

[*Insert Table 1 about here*]

In terms of significant correlations ($p < .05$) between the predictors and the criterion variable, intention to participate in PE had strong positive correlations with past participation ($r >= 0.50$) and moderate positive correlations ($r = 0.30$ to 0.49) with attitudes, past training, allocating time for PE, rewarding participation in PE, and moral norm. Being in the agricultural sciences (compared to Humanities), being funded as a PI or Co-PI, being funded by NSF, perceiving presence of PE in the institutional mission statement, being aware of the existence of a PR/Press Office, perceived behavioral control and descriptive norm were all weakly correlated ($r = 0.10$ to 0.29) with the dependent variable. Also, being in the Engineering & Technology field had moderate negative correlations with intention ($r = -0.20$).

As mentioned in the methodology section, hierarchical multiple regression was used to determine the predictors of intention to participate in PE in the next 12 months. The independent variables were entered in six blocks (see Table 2). In the first block, sex along with post-doc and

professor (dummy variables of status) were entered, accounting for 1.5% of explained variance. Being a professor was a significant predictor at Step 1 ($\beta = .12$, $p < .05$).

[*Insert Table 2 about here*]

The dichotomous variables corresponding to the major fields of research were entered at Step 2, adding 3.4% to explained variance. Here, the effect of being a professor disappeared and the only significant predictor was being in the agricultural sciences ($\beta = .18$, $p < .05$).

At Step 3, past training and past participation in PE were entered, adding a large 25.4% increase of explained variance. Both variables were the only significant predictors at this step: past training in PE ($\beta = .17$, $p < .001$) and past participation in PE ($\beta = .44$, $p < .001$).

After that, normative pressures (role as a PI or Co-PI, being funded by NSF, presence of PE in mission statement), institutional facilitators (awareness of PR/Press Office, need of approval to talk to media), and institutional incentives (allocating time for PE, rewarding participation in PE) were entered at Step 4, adding 3.9% of explained variance. With the addition of this block, being funded as a PI or Co-PI ($\beta = .09$, $p < .05$), allocating time for PE ($\beta = .09$, $p < .05$) and rewarding participation in PE ($\beta = .10$, $p < .05$) became significant determinants of intention. The effect of past training ($\beta = .16$, $p < .001$) and past participation in PE ($\beta = .40$, $p < .001$) also remained significant at this Step without considerable variations in the regression coefficients from the previous block.

At Step 5, the TPB variables (attitude, subjective norm, perceived behavioral control) were entered, adding an additional 4.2% of explained variance. Attitudes towards PE was the only significant TPB variable in this block ($\beta = .20$, $p < .001$). Past training in PE ($\beta = .14$, $p <$

.01), past participation in PE ($\beta = .34$, $p < .001$), and being funded as a PI or Co-PI ($\beta = .09$, $p < .05$) also remained significant.

Finally, other perceived norms were entered at Step 6, which added 3.4% of explained variance. Moral Norm ($\beta = .15$, $p < .01$) and managerial norm ($\beta = .10$, $p < .05$) were significant, while descriptive norm was not. Past training in PE ($\beta = .13$, $p < .01$), past participation in PE ($\beta = .30$, $p < .001$), being funded as a PI or Co-PI ($\beta = .10$, $p < .05$) and attitude towards PE ($\beta = .14$, $p < .05$) remained significant with the addition of the last block.

As we can notice, the amount of variance added by block 3 (past training and participation) was 25.4%, by far the largest contribution to predict intentions. Past participation and past training, indicators of experience and potential skills, had powerful effects on explaining the dependent variable, which is consistent with reasoned action models (e.g. IMBP) and previous studies of researchers' engagement in that skills and experience not only affect intention and behavior indirectly, but also do that directly. Background variables included in blocks 1 and 2 (demographics, status, and fields of science) had low contributions to R^2 change, 1.5% and 3.4% respectively, which were also not significant, making sense in terms of reasoned actioned models such as TPB and its extensions, because demographics are considered to be mediated by the most proximal determinants of intention.

Although an apparent low percentage of explained variance resulted from addition of blocks 4, 5, and 6, these were statistically significant contributions of 3.9%, 4.2%, and 3.4%, respectively. In the case of block 4 (institutional factors) its contribution can be explained by the inclusion of "funded as a PI or Co-PI" which was the only significant determinant of this block in the final model. The same occurred in block 5 (TPB constructs), in which attitude was the only variable statistically linked with intention. In this case it is surprising that just attitude constituted

a determinant of intention, taking into account the strength of the TPB as a model of reasoned behavior. In block 6, correspondent to other perceived norms (descriptive, moral, managerial), the significant effect on intentions resides in the contribution of moral norm and managerial norm. In other words, a sense of duty to participate in PE and the perceived support of supervisor to do PE, were the significant factors, which was expected based on prior research. In sum, there is no evidence that the TPB constructs are significantly better at explaining behavioral intentions than past training, past behavior, some perceived norms and institutional variables.

The final regression model accounted for 40.3% of explained variance. Past training in PE, past participation in PE, being funded as a PI or Co-PI, attitudes towards PE, moral norm, and managerial norm emerged as significant independent predictors of a researcher's intention to participate in public engagement activities in the next year.

Therefore, five of my hypotheses (H1, H4, H5, H6 and H7) were supported by these results, as attitude, moral norm, past participation, managerial norm, and past training were significant determinants of intention. Notably, perceived behavioral control, one of the three constructs of TPB and a consistent predictor in different sets of behaviors (even in a previous study of scientists' engagement), was not a significant determinant in the present study. Hence, H2 was rejected. Moreover, descriptive norm, one of the proposed perceived norms added to the model, was not a significant predictor either, which does not provide support to H3. Finally, contrary to expectations, being funded by NSF did not constitute a significant determinant of intention, rejecting H8.

In terms of perceived institutional incentives, my first research question asked whether the perception of institutions allocating time for PE or rewarding participation in PE, influence a researcher's intention to participate in PE. When entered at Step 4, both factors were significant

at the $p < .05$ level, but their effect disappeared in the final model, suggesting that they are mediated by other variables. My second research question interrogates about the influence of perceiving PE as part of the institutional mission statement on intention to participate in PE. Although showing significance at the bivariate correlation level ($r=.24$, $p<.001$), it was not a significant predictor in the any of the regression models.

A third research question asked if the role in a funded project, specifically being a PI or Co-PI, influence intention to participate in PE. It turned out that being a PI or Co-PI was a significant determinant since Step 4 (when it was entered), as well as in the final model once all other variables were controlled for.

In addition, research questions 4 and 5 asked whether perceived institutional facilitators, such as awareness of existence of a PR/Press Office and the need of approval to talk to the media, influence intention to participate in PE. In both cases the answer is no; they were not significant predictors of intention, though awareness of a PR/Press Office was significant at the bivariate correlation level ($r=.21$, $p<.001$).

