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Contextualizing Visitor Participation: Science Centers as a Platform for Scientific Citizenship

Andrea Bandelli

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Dr. Riemer Knoop (Reinwardt Academie, Amsterdam University of the Arts)

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Prof. Dr. Juliette Walma van der Molen (University of Twente)

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Contextualizing Visitor Participation: Science Centers as a Platform for Scientific Citizenship

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door

Andrea Bandelli
geboren te Trieste, Italië

promotor: prof.dr. E.A. Konijn

To Sally

Contents

1. General Introduction	9
1.1 Science Centers and Public Engagement with Science	10
1.2 Research Framework	12
1.3 Theoretical Approach	13
1.4 Methodological Considerations	14
1.5 Limitations	16
1.6 Outline of the Dissertation	16
1.7 References	18
2. The Need for Public Participation in the Governance of Science Centers	27
2.1 Abstract	27
2.2 Introduction	27
2.3 Democratizing the Science Museum	29
2.4 Science Centers and their Publics	31
2.5 Sharing Authority for Public Programs	33
2.6 Visitor Voices	35
2.7 Discussion	37
2.8 References	41
3. Science Centers and Public Participation: Methods, Strategies, and Barriers	49
3.1 Abstract	49
3.2 Introduction	49
3.3 Method	53
3.4 Analysis	54
3.4.1 What Are the Current Processes of Decision Making in Science Centers?	55
3.4.2 Are There Methods and Strategies to Include the Public in the Decision-Making Processes in Science Centers?	56
3.4.3 What Are the Barriers and Obstacles That Limit or Prevent Public Participation in Museums?	60
3.5 Discussion	65
3.5.1 Toward a Public Model of Governance?	65
3.5.2 Implementing Two-Way Communication in the Governance of Science Museums	66
3.6 Conclusions	68
3.7 Acknowledgments	69
3.8 References	70
4. Public Participation and Scientific Citizenship in the Science Museum in London: Visitors' Perceptions of the Museum as a Broker	79
4.1 Abstract	79
4.2 Introduction	79
4.3 Public Participation in Science Museums	81

4.4 Method	83
4.5 Results	86
4.6 Discussion	93
4.7 Acknowledgments	96
4.8 References	97
5. European Science Centers as Brokers of Public Participation	105
5.1 Abstract	105
5.2 Introduction	105
5.3 Three Levels of Public Participation in Science Centers and Museums	108
5.4 Methodology	110
5.5 Results	113
5.6 Discussion and Conclusions	120
5.7 Acknowledgments	122
5.8 Appendix	123
5.9 References	125
6. General Discussion	133
6.1 Summary of the Main Findings	133
6.2 Discussion of the Results and Theoretical Implications	136
6.2.1 Democratizing Public Participation	136
6.2.2 Engaging the Already Engaged	138
6.2.3 The Political Agency of Science Centers	139
6.2.4 Re-aligning Science Centers with their Public	140
6.3 Methodological Considerations	142
6.3.1. Methodological Strengths	142
6.3.2 Limitations and Weaknesses	143
6.4 Directions for Future Research	143
6.4.1 Study Relevance at Local Level	144
6.4.2 Include Non-visitors	144
6.4.3 Study the Impact of Science Centers on Scientific Citizenship	145
6.4.4 Study Broader Concepts of Participation	145
6.5 Implications and Recommendations for Practice and Policy	146
6.5.1 Broaden the Scope of Co-development	146
6.5.2 Focus on Adult Visitors	147
6.5.3 “Bring the political back in”	147
6.6 Final Conclusions	149
6.7 References	150
Summary	159
Thank you	163





Contextualizing Visitor Participation: European Science Centers as a Platform for Scientific Citizenship

1. General Introduction

The studies presented in this dissertation examine the context of public participation in science centers and museums in Europe. Visitor participation is a high priority for all museums today; long gone are the days when a visit to a museum meant passively staring at static displays and artifacts, while reading technical labels printed with the smallest font available. Nowadays, science museums – and science centers in particular – are like laboratories where almost everything is in motion, where visitors touch, manipulate, make and dismantle the exhibits on display. But this “hands on” approach, as it is commonly defined, is not limited to the physical displays. During the visit, visitors touch, manipulate, make and dismantle also the meanings and concepts about contemporary science, technology and innovation that are presented in the exhibitions and surrounding programs. Visitors are not anymore passive receivers of information, but instead they become active contributors of meaning. They can effectively participate in creating and negotiating the knowledge found in science centers and museums.

Science centers are also tightly connected and collaborate with a broad range of civil society and governmental organizations, including schools, scientific and other cultural institutions. A visit to a science center is, therefore, not only an opportunity to learn about science; it becomes an opportunity to participate in how science is communicated and reflected in society. Science centers offer their visitors access to scientific knowledge as well as the agency to play a role in how contemporary scientific knowledge is shared and integrated in society. They can be considered places where visitors become scientific citizens, that is, places where the public is qualified to participate in conversations and societal discussions related to scientific knowledge.

The current research examines what happens when the public participates in a science center, how institutions manage participation and how visitor participation is related to scientific citizenship. This chapter provides an introduction to the current position of European science centers and museums in the field of public engagement with science and scientific citizenship. It presents also the theoretical framework and the methodological approach of this thesis, as well as an outline for each of following chapters of this dissertation.

1.1 Science Centers and Public Engagement with Science

The engagement of citizens with science is currently a cornerstone of European science and innovation and it has become an indissoluble component of science policy. Inclusiveness, that is, the mechanisms and policies to ensure that all citizens have the opportunity to participate in the development of research and innovation, is one of the pillars of “Responsible Research and Innovation”, the European Commission’s approach to support research and innovation (Owen, Macnaghten, & Stilgoe, 2012; Stilgoe, Owen, & Macnaghten, 2013). Moreover, at a national level, in many countries current policy documents on science and research recommend and support public engagement and in some instances even prescribe it as a requirement for access to funding (Neils Mejlgaard, Bloch, Dedn, Ravn, & Nielsen, 2012). Public engagement with science is nowadays a critical component in the development of science and innovation.