Finally research question 6 asked about the influence of demographics factors such as sex, status and major field of research on intention to participate in PE. None of them emerged at significant predictors in the regression analysis. As an interesting detail, at Step 2, after controlling for sex and status, being in the agricultural sciences showed a significant effect ($\beta=.18$, $p<.05$), influence that disappeared at Step 3. At the bivariate correlation level, intention showed a significant positive correlation with being in the agricultural sciences ($r=.19$, $p<.001$) as well as a negative correlation with being in the Engineering and Technology field ($r=-.20$, $p<.001$).

Chapter 5: Discussion

The present research project examined the determinant predictors of researchers' intention to participate in public communication of science and technology, or simply public engagement (PE). The goal was to enhance our understanding of the elements that lead scientists to engage in interactions with non-experts. Built on previous research in the area, especially studies aiming prediction of this engagement (Poliakoff & Webb, 2007; Besley et al., 2012; Dudo, 2012), I applied an expanded model of the theory of planned behavior (TPB; Ajzen, 1991). Specifically, the study investigated the influence of demographic factors (sex, status, field), past behavior, past training, attitude, subjective norm, perceived behavioral control, descriptive norm, moral norm, managerial norm, normative pressures (being funded as a PI or CO-PI, being funded by NSF, perceiving PE in mission statement), institutional facilitators (awareness of PR Office, need of approval to talk to the media), and institutional incentives (allocating time for PE, rewarding participation in PE), on a researcher's intention to participate in PE.

The results indicated that there are six major significant determinants of a researcher's intention to participate in PE in the next 12 months, namely past training in PE, past participation in PE, being funded as a PI or Co-PI attitude, moral norm, and managerial norm. In turn, these factors together suggest that three big aspects play important roles in scientists' engagement behavior: experience, liking, and accountability.

First, background variables such as past training and past participation in PE are components of the experience built by researchers in their careers, which leads to create and consolidate communication skills as well as to provide a sense of efficacy to perform public communication. Second, the affective component was also clear in this study, judging by the significance of the positive attitudinal evaluations of PE, which basically represent the idea of

liking the behavior in question (e.g. I like this, it's a good idea, it's wise). Third, the significance of moral norm, managerial norm and role as a PI or Co-PI shows that a sense of responsibility is also central in decision making to perform PE. Researchers apparently consider public communication as part of being accountable to their role as researchers (many of whom are publicly funded and think need to justify the use of tax dollars, or just because they think sharing knowledge can help society), or as part of their responsibilities with supervisors and advisers that support them, or because of their role as leaders of funded research projects who are expected to create, discover, mentor, innovate, and communicate.

Next in this chapter, I will present some of the limitations of the study and then discuss in more detail the implications of the findings, as well as offer some overall recommendations and proposed lines of inquiry.

Limitations

The present study has several limitations. Some issues come from the sample. First, the sample was drawn from a single university in the U.S., so that readers should be cautious about generalizations made from the data. In addition, although North Carolina State University (NCSU) is a land-grant research-intensive university, active in a diversity of fields, the actual academic offer and research tradition at NCSU might have led to an overrepresentation of the fields of Engineering and Natural Sciences, and an underrepresentation of the Medical & Health Sciences. Response bias could also have affected the final sample as well. Given that I invited a random sample of scientists, there is the risk that respondents have been those already involved, interested and/or holding positive views of PE, leading to an overestimation of the actual level of

attitudes, intentions, and past participation in PE. The response rate (22.6%) might also seem apparently low, but it is consistent with other online surveys.

Other limitations stem from measurement procedures and the selection of independent variables. As stated in parts of the discussion, some of the constructs of the theory of planned behavior (i.e. subjective norm and perceived behavioral control) were measured with just a single item, raising concerns of content validity. Similarly, even though it was a comprehensive selection of demographic, background, institutional, and cognitive factors as independent variables for the regression models, the final model does not intend to cover every possible predictor. Other variables, such as media-related factors, personality, and additional institutional aspects could have been potential determinants of the dependent variable. Likewise, other theoretical perspectives may provide insightful inputs to analyze scientists' participation in public communication.

Finally, even considering these issues, some strengths of the present study, such as the random sampling procedure, consonance with prior science communication research, a relatively good number of respondents for a single university, and the use of proper analytic procedure, might have balanced or outweigh probable limitations. In the following section I will discuss how the results can be interpreted in terms of theoretical assumptions and practical implications.

Past Participation

Similar to Poliakoff and Webb's (2007) findings, past participation in PE was the stronger predictor of a researcher's intention to participate in PE over and above perceived institutional factors, TPB constructs, and other perceived norms. As stated in the literature review, this finding probably just shows that the same factors that affected researchers'

participation in the past continue to do so in the present, but without explaining why. Therefore, it can be predicted that if scientists took part in PE activities in the past year, they will probably repeat the behavior in the next 12 months. This is in line with Wellcome Trust (2000) which found that researchers who have experience interacting with non-experts audiences are more likely to engage again in public communication activities.

From an institutional perspective, this also points out that if one wants to make plans for outreach and engagement by mobilizing the community of researchers, the first option candidates will be those who have participated in the past. However, it also highlights the necessity to identify other cognitive and institutional factors that can stimulate the participation of those who have not participated in the past.

From a journalistic standpoint, this result can signify that if a reporter wants to talk to scientists they may want to look for their past participation in interviews with the media in order to increase the likelihood to accept the invitation. This does not mean that other factors do not play a role, such as specific attitudes towards media or preference for certain types of media, nor that if a researcher has not participated in the past he would reject your proposal. The same reasoning could be applied to other types of public engagement activities (e.g., engaging with policy makers, talking to schools); past behavior can also be an indicator of preferences for certain types of PE activities.

Another key result, analogous to Poliakoff and Webb's (2007) study, is the attenuation effect in past behavior (from β=.44 to β=.30) after introducing in subsequent blocks the institutional factors and the cognitive variables such as TPB constructs and other perceived norms, some of which remained significant in the final model after controlling for past behavior and past training. This points out the importance of taking into account the cognitive

determinants of a scientist's intention to engage as targets of intervention, beyond just relying on past experiences. In other words, we know that routine and experience influence intention to a certain extent, but yet a big part of scientists' decisions regarding PE resides on reasoned planning based on beliefs, attitudes, perceived norms and institutional factors.

Having had experiences in PE activities can also be considered an informal and practical way to acquire skills in communicating about science with non-specialists. Another significant predictor of intention was past training, which is a more formal method of building competences.

Past Training

Having been trained in communicating research to broader audiences (past training in PE) was found to be another significant predictor of intention to participate in PE. This result is in line with prior research (Dudo, 2012; Dunwoody et al., 2009; Royal Society, 2006; Wellcome Trust, 2000) and confirms the importance of educational strategies oriented to build skills and competences to interact with non-experts. It is clear that past training is affecting intention formation and apparently does so not mediated by other variables. I would have expected the effect of past training on intention to be mediated by perceived behavioral control, for example, but this does not seem to be the case.

If the goal is to promote science-society interactions, the practical implications of this finding may seem obvious: institutions should strategically invest resources in carefully planned and meaningful training of scientists. These types of initiatives are increasingly being implemented by universities, private organizations, and scientific societies such as the AAAS, which promotes workshops to train scientists to engage with society and policy makers.

It has been suggested that we do not want or expect that all scientists should be engaging with the public (Person, 2001 as cited in Dudo, 2012). However, considering the low level of training reported by scientists (in the present study 52% have never participated in training and 19% have participated once), there is still a lot of room to incorporate communication insights into the scientific community, especially knowing that training is a determinant of potential engagement with the public.

Some questions that remain for further analysis are: what are the best moments of a researcher career to perform this type of training? What are the researchers' attitudes towards participating in communication training? What are the aspects to be included in the training, considering ongoing changes in communication channels and the public sphere? In respect to these points, literature in the area is emerging (see Besley & Tanner, 2011; Baram-Tsabari & Lewenstein, 2012; Mulder et al., 2008; Mogull, 2008; Turney, 1994)

Besides the background influence of past behavior and past training on the formation of intentions to do PE, the impact of organizational factors -those aspects mostly controlled by the scientific organizations that provide affiliation and funding to researchers (e.g., universities, agencies)- was also examined and is presented next.

Institutional Factors

The present study also analyzed the extent to which researchers' involvement in PE was influenced by perceived institutional factors. These institutional aspects were divided in three groups: normative pressures, institutional facilitators, and institutional incentives. First, normative pressures included source of funding (specifically being funded by National Science Foundation-NSF, an agency that requires PE plans), role in a funded project (specifically being

funded as a PI or Co-PI), and the perceived presence of PE in the institutional mission statement. These aspects were thought to constitute a pressure for researchers to comply with explicit engagement norms, and elements indicating the incorporation of PE into the culture of the institutions.

Second, institutional facilitators included awareness of the presence of a PR/Press Office, and decision autonomy to talk to the media. These elements represent one organizational structure and one procedure that might simplify the participation of scientists in public engagement. Third, institutional incentives included allocating time for PE and rewarding participation in PE. These items were related to specific policies aiming to incentivize participation and also potential signs of the inclusion of PE as part of the organizational culture. Now, I will discuss the results for each group of institutional factors.

Normative pressures. Regarding normative pressures, it was surprising that H8 was rejected, which means that being funded by NSF did not constitute a determinant of intentions. Although a significant weak correlation was seen at the bivariate level, it was not a significant factor in the regression model. According to the NCSU Office of Research, Innovation, and Economic Development (NCSU, 2013), NSF funding was responsible for 30% of the research expenditures at NC State University in the FY 2013. In addition, 25.5% of respondents reported having received funding from this agency. The sample was a good opportunity to test if the Broader Impacts (BI) criteria, a requirement of NSF to approve grants, are achieving the purpose of stimulating public engagement.

Results suggests that NSF funded researchers may not be motivated by this requirement, any more than they would be normally. The simpler explanation could be that this is a minor

factor not even significant, which is surpassed by other more powerful such as attitude and moral norm, among others. It is possible that intentions to do PE are already elevated among researchers at a public land-grant university in the US, which means that the NSF requirement may not have an effect in this particular context.

An additional possible reason might be the fact that public communication activities are just one of several elements defined by NSF in their explanation of what the BI criteria implies. Thus, researchers are focusing on meeting the BI criteria by stating in the proposals how research itself may benefit society, and not giving much importance to communication activities. In other words, they do not interpret BI criteria as communication and engagement with non-experts.

Another way look at it is that researchers make the effort to write excellent plans of public engagement to meet the communication part of the BI criteria, but just to get the grant, after which they forget about it, not forming intentions and consequently not participating. This also generates some questions. For instance, whether these plans to engage with society are assessed in the grant post-implementation evaluation, and how a failure to implement these plans affects future proposals.

It could also be that the measure was flawed. Just because a person has funding from NSF does not necessarily mean that he or she is directly responsible for engaging. A potentially better approach to understand in detail how researchers perceive and are influenced (or not) by the NSF's BI criteria would be through qualitative methods (e.g., interviews, focus groups).

In respect to the role in a funded project, one important finding of this study is that, independently of the source of funding, being a Principal Investigator or Co-Principal Investigator (PI or Co-PI) significantly predicts intentions to participate in PE, even after controlling for the remainder factors. The reason for this relationship is unclear, but it can be

hypothesized that being in a position of (research)leadership may increase the perceived pressure to comply with the expectation of the role of PI/Co-PI (expert, mentor, disseminator, discoverer) or increase the sense of duty to perform PE. Alternatively, the impact might be significant just because the majority of PI or Co-PI are professors, who in turn showed a higher intention to participate in PE. It also points out the importance of investigating the effect of the leadership role on engagement beyond the source of funding, as well as its relationship to other variables.

Another possible factor considered as a normative pressure, was the presence of PE in the mission statement of the institution or academic unit. RQ2 asked whether intention to participate in PE was influenced by researchers' perception of this organizational statement. The rationale behind this is: if researchers perceive that PE is included in documents that explicitly communicates the organizational culture (e.g., mission statement), they might be willing to comply with that cultural rule or norm, and therefore, they would be willing to participate in PE. Results show that some scientists might be aware of their institutions including PE in their declaration of principles, but this perception was not a significant factor.

In the questionnaire, scientists were asked to think about the mission statement in the framework of their Colleges/Institutes, all of which include engagement with society as part of their statements. These facts were checked through review of their websites. This result implies that just knowing that the institution value PE (at least in theory) does not translate into behavioral intentions, and that other types of stimuli are influencing them.

Institutional incentives. I also asked whether perceived incentives to participate in PE affect researchers' intention to do PE. Specifically, I tested the influence of institutions allocating time for PE and rewarding participation in PE. Interestingly, both variables were correlated with

intention at the bivariate level, as well as both factors were significant when entered in block 4 of the regression model, but the predictive significance disappeared once TPB constructs and other perceived norms were entered in subsequent blocks. Whether these incentives affect intention through the mediation of other variables was unclear using the present statistical analysis.

In the present study, 20% and 29% of respondents, respectively, perceived that their colleges do allocate time and do reward participation in PE, but data also indicates that these perceptions are not significantly affecting the formation of intentions. I did not perform a check of this perception with actual incentive policies at the university or college level, to effectively compare perception with reality or to see signs of the incorporation of PE into the organizational culture. Additional scrutiny may provide better insights in this area.