In spite of the acknowledged role that European science policies grant to public engagement, the governance structures responsible to accommodate it are continuously being re-discussed and shaped by a process of critical reflection (Felt & Wynne, 2007; Hagendijk & Irwin, 2006; Irwin, Jensen, & Jones, 2013; Irwin, 2006). Consequently, the methods to foster and support public participation are rapidly changing. Initially, initiatives to engage the public in discussions affecting science policy have been formal and structured, largely inspired by theories of deliberative democracy (Tlili & Dawson, 2010). Public participation was enabled by rather sophisticated processes such as consensus conferences, citizens’ juries, scenario workshops, etcetera (Durant & Joss, 1995; Rowe & Frewer, 2005). Nowadays, more innovative and informal approaches to public participation are applied and shown to be effective to overcome the limitations of the formal procedures (Cornwall, 2008; Horst & Michael, 2011; Horst, 2011; Stilgoe, Lock, & Wilsdon, 2014). Examples of such limitations are the fact that public participation is restricted to small publics (Goodin & Dryzek, 2006; Longstaff & Secko, 2014), is affected by institutional framings (Bickerstaff, Lorenzoni, Jones, & Pidgeon, 2010; Wynne, 2007), and causes the emergence of democratic deficits (Lovbrand, Pielke, & Beck, 2010; Niels Mejlgaard & Stares, 2012). New engagement methods and platforms are thus being advocated in order to create, in an iterative process, the new images of political and policy institutions necessary to sustain responsible innovation and technological development (Irwin, 2014; Nowotny, 2014).

In this context, science centers and museums in Europe represent a unique platform to develop and implement innovative public engagement opportunities for a wide public. These institutions communicate current science and technology with millions of visitors every year and they constantly develop strategies and methods to interest and engage the public with science, technology and innovation. Ecsite, the association of European science centers and museums, describes these institutions as places that *“stimulate creativity, enable dialogue, spread tools for innovation. They are vibrant hubs, providing a common ground where all stakeholders can meet and discuss controversial and contemporary issues about science and technology. They inspire young visitors to embark on scientific careers. They contribute to changing attitudes towards science and technology”* (Ecsite, n.d.). To this day, science centers and museums participate in numerous projects funded by the European Commission to implement formal and informal public participation in science. In many cases, they also fulfill a national role as reference centers for public

engagement and science communication. They are less and less focused on only exhibiting science concepts and increasingly on engaging the public with the societal relevance of science.

In this respect, science centers and museums have recently played a groundbreaking strategic role in European policy. In 2013 the first large-scale public participation pilot project organized by the European Commission to include citizens' perspectives in defining research and innovation priorities for the framework programme 'Horizon 2020' was implemented in science centers and museums of all European countries ("Voices for Innovation - European Commission," 2014). Science centers were an optimal platform for this pilot initiative because they offer multiple opportunities to get information and to learn about science and technology, combined with the possibility to participate in the societal discussions relevant to these themes. Therefore, they can be considered a platform for scientific citizenship (Horst, 2007; Irwin, 2001), that is, places where citizens can increase their scientific competence and also have the opportunity to take part in the discussions and processes that shape and govern the development of science in society.

While many studies are available on how science centers support the learning process of their visitors (for example, Bevan & Semper, 2006; Falk & Dierking, 2000; Falk & Gillespie, 2009; Johnson, 2006), there are surprisingly few studies about how science centers support scientific citizenship. Despite the fact that a growing number of institutions are actively developing programs and exhibitions to introduce and implement public participation in science within their activities, the research is lagging behind the practice. Very often programs are not thoroughly evaluated or studied, and evaluation results are not publicly shared (M. Davies & Heath, 2013). Most importantly, despite the collective role that science centers have in European policy as institutions for science engagement, research published so far has focused on single institutions, overlooking the impact of participatory activities on public policy (S. R. Davies, McCallie, Simonsson, Lehr, & Duensing, 2008; S. R. Davies, 2011; McCallie et al., 2009). In general, studies that examine the engagement of visitors in European science centers at macro-level are still scarce (Falk, Needham, Dierking, & Prendergast, 2014). With little available research to inform and reflect about the practices, there is a risk that the burgeoning activity of science centers in the field of public participation remains informed by assumptions and stereotypes. Practitioners may preserve entrenched approaches and understandings of public participation which are difficult to change without appropriate evidence and new knowledge.

In view of the above, the current research aims at furthering the knowledge about public participation within European science centers by focusing on three main questions:

- What is the role of public participation in the institutional structure of science centers?
- What are the opportunities and barriers in European science centers to enable public participation?
- What is the relationship between scientific citizenship and visitor interest to participate in science centers and museums?

The scope of these questions is necessarily broad, in order to cope with the many and rapid developments in the field. The effort of contextualizing participation in science centers can be effectively described as ‘shooting at a moving target’. The policy frameworks change quickly; the professional field, usually driven by enthusiastic practitioners, develops new initiatives at an increasingly faster rate; the theoretical developments manifest many tensions (Delgado, Lein Kjolberg, & Wickson, 2010) which reveal the complexity of the issues at stake. The current research aims therefore at identifying the main constituents that affect public participation in European science centers and provide new insights on how they are related to each other.