Regarding time, we know that it has consistently been mentioned in researchers' engagement studies as one of the top personal barriers to communicating with the public (Wellcome Trust, 2000; Martín-Sempere et al., 2008; Royal Society, 2006; Andrews et al. 2005; Watermeyer, 2005; Kreimer et al., 2011; Gascoigne & Metcalfe, 1997). Several scientists say they do not plan to participate in PE because it takes time, which is a precious asset that has to be mostly used for research, writing papers and teaching. That is a personal consideration that deters from participation, and it is a belief that might have roots in the culture of science acquired through training and practice. Considering the present study findings, I can add that incentivizing PE through the allocation of institutionally "sponsored" time may also not be a strong reason to motivate researchers to engage with the public.

In respect to the perception of institutions rewarding participation in PE, one limitation of the present data is that the question was asked in general (Does your college/institute reward participation in PE?). The item did not specify whether it refers to a financial reward, credit

towards tenure or other type of assessments, or a just moral reward (see Loaiza, 2012). Further studies should specify the type of reward in order to draw proper inferences regarding the influence of rewards in scientists' communicative behavior.

Institutional facilitators. Whether or not the perception of facilitators, such as communication structures and procedures, influence a researcher's intention to participate in PE was also a question of the study. RQ4 asked about the awareness of the presence of a Communication/PR/Press Office, and RQ5 about the decision autonomy to talk to the media. Findings suggest that there is no significant impact of these factors on behavioral intention.

Most of participants (65.5%) reported the existence of a Communication/PR/Press Office at their College/Institute. An additional check to the actual presence of these communication instances at NC State University showed that there is a public information officer assigned by the University Communication/News Services to each of the colleges at the institution, aiming to inform the public about ongoing learning initiatives and research results[4]. In addition, each of the 10 colleges at the university has at least one person in charge of an office dedicated to communications, public relations, media, and/or marketing, which was confirmed through each college's website.

However, the fact that being aware of this communication infrastructure was not a determinant factor for engagement intentions suggests additional questions, such as whether researchers know how to access the people in charge and how they can help them to get involved in public communication. Moreover, are the researchers aware but just do not use it, do they trust these offices to mediate science communication, do the offices need to increase connection with

[4] See institutional website http://news.ncsu.edu/about/

researchers. Alternatively, if none of these issues is occurring, it might just be that others factors have much more influence. In fact, at the bivariate level there was a correlation of being aware of a communication office with intention to participate in PE, but the variable did not show significance as a predictive factor.

Furthermore, the analysis failed to link the autonomy a researcher has to talk to the media (needing approval from a supervisor or other direct superior) and intention to participate in PE. This finding is contrary to Dudo (2012), who found that autonomy was a significant predictor of participation. Interestingly, in my results, just a small portion (8.5%) of respondents indicated that they need approval to talk to the media. Even knowing that decision autonomy has not a significant impact on intentions, the fact that a requirement like this is still being implemented by supervisors (at a low level, at least judging by the 8.5%) raises questions of why. Do they want to check for accuracy? Do they want to know about opportunities to publicize themselves? Do they want to give advice in communication? Or do they want special promotion of their departments?

Unawareness. Of the perceived institutional factors analyzed in the study only being a PI or Co-PI had a significant independent impact on intention to participate in PE. But what really constitutes a remarkable finding is something observed at the descriptive results level. There is a high level of unawareness of several of these normative pressures, institutional incentives and institutional facilitators. In other words, there is a high percentage of "don't know" answers to these items. Considerable amounts of participants are not sure or are ignorant of the presence of PE in the mission statement (50%) and of the existence of a communication/PR office (32%), two aspects that were checked as being actually implemented by all colleges at the university. In addition, the majority of respondents do not know whether or not they need approval to talk to

the media (60%), if their college allocates time for PE (53%), or if their college reward participation in PE (58%).

In line with prior qualitative research (Andrews et al 2005; Matthews et al., 2005; Ecklund et al., 2012) these data suggests the persistence of a communication challenge for the universities and its colleges and institutes: to provide researchers clear information about their policies, incentives, procedures, and available infrastructure that might facilitate participation in public communication and engagement activities.

We saw that the institutional factors may not constitute significant determinants of a researcher's intention to participate in PE, except for the role in a funded project (being a PI or Co-PI). In the next sections, I will examine how cognitive elements might shape decisions to engage with the public.

Theory of Planned Behavior

It was hypothesized that two of the three determinants of behavioral intention proposed by the theory of planned behavior (TPB), attitude and perceived behavioral control, will be significant predictors for the specific case of researchers' intention to participate in public engagement activities in the next 12 months. My results confirmed just the significant effect of attitude towards PE on intention, after controlling for demographics, past training, past behavior institutional factors, and other perceived norms.

Neither subjective norm (what colleagues think) nor perceived behavioral control showed significant impact on the formation of intentions. Apparently, these findings suggest that the TPB might not be an appropriate model to explain and predict scientists' engagement. However, I should be cautious and acknowledge that perceived behavioral control and subjective norm were

measured with just a single item each, which might not represent all elements of the constructs. They are usually tested with a minimum 2 measures each. This raises some concerns of content validity and affects my attempts to make strong inferences from the results regarding these variables and the TPB.

Even with these measurement limitations, the fact that subjective norm was not significant –similar to Poliakoff and Webb (2007) and Dudo (2012)– suggests that scientists do not care about what their colleagues think of them doing PE (i.e., whether it generates a negative image or not, disapproval or not). Moreover, it may indicate a possible vanishing of the belief that the scientific community looks down to those scientists who go public (Carl Sagan effect).

Similarly, in relation to behavioral control, perceiving it as a difficult or easy task did not impact intentions. This result suggests that some scientists might have intentions to do PE even if they think it is difficult, and vice versa; other researchers who think it is easy may not have intentions to do it.

What is clear is that attitude is an independent determinant of a researcher's intention to participate in PE, in line with prior research on science communication, as well as with the TPB assumptions. A positive general attitude towards PE was the third most important independent predictor of intention, after past behavior and moral norm (sense duty to participate in PE). Most scientists view PE as good, wise, pleasant, beneficial, worthwhile and enjoyable, taking into account that the mean scores for each of these characteristics were all above 5 in a scale of 7. In sum, scientists who have a positive affective evaluation of PE will be more likely to participate in public communication activities. Communication interventions should therefore focus on generating these types of affective states in order to encourage participation. For example, highlighting the benefits can be an effective way to influence attitudes, not just by

communicating them to scientists by mediated channels, but especially if researchers can experience the benefits directly (by themselves, as part of a research team, or looking at the example of other scientists at the institution), as a result of a public engagement activity. In addition, interpersonal communication from direct supervisor (see next section) can also help in building positive attitudinal states.

Furthermore, we know that besides just a general affective evaluation, TPB also suggest the influence of underlying beliefs about potential outcomes of the behavior on intention (via attitudes) and a way to influence attitudes and behavior is to change existing beliefs. However, although they beliefs regarding outcomes of public engagement were measured as part of the questionnaire, its impact on attitude and intention need to be subject of additional analysis that were not performed in the present study. Once identified the beliefs that significantly affect attitude, communication interventions and messages aiming at change should target those specific beliefs.

Besides the TPB constructs, additional cognitive factors influencing intentions to do PE were tested. Next, I analyze the impact of moral, managerial and descriptive norm.

Other Perceived Norms

Surprisingly, descriptive norm did not have a significant impact on explaining intention to participate in PE, differing from previous studies that found influence of descriptive norm on researchers' intention to do PE (Poliakoff & Webb, 2007; Royal Society, 2006), in which it was a significant determinant. Considering that these studies were done in the UK, cultural differences may have played a role in having opposite findings. My results suggest that scientists are not affected by the perception of what one of their expected referent groups -colleagues they respect

the most- are actually doing, at least with respect to public engagement. If scientists are not modeling or imitating the behavior of those around them and those peers they admire -notion that have been suggested by social learning theory (Bandura, 1986) and Fishbein (2007)- are there other norms influencing their participation in PE?

For instance, managerial norm constituted an independent significant predictor of intention in the final model. This norm was operationalized as the level of support from the institutional management (dean, director, head of department, supervisor) regarding a researcher's participation in PE. In some way it is similar to a subjective norm (what colleagues think) but it is specifically related to how opposed or supportive the direct superior is when it comes to participation in PE, instead of just considering the perception of what respected colleagues (not necessarily direct supervisor or superior) think about a researcher doing public communication. In another way it also reflects the level of incorporation of PE into the organizational culture.

In sum, scientists feeling supported by their direct superiors or institutional management will be more likely to create intentions to perform public engagement in the future. If the goal is to promote participation, this result points toward the need of institutions to encourage especially those in leadership positions to demonstrate support and approval of PE. The key might be proactive and clear communication with the body of researchers through interpersonal and mediated channels. The mechanisms and effectiveness of this communication deserves additional examination.

Among the additional perceived norms, another significant factor affecting intentions was moral norm. A researcher's sense of duty to perform PE was the second strongest determinant of intention to do PE in the next 12 months, just behind past participation. This finding opposes

Poliakoff and Webb (2007), who found no significant effect of moral norm. Again, differences can be attributed to cultural differences between the U.S. and U.K., which raises opportunities for further analysis of cross-country variances.

However, results are in line with Dunwoody et al. (2009) who studied US biomedical scientists and concluded that appealing to moral and ethical values may be a better catalyzer of public engagement behavior. It is also consistent with Besley et al. (2012), whose findings indicate that not seeing science communication as part of a researcher's job was related with lower levels of participation. Interventions targeting moral norm may range from simple references to the ethical imperative of doing PE, to mid and long term changes in the culture of scientific communities. Such plans entail strategies of formal and informal education and communication, in order to create or reinforce the belief that engaging non-experts is part of a scientist's job and a usual part of the process of doing science (Dudo, 2012).

All in all, it seems that researchers do not care so much about what their colleagues think about them doing PE (subjective norm) or whether or not their colleagues are participating in PE (descriptive norm), but do rely more on their own moral belief that every researcher has the duty to communicate with a broader audience and the level of support of their direct superiors, when planning science communication behaviors.

The last findings to be discussed consist of the demographic variables, which are presented in the next section.

Demographics

Results indicate that demographic factors are not significant predictors of scientists' engagement. This study failed to link the effect of sex, status and field of research with intention

to participate in PE. There were some positive correlations between being a professor, being in the agricultural sciences, being in the social sciences, and the dependent variable, as well as a negative correlation with being in the field of Engineering and Technology. At the descriptive level, results are consistent with prior research on scientists' engagement. Women reported slightly higher levels of attitude and intention to do PE, but men participated at a somewhat higher rate, which is in line with Besley et al. (2012) and Von Roten (2011). Concerning status, professors showed higher intentions to do PE than postdocs, and postdocs more than research assistants, in agreement with Royal Society (2006), Dunwoody et al. (2009), Bauer and Jensen (2011) and Dudo (2012). Regarding fields of research there is ambiguity in previous findings, but the present study found that those in the agricultural and social sciences exceeded the rest of the fields on the level of intention to participate in PE.

This suggests different levels of intention and participation across the disciplines, status, and genders, but lacks explanatory and predictive value. Findings are also consistent with reasoned action approaches (e.g. TPB or IMBP) in that background variables like demographics influence behavior indirectly, through the mediation of more proximal determinants of intention: attitude, perceived norms and self-efficacy.

As part of this discussion, I also offer a summary of insights providing general strategies or suggestions aiming at the stimulation of researcher's participation in PE.

Overall implications

Implications of these findings may be more applicable to similar research universities in the United States, but also entails recommendations that might be useful for a great deal of contexts. These include the confirmation of the potential effectiveness of training schemes in

stimulating participation in public communication activities, as well as the importance of incorporating unexperienced researchers to engagement opportunities, given that experience (past participation) can trigger future behavior. Moreover, communication interventions should also target attitudes through messages that generates positive affective states and reinforces potential benefits of the specific PE activity.

Another conclusion points out the fact that researchers seem to be more motivated by an intrinsic moral obligation to do PE, than by what their colleagues do or think. Therefore, interventions should also appeal to ethical imperatives instead of social proof (subjective norm, descriptive norm), which apparently are not substantial determinants in these type of behavior.

Likewise, other communication strategies at the institutional level are suggested, such as a proactive communication from supervisors and those in leadership positions at research organizations in order to demonstrate their team members and advisees support of PE. Also, in relation to managerial positions, a surprising finding was that being funded as a PI or Co-PI was a significant predictor, which probably has more to do with a sense of being accountable due to expectations of their role as a funded scientists, rather than as an institutional factor. What can be suggested is to take advantage of this perception and involve them in outreach, engagement, and media campaigns.

Regarding the normative pressures, one fascinating conclusion is that, researchers might not be perceiving the NSF Broader Impact Criteria as a factor that stimulates public engagement. However, my recommendation is that further research has to be done to confirm this hypothesis and elucidate the reasons behind this view.

Finally, even though most of the institutional factors were not significant predictors, the descriptive results draw attention to the high level of unawareness regarding the presence of PE

in the mission statement, the existence of a PR/Press office, the need of approval to talk to the media, the allocation of time for PE and the provision of rewards for participating in PE. This finding highlights the necessity to provide researchers clear information about incentives, procedures, and infrastructure that facilitates engagement with non-expert publics.

In sum, wrapped up together, the six significant predictors of a scientist's intention to do PE can be synthesized to three themes or factors that appeared as central to stimulate this type of communicative behavior: experience, liking and accountability. Experience represented the most powerful factor leading to public science communication. However, experience being equal (scientists having similar training and past participation), strategies to encourage PE should take into account the liking and the accountability factors. In other words, above and beyond training and experience, institutions should appeal to the affective and ethical imperatives to PE.