1.2 Research Framework

This research is rooted both in the theory and practice of science centers and museums and the larger field of science and technology studies. Visitor participation is the defining element of contemporary science centers and museums, in contrast to traditional object-driven and object-centered museological approaches (Koster & Falk, 2007; Schiele, 2008). It is at the core of the transformation of science centers from “secular cathedrals” and “educational playgrounds” (Durant, 2004, p. 50) to forums that present and discuss contemporary and unfinished science (Hine & Medvecky, 2015). In the past, science centers were criticized for not producing actual knowledge (Lewenstein & Allison-Bunnell, 1999), and for being institutions where visitors are only receivers of information (Bradburne, 1999). Today, by enabling participation in the discussions of contemporary, policy-relevant technoscience, they facilitate the inclusion of situated knowledge and civic epistemologies (Felt & Wynne, 2007; Michael & Brown, 2005) in larger public engagement processes. They also contribute to reduce the divide between experts and non experts (Callon, 1999; Evans & Plows, 2007). Enabling visitor participation in contemporary science increases the societal role of science centers and increases their relevance (Koster & Falk, 2007). However, it has also consequences on the ethical standards they are expected to maintain (Sandell, 2012), as well as the potential to change their ontologies and institutional forms (F. Cameron, 2010, 2015). In short, public participation is not something science centers can simply ‘switch on’ and continue their business as usual. Some of the institutional changes brought by increased visitor participation are explicit and visible, such as for example attracting non-traditional audiences to exhibitions (Science Museum Visitor Research Group, 2004). However, many institutional effects brought by public participation are implicit and therefore difficult to identify and to manage, because they can only be uncovered by reflecting on the very same practice that is being implemented (F. Cameron, 2011; Chilvers, 2012; Horst, 2011; Wynne, 2011). Failing to engage in this process of reflexivity is a reason for perpetuating assumptions and practices which may lead to social exclusion (Dawson, 2014b) and undermine equity and access (Dawson, 2014a). Answering the question of how public participation is contextualized within science centers is crucial to better understand some of these implicit effects and to strengthen the legitimacy of the institutions’ societal role.

The benefits of a better understanding of how science centers implement public participation and how visitors actually participate are not limited to the field of science

centers alone. Previous studies (S. R. Davies et al., 2008; Felt & Fochler, 2008, 2010) have shown that even when the stated goal of public participation is not to engage with governance or to impact policy, participatory activities nevertheless shape the public's perception of science governance. In other words, what happens in the science center does not stay in the science center: visitors create images of relationships between stakeholders, of innovation processes and of the very meaning of public participation which have an effect beyond the actual implementation of a specific program or activity. Science centers in this regard are not neutral players (Sharon Macdonald, 1998), and the practices they implement contribute to the public imaginary of a much more complex structure of governance, democracy and society. In fact, the construct of scientific citizenship that emerges from science centers also creates specific images and understandings of the public itself. Visitors enact different concepts of 'the public', depending on how scientific citizenship is understood and implemented in the science center.

For example, when the emerging construct is a normative ideal of active, strong citizenship (Horst, 2007; Niels Mejlgaard, 2009), the public is expected to participate in democratic discussions concerning the relationship between science and society. When a liberal concept of citizenship emerges, individual interests play a more important role than civic responsibilities and citizens have an interest and an opportunity to participate rather than the obligation to do so (Niels Mejlgaard & Stares, 2012). These two interpretations of scientific citizenship lead to different concepts of the public. According to the former, public participation is evaluated against a normative ideal, ascribing any difference between the actual and expected participation to a democratic deficit among the public. According to the latter, public participation is evaluated against individual expectations of appropriate participation, based on preferred expectations and conceptions of governance (Niels Mejlgaard & Stares, 2012). Public participation, and the lack thereof, can be thus interpreted either as an expression of democratic agency and civic interest, or as a personal opportunity to participate in a governance system which may or may not correspond to the public's expectations.

Contextualizing opportunities for participation in science centers will help to understand which kind of public(s) – or better, scientific citizens – science centers are in fact shaping. It is not a simple matter of choosing one interpretation of scientific citizenship against another, but rather about understanding which factors influence visitor participation in science centers. Are science centers a locus of participation by themselves, or are they a broker of participation, fulfilling an instrumental role to connect the public to a more complex system of science governance? Being able to answer this question will also allow other (scientific) institutions understand to which extent science centers can be instrumental in reaching out and engaging publics that otherwise would not interact with other science organizations.

1.3 Theoretical Approach

This research fills a gap at the intersection of two academic fields of study, namely museum studies, and science, technology and society (STS) studies. The two fields are currently still quite separated: the former pays little attention to issues of public participation in science, and the latter has largely ignored museums and science centers. For

instance, the journal *Public Understanding of Science* has published in total 13 papers about museums in 20 years between 1992 and 2011 (on a total of 465 published articles); the journal *Science Communication* only 10, including one by the author of this dissertation.

For the museological part, the theoretical framework of this research is based on seminal works by Dana, Weil, Cameron, Low (D. F. Cameron, 1971; Dana, 1917; Weil, 2006). These authors have influenced much of the contemporary thinking about the social and democratic role of museums and science centers. We rely on this framework to understand museums and science centers as institutions with a strong civic component and as public institutions where the public can reflect about societal developments. More recent contributions by Sandell, Bradburne and Cameron, among others (Bradburne, 1998; F. Cameron, 2005, 2008; Sandell, 2003), have been further instrumental in analyzing the process of change that has characterized museums and science centers in the last decades and identifying institutional challenges created by visitor participation. Additional perspectives on how museums structure and implement public participation were provided by Simon (2010).

The science, technology and society (STS) theory that substantiates the framework for this research draws mainly from three areas. The first one includes the studies on situated and experiential knowledge (Broerse, de Cock Buning, Roelofsen, & Bunders, 2009; Collins & Evans, 2002; Glicken, 1999; Irwin & Michael, 2003; Irwin, 2001; Scott & Du Plessis, 2008; Wynne, 2007). These authors have demonstrated how knowledge located among the lay public becomes a substantive factor in the process of public engagement with science. We apply these approaches to museum visitors to investigate to which extent their knowledge can be shared and integrated in the museum. The second area includes studies of scientific citizenship (Bickerstaff et al., 2010; Horst, 2007; Irwin, 2001; Jasanoff, 2004; Niels Mejlgaard & Stares, 2009, 2012; Michael & Brown, 2005). These studies provide the definition of scientific citizenship as competence and participation, and the conceptual structure to define the dynamic relationship between the public and the system of science governance. Finally, the third area includes studies on public engagement (S. R. Davies, 2009; Felt & Fochler, 2010; Horst, 2011; McCallie et al., 2009; Stilgoe, 2007; Wynne, 2006). These studies provide the theoretical foundation necessary to consider public participation in science centers as an activity with an actual impact on policy, that is, whose effects go beyond the cognitive experience of the visitors. (cfr. S. R. Davies et al., 2008).

We have drawn thus from both fields of museum and STS studies, with the aim of creating a bridge between the two disciplines. This approach provides a unique theoretical ground to study the agency of visitors to science centers and museums. With this approach, visitor participation can be analyzed in the context of the institutions where it takes place, and in the larger context of the relationship between science and society.