Future Research

Numerous ideas regarding potential lines of inquiry on scientists' engagement emerged from my results and discussion. First, regarding the use of the TPB as a model to predict researchers' participation in PE, future research should undertake a careful revision of the operationalization process (for all the TPB variables) in order to achieve a more solid validity of the measures, and as a consequence, of the inferences drawn from the data. This is necessary to appropriately confirm whether or not TBP may be a good fit to explain and predict this type of behavior. In addition, other theoretical frameworks can provide meaningful perspectives to understand researchers' involvement in PE. For example, concepts from social exchange theory (e.g., costs and benefits perspective, preference for certain activities) and social cognitive theory (e.g., reciprocal determinism, outcome expectations) can be explored as alternative models. In

addition, this study did not consider scientists' media use, perception of general and specialized media, and other related variables such as the concept of *medialization*, which was only tested by Dudo (2012) and found as a significant predictor.

Another area that deserves additional scrutiny is the role of science communication training in the formation of actual skills and its interplay with actual experience to influence communication behavior. In the same line, the type of content covered in these training initiatives, the specific moments to implement training in a researcher's career, and the attitudes towards training could represent factors affecting researchers' engagement with non-experts.

An important aspect that also requires further examination is the impact of the NSF's Broader Impacts criteria on a researcher's motivation to do PE. Although this study fail to link NSF funding with higher level of participation, results are not definitive and suggests that a qualitative approach may shed more light on how this requirement is perceived, processed and responded. Similarly, the present research explored the role in funded project (being a PI or Co-PI was a determinant of engagement) but further research is necessary to explain how the dynamics of leadership and cooperative research projects may be influencing participation in PE.

Finally, results concerning perceived institutional factors should be considered exploratory; therefore, additional scrutiny regarding the extent to what PE has been incorporated as part of the organizational culture of American scientific institutions (see Neresini & Bucchi, 2007, as a baseline) and how researchers perceive this incorporation, will be beneficial to advance towards comprehending the real impact of these processes on participation in PE activities.

Chapter 6: Conclusion

This study aimed to enhance our understanding of the factors that lead scientists to engage in communication activities with non-expert audiences. Built on prior research on science communication, this project constitutes the first application of an expanded version theory of planned behavior as a model to predict scientists' engagement with the public in the United States; a similar investigation was performed by Poliakoff and Webb (2007) in the U.K, and other frameworks were used by American researchers (Dudo, 2012). Specifically, I examined whether demographic, institutional and cognitive factors predict a researcher's intention to participate in public engagement (PE) in the next 12 months.

Findings discussed in previous sections indicate that there are six determinants of scientists' intentions to engage with the public: past training, past participation, attitude, moral norm, managerial norm and role in a funded project. In other words, a researcher will be more likely to participate in public engagement activities in the future if: (a) has been trained in communicating to broader audiences, (b) have participated in PE activities in past year, (c) holds positive attitudes towards public engagement, (d) have a sense of moral obligation to do PE as part of his role as scientist, (e) feels support from supervisors or other direct superiors, and (f) he or she is a principal or co-principal investigator in a funded project, independently of the source.

Equally interesting are the results related to the factors that did not constitute significant predictors of intention. Sex, status, major field of research, being funded by NSF, perceiving PE in mission statement, awareness of a PR office at the institution, decision autonomy to talk to the media, allocating time for PE, rewarding participation in PE, behavioral control (efficacy belief), subjective norm (what colleagues think of PE), and descriptive norm (what colleagues do in PE),

did not have an important effect in a scientist's decision to get involved in communication with the public about their research.

Regarding the theoretical model used, this study suggests that the Theory of Planned Behavior constructs are not better at explaining scientists' PE than other variables such as past training, past behavior, moral norm or managerial norm. Concerning the six significant predictors of researchers' intention to do PE, in the implications sections I synthesize them into three factors that are central to promote scientists' engagement: experience, liking, and accountability.

Recommendations within these areas include carefully prepared training programs, connecting unexperienced researchers to engagement opportunities, and communication interventions that generates positive attitudinal states and emphasizes potential benefits of PE. Furthermore, it highlights the importance of appealing to moral imperatives to perform PE instead of social proof, as well as the key role of supervisors to clearly and proactively communicate support towards PE. Likewise, regarding perceived institutional factors, the fundamental piece of advice is to provide researchers clear information about available incentives, procedures, and communication infrastructure that facilitates engagement with non-expert publics. In sum, providing communication training and opportunities for getting experience are valid ideas to stimulate PE, but beyond that, researchers also consider affective predispositions and a sense of accountability when making decisions about participating in PE.

In conclusion, there is a positive panorama for the study and the practice of science communication, specifically for the mobilization of researchers to engage non-experts in the context of a knowledge-based economy and democratic society that demands information and participation in science and technology issues. The more scholars understand scientists' views of and attitudes towards science communication, as well as the factors that shape their intentions

and behaviors, the more effective strategies can be implemented to close the communication gap between science and society. This research adds a contribution to this mobilization, which is part of a bigger puzzle, that also comprise the integration of several elements, such as effective models of science communication, risk communication, understanding of the publics, evaluation of the current communication channels, emergency of new media and platforms for engagement, science education, and efficient policy-making, among others. Fortunately, there is an increasing interest from the scholarly community as well as from policy makers and practitioners to learn and integrate current insights into meaningful projects.

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Tables

Table 1. Level of PE activity among researchers		
Participation in the last year	**Frequency**	**Percent**
No active in PE	48	13%
Active in 1 or more PE activities	325	87%
Valid cases	373	100%
Missing	31	
n=	404	

Table 2. Hierarchical Multiple Regression of Researchers' Intention to Participate in PE on Predictor Variables

Block	Variable	Zero-Ord Correl.	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
1	Sex	0.05	0.06	0.05	0.05	0.07	0.06	0.03
	Status/Post-Doc	0.03	0.06	0.06	0.05	0.07	0.06	0.05
	Status/Professor	0.11	0.12*	0.10	-0.03	-0.09	-0.09	-0.01
	Status/Research Asst. (excluded category)	-0.11*						
	Cumulative R^2 (%)		1.5					
2	Math & Natural Sciences	0.02		0.10	0.05	0.06	0.06	0.04
	Engineering & Technology	-0.20***		-0.01	-0.06	-0.04	-0.02	-0.03
	Medical & Health Sciences	-0.11		-0.01	-0.02	-0.03	-0.02	-0.01
	Agricultural sciences	0.19***		0.18*	0.04	0.04	0.02	0.00
	Social sciences	0.13		0.13	0.04	0.06	0.08	0.09
	Humanities (excluded category)	-0.47						
	Cumulative R^2 (%)			4.9				
3	Past training in PE	0.30***			0.17***	0.16***	0.14**	0.13**
	Past participation in PE	0.50***			0.44***	0.40***	0.34***	0.30***
	Cumulative R^2 (%)				28.8			
4	Role as PI or Co-PI	0.18***				0.09*	0.09*	0.10*
	Funded by NSF	0.06***				0.06	0.06	0.06
	PE in mission statement	0.24***				0.01	0.02	0.02
	Awareness of PR Office	0.21***				0.05	0.03	0.04
	Approval to talk to media	-0.04				-0.05	-0.02	-0.03
	Allocating time for PE	0.32***				0.09*	0.07	0.06
	Rewarding participation PE	0.35***				0.10*	0.08#	0.04
	Cumulative R^2 (%)					32.7		
5	Attitudes towards PE	0.40***					0.20***	0.14*
	Subjective Norm (colleagues)	0.07					0.03	0.00
	Behavioral control	0.23***					0.05	0.07
	Cumulative R^2 (%)						36.9	
6	Descriptive Norm	0.26***						0.04
	Moral norm	0.36***						0.15**
	Managerial norm	0.26***						0.10*
	Cumulative R^2 (%)							40.3
	Model Summary		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	Contribution to R^2 Change (%)		1.5%	3.4%	25.4%	3.9%	4.2%	3.4%

Notes: n=404. Cell entries in first column are correlation values with the dependent variable. In the rest of the columns the standardized regression β value was entered. *p < .05 / **p < .01 / ***p < .001

APPENDIX

Appendix A

PRINT VERSION OF ONLINE QUESTIONNAIRE

NC State University
Survey on Researchers and Public Communication

First, we want to ask some questions about your workload and the funding you receive for your research.

1. Thinking about your general workload in the past 12 months, how often did you perform the following tasks?

	Never	Rarely	Occasionally	Sometimes	Frequently	Quite Often	Very Often
Administration	☐	☐	☐	☐	☐	☐	☐
Teaching, advising, and/or mentoring	☐	☐	☐	☐	☐	☐	☐
Research, Scholarship, and/or Creative Activities	☐	☐	☐	☐	☐	☐	☐
Outreach or extension	☐	☐	☐	☐	☐	☐	☐
Service	☐	☐	☐	☐	☐	☐	☐
Taking courses (Grad students only)	☐	☐	☐	☐	☐	☐	☐

2. In the past 12 months, have you received research funding? Select all that apply

☐ I have received research funding as a Principal Investigator or Co-Principal Investigator

☐ I have contributed to funded research where I was not the Principal Investigator or Co-Principal Investigator?

☐ I have not received funding

IF received funding
2.b. Where did the research funding come from? Select all the sources that apply

☐ University sources	☐ Federal / National Science Foundation (NSF)
☐ Foundations, Nonprofits, and/or Professional Associations	☐ Federal / National Institutes of Health (NIH)
☐ Industry	☐ Federal / Other
☐ State and/or local government funds	☐ Other

As you may know, researchers from different disciplines, ranging from life sciences, to engineering, to humanities and social sciences, engage at some point in interactions with non-experts outside their fields and academic circles.

For the purposes of the present study we define this process of communicating with non-specialist audiences about your research or area of expertise as **public communication** or **public engagement**. This includes all activities performed outside academia that are related to your research, whether it focuses on science, technology and engineering or the social sciences, arts, and humanities.

We would like to know your views about communicating your research outside academic circles.,

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3. Below are different adjectives that might be used to describe these communication activities. Even though some of these descriptions might seem similar, I'm interested in knowing how do you personally feel about taking part in public engagement activities? Would you say these activities are...

	Extremely	Very	Somewhat	Neither	Somewhat	Very	Extremely	
Bad	☐	☐	☐	☐	☐	☐	☐	Good
Unenjoyable	☐	☐	☐	☐	☐	☐	☐	Enjoyable
Pointless	☐	☐	☐	☐	☐	☐	☐	Worthwhile
Unpleasant	☐	☐	☐	☐	☐	☐	☐	Pleasant
Foolish	☐	☐	☐	☐	☐	☐	☐	Wise
Harmful	☐	☐	☐	☐	☐	☐	☐	Beneficial
Difficult	☐	☐	☐	☐	☐	☐	☐	Easy
	Extremely	Very	Somewhat	Neither	Somewhat	Very	Extremely	

We would also like to know about your preference for specific engagement activities.

4. If given the choice, <u>how willing</u> would you be to perform the following activities?

	Not at all willing	Very unwilling	Somewhat unwilling	Neither willing nor unwilling	Somewhat willing	Very willing	Completely willing
Giving a public talk to non-experts	☐	☐	☐	☐	☐	☐	☐
Speaking in a public hearing/debate about scientific issues	☐	☐	☐	☐	☐	☐	☐
Being interviewed for a newspaper or magazine	☐	☐	☐	☐	☐	☐	☐
Being interviewed on a TV program / News	☐	☐	☐	☐	☐	☐	☐
Being interviewed on a radio program or podcast	☐	☐	☐	☐	☐	☐	☐
Communicating about your research to non-expert publics via online social media	☐	☐	☐	☐	☐	☐	☐
Writing for popular audiences (e.g. book or chapter, articles for popular magazines)	☐	☐	☐	☐	☐	☐	☐
Drafting a press release	☐	☐	☐	☐	☐	☐	☐
Participating in a university open house day (e.g. inviting student groups or the general public)	☐	☐	☐	☐	☐	☐	☐
Interacting with non-specialist publics in a science fair or similar information days outside the university	☐	☐	☐	☐	☐	☐	☐
Talking to children and teenagers in schools	☐	☐	☐	☐	☐	☐	☐
Advising or collaborating with policy-makers	☐	☐	☐	☐	☐	☐	☐
Advising or collaborating with NGO	☐	☐	☐	☐	☐	☐	☐
Being a guide in a science center or museum	☐	☐	☐	☐	☐	☐	☐

5. **Now thinking about your actual participation in the same public communication activities, <u>in the past 12 months</u> how many times have you...**

	Never	Once	2 or 3 times	4 or 5 times	6 or more times
Given a public talk to non-experts	☐	☐	☐	☐	☐
Spoken in a public hearing/debate about scientific issues	☐	☐	☐	☐	☐
Been interviewed for a newspaper or magazine	☐	☐	☐	☐	☐
Been interviewed on a TV program / News	☐	☐	☐	☐	☐
Been interviewed on a radio program or podcast	☐	☐	☐	☐	☐
Communicated about your research to non-expert publics via online social media	☐	☐	☐	☐	☐
Written for popular audiences (e.g. book or chapter, articles for popular magazines)	☐	☐	☐	☐	☐
Drafted a press release	☐	☐	☐	☐	☐
Participated in a university open house day (e.g. inviting student groups or the general public)	☐	☐	☐	☐	☐
Interacted with non-specialist publics in a science fair or similar information days outside the university	☐	☐	☐	☐	☐
Talked to children and teenagers in schools	☐	☐	☐	☐	☐
Advised or collaborated with policy-makers	☐	☐	☐	☐	☐
Advised or collaborated with NGO	☐	☐	☐	☐	☐
Served as guide in a science center or museum	☐	☐	☐	☐	☐

This section includes items about policies and practices at your institution regarding public communication of science and technology.