1.4 Methodological Considerations

The broad scope of the research undertaken in this dissertation and the challenge of positioning it at the intersection of two academic fields, required different methodological approaches for the different sections of our research.

In the first part, we develop a conceptual understanding of the institutional

effects of public participation in science centers. We combine the theoretical discourse from museum studies literature with a review of current participatory practices, and analyze the potential of public participation to affect the epistemology of the museum, and thus its decision making process. This section therefore relies on literature review.

The second part of the research aims at strengthening the theoretical understanding of how science centers enable public participation, and in particular of what the barriers and obstacles to its implementation can be. Science centers and museums have many different organizational and institutional forms and the context in which they operate varies greatly. Rather than adopting organizational models or structures to analyze a sample of institutions, we opted for a grounded-theory approach (Glaser & Strauss, 1967; Strauss & Corbin, 1998, 1997) in order to develop a theoretical approach based on a series of case studies through in depth interviews. With this approach we could cover both the wide range of different institutional formats, cultures and structures, and also the depth and diversity of staff roles and experiences within each institution. To guarantee a high degree of openness and transparency during the interviews, we anonymised the institutions' and staff names in the final results.

The third part of the research focuses on visitors' interest in public participation and the factors affecting such interest. Usually, studies on visitor participation are confined to a single institution, and therefore one language. Such setting allows a wide choice of quantitative and qualitative methodologies, including interviews and focus groups. However, qualitative methods become very costly and impractical for large scale, multi-institutional studies across countries and are difficult to compare. To be reliable, they require coordinated and coherent training for all the interviewers in each location, the adoption of consistent inquiry methodologies and an adequate understanding of local and cultural contexts. Under these circumstances, a quantitative approach based on visitor surveys is likely to be more efficient and reliable. We developed a visitor survey which could be translated in multiple languages and administered to visitors of science centers and museums. The survey questions relative to scientific citizenship and science engagement were adapted from previous quantitative studies on similar topics (Niels Mejlgaard & Stares, 2009) and build on our theoretical analysis; the survey was subsequently reviewed by several professionals active in the science center field. The survey was first tested at the Science Museum in London and subsequently fine-tuned. A slightly updated version was applied to a sample of six institutions representative of the current landscape of European science centers and museums. To our knowledge, this is currently the only study on science centers which offers such a broad European scope¹. To analyze the relative strengths of relationships among the factors contributing to visitors' interest in public participation, we used structural equation modeling (SEM) analysis. SEM is a statistical technique which allows to test and estimate variables and to construct latent variables, which are not measured directly but estimated from other observations (Kline, 2011). In our case, the variables relative to the interest in participation are latent variables (i.e., theoretical constructs), which were measured ('observed')

¹ The *International Science Center Impact Study* (Falk et al., 2014) is the only other cross-organizational study recently published on a related subject. While it represents an impressive analysis of 17 institutions from 13 countries and its findings are very insightful, it includes 6 European institutions from a smaller geographical representativeness than our study (3 of the 6 institutions are from Scandinavian countries; the other three are from Portugal, UK and Belgium).

by the respective items in the survey. The advantage of using SEM compared to regression analysis is that SEM allows researchers to develop more complex path models with direct and indirect effects, and it uses the actually observed variables, rather than composed scales, to test relations among the latent variables. More detailed methodological considerations for each of the studies are provided in the relative chapters.

1.5 Limitations

In this research we focus on the visitors' interest to participate in science centers and museums, and how public participation is contextualized within these institutions. The aim of the research is therefore to better understand the role of visitor participation in shaping the scientific citizenship that science centers and museums support. In order to do so, we adopt a broad understanding of visitor participation that encompasses all activities where visitors are actively sharing their knowledge and ability with other visitors and with the institution. Therefore, we do not cover in detail the many ways in which public participation is actually implemented in science centers. Other resources on the subject provide excellent advice on the methodologies and procedures that can be employed by science centers and museums to involve and engage the public in participatory activities (for example, Engage2020, 2015; Simon, 2010).

1.6 Outline of the Dissertation

Chapter 1 is the present introduction to the dissertation. In chapter 2, we examine what the institutional impacts are of adopting a participatory approach in science centers and museums. We argue that public participation in a science center is a democratic process: If science centers enable public participation to engage their visitors in activities which have an impact on European, national or local policy, then public participation should apply to the institutional governance of the science center as well. To achieve this, we argue, the governance structures in museums and science centers should include the public as an integral component in the decision making process.

Chapter 3 presents the results of a qualitative research study conducted to describe how science centers enable public participation within their institutions. By means of 22 face-to-face, in-depth interviews in five European science centers and museums, we identify how the governance structures of the institutions are organized, who are their main stakeholders and what are the barriers and obstacles to public participation. We proceed then to discuss possible solutions to overcome these barriers.

In chapter 4, we introduce a quantitative approach to measure how scientific citizenship and existing engagement with science are related to the visitors' interest in participating in the museum. We identified three forms of visitor participation: 1) Sharing opinions and feedback (the museum as 'forum'); 2) co-developing programs and activities; and 3) participating in the governance of the museum. We applied a survey to 364 adult visitors to the Science Museum in London to measure their interest in the three forms of participation, as well as their existing level of engagement with science and perceptions of the museum as a platform for scientific citizenship. Results

indicate that the three forms of public participation are related in very different ways to scientific citizenship and previous engagement with science. The ‘forum’ function of the museum is strongly related to how visitors perceive the museum as a platform for scientific citizenship, whereas the interest in co-development is mostly related to the existing engagement with science of the visitors.

In chapter 5, we further refine this approach to assess how scientific citizenship is related to public participation. We present a study conducted among 652 visitors from a sample of six science centers and museums throughout Europe. The choice of the institutions in the sample reflects geographical representativeness and different levels of public engagement and participation across Europe (Niels Mejlgaard, Bloch, Degn, Nielsen, & Ravn, 2012; Niels Mejlgaard & Bloch, 2012; Niels Mejlgaard & Stares, 2009, 2012). Therefore, this study provides a reliable portrait of how visitors across Europe consider science centers as platforms for scientific citizenship. The study analyses the factors that affect visitors’ interest in public participation, and how it is related to the scientific citizenship that science centers enable. Across all institutions, the interest to participate in debates and discussions is strongly related to how the institutions support scientific citizenship, while the interest to co-develop follows more traditional patterns of access and interest in science.

In a concluding chapter 6, we discuss the results of the research endeavor as presented in this dissertation. We reflect on its relevance to improve the professional practice of science centers and museums. We also discuss its limitations and we identify directions for future research.

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2.

The Need for Public Participation in the Governance of Science Centers²

2.1 Abstract

Science centers and museums are developing new strategies to increase inclusiveness, to engage the public more actively and to respond to the need to present contemporary science and research as part of their public programs. In order to do so, they need to increase the level of public participation not only to inform the development of specific exhibitions and programs, but also to share authority in their interpretive and decision-making process. However, existing models of governance do not allow for a formal role of the public in the decision making process. We review current practices in Europe and argue that a new model of governance for science centers is needed where public participation and consultation activities are integral components alongside the board, director and staff.

2.2 Introduction

Science centers and museums traditionally use exhibitions, programs and events to engage and inform the public. In the last decade, the need to develop new strategies for achieving a higher level of public engagement with contemporary science has emerged in European science centers. As institutions active in the field of science communication, science centers are coming to terms with the profound shift that occurred in the public communication of science and technology studies in the late 1990s. This shift can be summarized as the move from the public understanding of science to the public engagement with science; from a 'deficit' communication model based mainly on providing the public with information in order to increase their science literacy, to one based on the dialogue between parties, and the acknowledgment of reciprocal competencies and priorities (Miller 2001; Wynne 1992).

Museums are also under pressure to become more inclusive and to strengthen

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their social role, often because their funding is linked increasingly to their performance and to a higher appeal across all socio-economic groups, including ethnic minorities and disadvantaged communities. Recent research suggests that museums need to shift both their purpose and role in society and their working practices radically, if they are to become effective agents for social inclusion (Sandell 2003). Furthermore, the constructions of social exclusion and inclusion among professionals in science centers, overall, fall short of the coherence and generality that government museum policies expect and demand (Tlili 2008).

Finally, science centers need to respond to current European policy which recommends that all institutions dealing with contemporary science and technology initiate and sustain a dialogue with the public in order to inform the development of European science policy and governance (European Commission 2002). Science centers' programs currently funded by the European Commission are required to include dialogue and participation activities. Similar policies can be found at a national level (Tlili 2008), where such participation activities are also a requirement for private funding bodies (such as the Wellcome Trust in the United Kingdom, for example). In order to develop and implement such 'dialogue-strategies', museums need a solid understanding of (a) the nature and results of public participation in all of their activities and (b) the potential of new forms of engagement to alter the relationship between the public and the museum itself. It is common in the field to talk about museum 'publics' - to highlight the multifaceted nature of the different constituencies of an institution. While we largely agree with this view, in the context of our analysis we consider 'the public' to be those people who make use of the space, programs, and exhibitions that the museum can offer or that might do so. In this sense, 'public participation' should be understood as 'open to the public', rather than 'for and by everybody'.

The relationship between museums and the public (i.e. not only the visitors to the museum, but also the potential visitors who do not yet interact with the institution, as well as other stakeholders such as educators, volunteers, donors, civil society organizations, etc.) has changed in recent years, from a situation where the public had little say in museum affairs to one where the sense of the public is an overriding factor (Combe McLean 1994). Pressure for change in this respect also comes from within the institutions: junior members of the staff challenge the museum management to respond to the needs of a plural society (Moore 1994).

The present study argues that science centers and museums should include public participation as an integral component in their governance, and that a new governance model is necessary in order to engage the public in the processes of:

(a) developing museum activities, (b) making decisions about museum operations and (c) participating in museum governance. To be effective, these forms of engagement require reciprocal trust between the active agents involved, including the museum with its components involved in the decision making process (the board, the senior management and staff) and the public. For the museum, it also means having the tools to listen effectively to the public and a clear understanding of the level of change that the institution is able to allow within its structure as a result of the public engagement.

In this paper, we will first discuss briefly the position of science centers in the process of change that has characterized the museum field in the past century, looking

at how the current governance structures of museums have been identified as possible barriers to effective public engagement. Secondly, we will argue that because science centers produce and mediate scientific culture with the public, they are subject to the policy recommendations that call for a thorough participation of citizens to contribute to and inform the direction and development of scientific research. Thirdly, we will provide an overview of methods used currently by science centers to achieve direct participation by visitors in their programs. Finally, we will discuss the need for a new model to study to what extent visitors can participate in shaping the programs of science centers and ultimately in their governance, as well as the nature and limits of such participation.

2.3 Democratizing the Science Museum

Science museums and science centers are in the process of a re-examination aimed at justifying their role and value for society, as well as understanding their function more clearly as 'public institutions' (Schiele and Koster 1999; Hein 2000; Friedman 2007; Koster and Falk 2007; Semper 2007). The recent public statements on science and evolution underwritten by all the members of the European network of science centers (Ecsite 2008) are a sign that science centers, both collectively and individually, are taking a clear stance on the role and function of science in society, despite the hostilities that such statements may provoke from some sectors of society. Similarly, the current discussion about public funding to science centers in the United Kingdom (House of Commons 2008) exposes the kind of examination going on in the field, aimed at demonstrating the value of science centers for their communities.