6. ***Thinking about the academic units you are affiliated with in the University, does your department and/or college/institute…***

	Department			*College/Institute*		
	Yes	No	Don't Know	Yes	No	Don't Know
…mention public engagement in its mission statement?	☐	☐	☐	☐	☐	☐
…have a Communication, Public Relations or Press Office?	☐	☐	☐	☐	☐	☐
…require approval before you talk to the media?	☐	☐	☐	☐	☐	☐
…allocate time for public engagement?	☐	☐	☐	☐	☐	☐
…reward participation in public engagement?	☐	☐	☐	☐	☐	☐

7. **Thinking about the degree of support you receive from your Department Head, Dean, Director, or other supervisor regarding your participation in public engagement activities. Would you say he or she is…**

Strongly opposed	Very Opposed	Somewhat opposed	Neither opposed nor supportive	Somewhat supportive	Very supportive	Strongly supportive
☐	☐	☐	☐	☐	☐	☐

8. **Thinking about the colleagues you respect the most, how frequently would you say they take part in public engagement activities?**

Never	Rarely	Occasionally	Sometimes	Frequently	Quite Often	Very Often
☐	☐	☐	☐	☐	☐	☐

We would also like to briefly explore your experience and views of training in public communication and engagement.

9. How many times in your career have you participated in training courses or workshops about communicating to public audiences?

Never	Once	2 or 3 times	4 or 5 times	6 or more times
☐	☐	☐	☐	☐

10. Please indicate the likelihood that you will take part in training programs about public communication in the future.

Very unlikely	Unlikely	Somewhat unlikely	Neutral	Somewhat likely	Likely	Very likely
☐	☐	☐	☐	☐	☐	☐

Below are a number of statements researchers might make about communicating to non-specialist audiences.

11. How much do you agree or disagree with each statement?

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly Agree
I do not have enough time to participate in public communication activities	☐	☐	☐	☐	☐	☐	☐
Taking part in public engagement would help me gain funding for my research	☐	☐	☐	☐	☐	☐	☐
Interacting with non-experts about my research helps me to improve my communication and teaching skills	☐	☐	☐	☐	☐	☐	☐
The public will misunderstand most aspects of my research	☐	☐	☐	☐	☐	☐	☐
Talking to the public will negatively affect my image in front of my colleagues	☐	☐	☐	☐	☐	☐	☐
Participating in public engagement helps me to progress in my career	☐	☐	☐	☐	☐	☐	☐
It is impossible to do research well and also engage with non-experts	☐	☐	☐	☐	☐	☐	☐
I like to engage with the general public because it is fun	☐	☐	☐	☐	☐	☐	☐
Every researcher has the duty to communicate with the non-specialist public	☐	☐	☐	☐	☐	☐	☐
I might get caught up in public controversies regarding my research if I participate in public engagement activities	☐	☐	☐	☐	☐	☐	☐
Participating in public engagement activities will enhance my social reputation	☐	☐	☐	☐	☐	☐	☐
I do not have enough training to participate in public engagement activities	☐	☐	☐	☐	☐	☐	☐
Interacting with the general public gives me a broader perspective on society	☐	☐	☐	☐	☐	☐	☐
Researchers usually do public engagement activities because it helps them to get tenure	☐	☐	☐	☐	☐	☐	☐
Doing public engagement is for those who are less capable of doing research	☐	☐	☐	☐	☐	☐	☐
Getting paid for participating in public communication would be a good idea	☐	☐	☐	☐	☐	☐	☐

12. Thinking of communicating your research to non-specialists… In the next 12 months, how likely is that you will participate in a public engagement activity?

Very unlikely	Unlikely	Somewhat unlikely	Neutral	Somewhat likely	Likely	Very likely
☐	☐	☐	☐	☐	☐	☐

Finally, we would like to have some general information about you and your current work as a researcher

13. What is your current status?

☐	Master's Student	☐	Associate Professor (without tenure)
☐	PhD Student	☐	Associate Professor (tenured)
☐	Post Doc	☐	Professor
☐	Assistant Professor	☐	Non-tenure-track faculty (e.g., adjunct, lecturer, research professor)

14. In sum, how many years of experience in research would you say you have in your career?

Enter number: _____

15. Which of these categories best describes your major field and subfield of knowledge and research?

☐ Natural sciences ❍ Mathematics & Statistics ❍ Computer and information sciences ❍ Physical sciences ❍ Chemical sciences ❍ Earth and related environmental sciences ❍ Biological sciences ❍ Other natural sciences	☐ Engineering and Technology ❍ Civil engineering ❍ Electrical engineering, electronic engineering, or information engineering ❍ Mechanical engineering ❍ Chemical engineering ❍ Materials engineering ❍ Medical engineering ❍ Environmental engineering ❍ Environmental biotechnology ❍ Industrial biotechnology ❍ Nanotechnology ❍ Other engineering and technologies
☐ Medical & health sciences ❍ Basic medicine (e.g. Human Genetics, Pharmacology) ❍ Clinical medicine ❍ Health sciences (e.g. Nutrition, Sports, Public Health) ❍ Health biotechnology ❍ Other medical & health sciences	☐ Agricultural sciences ❍ Agriculture, forestry, and fisheries ❍ Animal and dairy science ❍ Veterinary science ❍ Agricultural biotechnology ❍ Other agricultural sciences
☐ Social sciences ❍ Psychology ❍ Economics and business ❍ Educational sciences ❍ Sociology ❍ Law ❍ Political Science ❍ Social and economic geography ❍ Media and communications ❍ Other social sciences	☐ Humanities ❍ History and archaeology ❍ Languages and literature ❍ Philosophy, ethics and religion ❍ Art (arts, history of arts, performing arts, music) ❍ Other humanities

16. What is your sex?

☐ Male ☐ Female ☐ Other

17. What is your ethnicity?

☐ Hispanic or Latino
☐ Not Hispanic or Latino

18. Which category best describes your race?

☐ American Indian or Alaska Native
☐ Asian
☐ Black or African American
☐ Native Hawaiian or Other Pacific Islander
☐ White
☐ Other

19. What is your country of citizenship?
Country: _____

IF Not United States:
19.b. How likely is that you will return to your home country within the next 5 years?

Very unlikely	Unlikely	Somewhat unlikely	Neutral	Somewhat likely	Likely	Very likely
☐	☐	☐	☐	☐	☐	☐

Thanks for your participation!