Despite the fact that some science centers prefer to distinguish themselves from traditional museums, for the purpose of this study they will be regarded as a subset of museums with their typical peculiarities and many commonalities with the larger group. As such, they are recognized by the International Council of Museums (ICOM) and included in the general definition of a museum (ICOM 2001). The distinction between science museums and science centers based on the presence of historical collections, or lack thereof (Durant 1992), tends to blur and can actually disappear at a time when, as anticipated by Durant, there is a convergence in both institutions upon the notion of highly interactive, themed exhibitions and programs. An institution is not defined merely by what is 'on the floor' (or in storage, for that matter), but rather by how its resources are used to achieve the goals framed by its mission and by the interactions developed with its public (Bradburne 2000). For example, several science museums use their collections in combination with hands-on exhibitions and innovative programs to support inquiry-based learning (such as the Science Museum and the Natural History Museum in London, and the Deutsches Museum in Munich). The increasing use of online tools and resources makes it even more difficult to base the definition of 'science center' on what is actually displayed in a physical location. Therefore, the terms 'science museum' and 'science center' will be used interchangeably throughout this paper, with the remark that in the case of larger research and collection-based institutions (such as some science museums and natural history museums), the points raised in this paper affect their public engagement components rather than their collection or scientific

research activities. In the museum field the idea of institutional renewal has been a constant for at least a century, and we can find several instances of scholars and practitioners arguing that a deeper relationship between the museum and its public is necessary in order to sustain the renewal process. Already in 1917, for example, John Cotton Dana proposed that museums should be the public's 'friend and guide', overcoming the idea of museums as a distant institution, and envisioning a museum that is much more relevant and closer to the citizens (Dana 1917).

A few decades later, Theodore Low (1942) framed the discussion on a need for change in museums by stating that museums find their rightful role only in relating to the vast changes that take place in society. Low (1942) identified the key element to sustain the process of change in the governance structure of the museum, and he concluded that museums must be willing to alter and modify their internal structure and ideas to fit changing world conditions and advances in social thought.

The role that Low ascribed to the trustees seems to be particularly relevant today, because the trustees may represent the 'link' between the museum and the entire community. It is significant that their role is not conceived of as 'guardians', but as an active governing body. This is a role that is absent in many contemporary science centers where, despite the fact that advisory and scientific boards exist, these can rarely be considered to express the voices of the public and the community, but rather those of the cultural and scientific elite. Therefore, it is understandable that the main obstacle to institutional change comes from the institution itself - where the staff has become the only bearer of the values that the museum should express. In the early 1970s Duncan Cameron, inspired by the appearance of the first science centers, focused the discussion upon the institutional change needed to move from the museum as a 'temple' to a 'forum'. The two functions are separate and cannot simply be put together in one institution. Science centers promoted a different role for the museum with their terminology - a 'true center' - a connecting place for different publics and activities than was usual in traditional museums.

However, Cameron concluded, if the internal structure does not reflect the new values the 'center' will not be any different from a 'temple' (Cameron 1971).

Nowadays, external forces such as fluctuating attendance and thinning financial support are two major drivers for science centers to re-examine constantly not only their efficiency and competitiveness with alternative informal learning and leisure opportunities (from online resources to 'edutainment' destinations), but also their mission and strategy, which requires a broader discussion about their capacity to adapt and even to survive (Bradburne 1998; Persson 2000b). At the same time, it is not uncommon for science centers to have boards of directors or trustees that are almost indistinguishable from those of a Wall Street financial institution. The competences that are deemed necessary at the board and director levels revolve almost exclusively around fund-raising and implementing efficiency (Griffin 2008), leaving the pursuit of the core values of the institution to the staff.

In conclusion, one of the main obstacles to institutional change that has been a constant throughout the last 100 years is the difficulty to harmonize the needs and values of the museum's internal organization with those of the public they serve. The instrument that museums employ to accomplish this task - their governance model - is often a static structure, modeled and designed in times when museums were much less

concerned about their public accountability (Friedman 1994). At the same time, museum boards do not necessarily welcome the process of democratizing museums that both museum professionals and funding agencies started to support from the 1980s (Dickenson 1991). In spite of the criticism that has been raised, the tension between the 'moral obligation' to keep the institution at whatever cost (Mares 2006) and the dynamics of the changing needs for public institutions create a stalemate which hinders the renewal of the governance forms. Thus, the current governance systems may not be dynamic enough to support the changing relationship of science centers with the public.

2.4 Science Centers and their Publics

Science centers promote the active involvement of visitors with science and foster inquiry-based discovery, and they also aim to inspire curiosity and promote lifelong learning about science (ASTC 2006). It is commonly agreed that the term 'science center' started to be acknowledged at the end of the 1960s with the establishment of the Exploratorium in San Francisco and the Ontario Science Center in Toronto. Thereafter, hundreds of institutions followed on a worldwide scale (Gregory and Miller 1998). The professional field has been in constant development and continuous critical reflection ever since, both informed and sustained by the developments in the Public Communication of Science and Technology (PCST) and science communication fields where science centers and science museums play a major role.

Together with institutions such as universities, research councils, the media and initiatives organized on a regular or *ad hoc* basis, such as science festivals and science weeks, science centers are effectively portrayed as a powerful 'bridge' between the 'doing of science' and the public at large. Generally, they have a reputation among the public and the scientists of being credible institutions that can facilitate a direct dialogue between science and the public (Einsiedel and Einsiedel 2004). Within the profession, they are considered politically neutral and non-judgemental settings (Bevan and Semper 2006; Johnson 2006). It remains to be proven, however, if the neutrality of science centers as described by the professionals in the field is shared by the public. In fact, without a mechanism to expose the epistemological basis of museum exhibitions and programs to the public, it is difficult to argue for such neutrality.

Most of the recent discussions and research on science centers have focused upon two fundamental issues, namely the learning process that occurs in association with a visit to a science center and the economic and social impact that science centers have on their communities. The outcomes of a visit to a science center and the learning potential for the visitors have been the subject of an extensive amount of academic research and literature (see, for example, CILS 2006 for an extended bibliography), while research on the social and economic impact is more limited (Persson 2000a) and is supported mainly by professional networks and associations.

In spite of the active discussions at a professional level regarding the capacity of science centers to identify, adapt and respond to the needs of the community they serve and to respond to societal changes, related research activities are still scarce. That is, while the efforts to understand the impact of science centers on the public are becoming widespread, the research on how museums listen effectively to the public is lacking.

On the one hand, the field of evaluation and visitor studies is still fairly recent (the Visitor Studies Association was founded in 1988 in the United States, while the European Evaluation Society started in 1994). On the other hand, it is usually focused upon the evaluation of specific programs and exhibitions, rather than on how the institution as a whole interacts with the public.

Science centers rely commonly on evaluations in order to obtain data about the value of their specific exhibitions and public programs. Even in the case of front-end studies, when the public is invited or engaged actively in sharing their views on potential topics and approaches for new programs and exhibitions, the process takes place when the project has already taken shape inside the museum. The front-end evaluation effort remains a tool for exhibition development, when it is not ignored, denied or simply 'lost' inside the organization (Dierking and Pollock 1998).

Despite the wide variety of approaches, the effect of evaluation studies on the governance of the museum, when it exists at all, is indirect. The reason for this has generally been attributed to poor internal communication in the organization, which leads to a dispersion of the research results and prevents stakeholder access to them (Dierking and Pollock 1998). Furthermore, the current information available to science centers' staff about prior knowledge and audiences' attitudes is still mainly anecdotal or conjectural, thus undermining the actual foundation of many front-end studies (Mayfield 2004).

We argue that the reason for the lack of a coherent approach to the study of public participation in museums is that there is no formal governance model where the public has an active role. Governance models still consider the public to be the receiver of the information prepared by the museum, and the interactivity and engagement with the exhibits and programs happen inside the boundaries of experiences designed by the museum. Feedback from the public to the museum can inform the development of more efficient and effective displays and programs, but it has no direct impact on the epistemological basis in the science center because there is no provision for the public in the decision-making process of the institution. Unless museums have a model defining the areas, actions and processes where the public is granted decision-making power, it will be difficult to assess where participation takes place and with what results.

For example, the Museum of Science and Technology in Stockholm used a variation of the future workshop methodology in its Science Center gallery, involving both high school students and the public in the design of new exhibits (Taxén 2004). The science center 'Città della Scienza' in Naples used the scenario workshop methodology for the development of the traveling exhibition 'Nanodialogue'. The Natural History Museum in London has appointed audience advocates in order to provide the necessary awareness for visitors from within the organization, and to develop a coherent strategy for consulting its visitors (Bicknell and Farmelo 1993). Such attempts need to be examined, evaluated and validated carefully, especially with regard to the new dynamics that they introduce between stakeholders and participants - changing design and management practices established over a long period of time (Taxén 2004). It is worth noting that, if fully implemented, the role of the audience advocates alters the exhibition development process (Koutsika 2006). In a similar way, any direct participation of the public in the decision-making process of the museum will lead to a profound change of pre-existing museum processes, and cannot be simply 'added' to the current organization.

2.5 Sharing Authority for Public Programs

Contemporary science, which is typically open and ‘unfinished’, presents a new challenge for science centers and their relationship with the public. Museums cannot forgo creating opportunities for dialogue about the societal aspects of current science, and this dialogue has the potential to impact the very nature of the epistemological process of the museum. The key to realizing this potential, however, lies in the role that science centers play in negotiating knowledge in our society.

Starting in the United Kingdom around the year 2000, a series of public policy documents established the need for dialogue in addressing science and technology issues in society, acknowledging a crisis of trust between the public and science and technology, including the relative ineffectiveness of the programs of public understanding of science based on the so-called ‘deficit-model’ (House of Lords 2000). In support of this view are ‘a new humility on the part of science in the face of public attitudes, and a new assertiveness on the part of the public’ (House of Lords 2000). This new mood for dialogue has found expression with the use of several participatory and consultation options, which fall largely into two categories: market research activities and public consultation exercises.

At the same time, science centers received an explicit reference as target organizations, and were identified as ‘natural venues for debate and consultation initiated by the Research Councils and other such bodies’ (House of Lords 2000). Soon afterwards, similar conclusions and recommendations were echoed at the European level with the establishment of the ‘Science and Society’ program by the European Commission and the publication of the corresponding Action Plan (European Commission 2002). This role for science centers as natural venues for discussions about contemporary scientific research, however, brings some profound consequences for their approach and their governance, as expressed clearly by Durant (2004):

“[It] has the potential to be every bit as significant for the work of science museums and science centers as the shift more than a generation ago from passive spectacle to active, discovery-based learning. This is because the focus on scientific research requires an almost entirely different approach to that adopted in conventional hands-on exhibitions, and this approach has radical implications for museums’ relationships - with the scientific community, with its visitors, and with one another” (Durant 2004, p. 50).

Science centers, which were fulfilling an ancillary function with regard to the ‘making of science’ thus far, and which were involved mainly in passive dissemination, recently became active players in the negotiation of contemporary science and knowledge (van Dijck 2003). It is common today to find public debates and discussions on contemporary science in the daily and weekly programs of many science centers in Europe. However, all the activities hosted in the science centers are subject to the influence of the environment in which they take place - the exhibitions, programs and institutional culture of the organization, even if the process was initiated by another body (such as the Research Councils, for example). Therefore, despite the fact that science centers are usually independent institutions, their ‘neutrality’ as places to host such debates can be discussed.

It should not come as a surprise that exhibitions and programs carry a broad range of political and social assumptions, as well as values, that are often hidden in

the final product, but are none the less a fundamental part of the developmental process and therefore influence the visitors' understanding. Often such assumptions lie in apparently minor details, such as the architecture of a building, the voice-over in a film or the choice of presentation for an exhibit (Macdonald 1998). When the science center acknowledges that its role is not a passive display, but instead an active player that supports its visitors in their understanding of science and technology, the exhibitions, programs and their development should be subject to public scrutiny in the same way as is the practice of science. The process of 'opening up' for a discussion of the content developed by the institution often causes friction within the organization (Gregory and Miller 1998).

However, as the same authors note, 'the emphasis on the public context in which their efforts are judged is a change that today's museums ignore at their peril' (Gregory and Miller 1998, 214). A governance model that includes public participation is therefore necessary as an instrument to guarantee the transparency of the epistemological process in the museum. It also implies moving away from the notion that museums are always objective and impartial. Nevertheless, they remain reliable and trustworthy institutions for their visitors (Cameron 2006).

The factual information provided in science centers is usually balanced, correct and reliable. Cognitive knowledge can be accessed in a direct way, and the factual arguments on which it is based are those that result from the scientific endeavor. However, exhibitions convey not only cognitive knowledge, which is based on technical expertise and is subject to a judgment of correctness, but also experiential and social knowledge based on personal experiences and social values. The latter two forms of knowledge carry a much higher level of emotional content and are subject to a judgement of appropriateness and goodness (Glicken 1999).

Experiential and social knowledge, which are often the ones more relevant to the public, can be accessed effectively by means of consultation, dialogue and participation with individuals and groups. When this is not the case, exhibitions result in being only individualized sensory experiences that fail to give the visitors tools and principles that they can apply elsewhere. In short, instead of building knowledge, they provide only a body of information, as was apparently the case of the 'Food for Thought' exhibition at the Science Museum (Macdonald 1998).

Glicken's argument of distinguishing between cognitive knowledge and experiential and social values coincides with the picture described by Seagram et al. (1993) in their framework for exhibition development. Seagram et al. argue that science centers are at a crossroads: either they support the consultation process to share authority for the making of meaning, and implement effective ways to build and display the experiential and social knowledge with the participation of those who shape it, or they substitute this emotional content with their own investigations and positions. Otherwise, they run the risk to 'remain as they are, serving steadily diminishing audiences, and becoming increasingly marginalized institutions, or to suffer intervention that will undermine their expert functions' (Seagram et al. 1993, 38).

Similar results have also been found in the international research project 'Exhibitions as Contested Sites - The roles of museums in contemporary society', covering science and history museums in Australia, Canada, the United Kingdom and the United States (Cameron 2005). Cameron's study points out how science museums can

change their role from being authorities on the subject to being knowledge brokers. In so doing, they empower audiences to complete the interpretive cycle and reframe the museum authority as one of expert mediator, informant and facilitator.

In conclusion, dealing with contemporary science creates a new relationship between the museum and the public. In order to preserve their reliability and trustworthiness, museums need to open their epistemological process to public scrutiny and, at the same time, they need to access knowledge and values which are held by the public, in addition to the expert knowledge available within the museum.

2.6 Visitor Voices

Despite the fact that engaging the public in a structural process to share authority on the design, development and deployment of exhibitions and programs has long been advocated, the evidence of such activities across the science center field is fragmented and incidental. In addition, it is not common for science centers to publish the results of their work. More importantly, however, the evidence does not represent systematic and consistent instances of public participation embedded in the decision-making process. The examples that we have encountered, thus far, can be placed into two categories: (a) activities to engage the public as informants to the staff in charge of the development of exhibitions and programs; and (b) opportunities for the public to contribute and add to the program or exhibition during their visit. Despite the useful insights that marketing research may offer, such as periodic visitor satisfaction polls, analysis of feedback forms and occasional focus groups, we believe it does not provide a direct way for the public to participate in the decision-making process of the museum, and therefore we have excluded it from our analysis.

Some examples of activities where the public acts as informant to the museum have been described above (e.g. participatory workshops and audience advocates), but it is important to emphasize that in the examples mentioned the museum still holds control on the final product, and the public is not on an equal footing with the museum in terms of decision-making.

Creating opportunities for dialogue, comments and responses to exhibitions and programs - activities known commonly as 'visitor voices' (McLean and Pollock 2007) - gives museums the possibility to share authority with the public on different levels, and can help to expose the often implicit influence of the museum environment on visitors' understanding (Gammon and Mazda 2000). These activities, however, cannot be considered real forms of participation in the governance, because of their incidental nature and because they usually affect only the last stage of the museum development process. For the public, giving feedback is a somewhat separate activity from visiting the museum, performed mainly at the end of the exhibition or in a separate, dedicated area.

However, giving the public a voice on the content does not imply engaging the public in the decision-making process. To illustrate this we can look at a common way to include visitor voices in the museum: the use of so-called comment cards, 'talk back' stations and written feedback in general. In some cases, these comments became an actual component of the exhibition (Pedretti and Soren 2003). For example, during the

'Memory' exhibition at the Exploratorium in 1998, a public 'timeline wall' was introduced where visitors could attach 'post-it' notes with their memories of specific years, thus creating a public logbook with the earliest memories they could remember. In the same institution, the web-based exhibition 'Remembering Nagasaki' collected visitors' memories about the dropping of the atomic bomb on Nagasaki. In fact, this created an exhibition made up almost entirely of actual visitor contributions. Other examples can be found in computer-based exhibits, such as the electronic voting and opinion banks in Explore At-Bristol and at the Wellcome Wing in the Science Museum in London.

At this stage, however, it is not possible to identify how such examples can be translated into actual strategies that science centers can use to share the authority of their programs with the public, because the results of the documented activities are still too scarce and heterogeneous. The increased attention to visitor voices has certainly contributed to changing the 'top-down' approach, led by curators and educators (with little or no information about the public), to a design process which includes, and often starts from, an assessment of the current interests and needs of the public (Screven 1993). However, we do not yet know whether museums actually share the authority of their programs with the public, or hand over part of it by means of these activities.

Paradoxically, a much stronger involvement of the public in actual decision-making takes place in activities hosted by science centers, but whose results affect organizations other than the museum itself. With the development of programs such as consensus conferences, workshops and other participatory activities, science centers are moving towards the 'agora model' of science communication (Regeer 2004), where science is constructed socially and the expertise of the public is recognized and valued. The Science Museum in London was a pioneer in this field, organizing the first consensus conference on plant biotechnology in the United Kingdom in 1994 (Durant and Joss 1995). La Cité des Science et de l'Industrie in Paris and the Deutsches Hygiene-Museum in Dresden soon followed by organizing similar events on their premises. In 2005, a European consortium of 12 institutions, including four science museums, undertook a large-scale public consultation process on the topic of brain science, and presented the results at the European Parliament during the final event of the project 'Meeting of minds - European citizens' deliberation on brain science' (Steyaert and Vandensande 2007). Although it is too early to generalize about this role for all science centers, as many challenges ahead are still unresolved, it is important to note that science centers have distinct advantages when compared with other institutions such as universities (Einsiedel and Einsiedel 2004).

Science centers have certainly developed and implemented various tools to gather public opinions and comments about their activities, exhibitions and programs. What seems to be missing is a clear definition of how such voices really 'count'. That is, how they could shape not only a specific aspect of the science center, but also how they may influence the strategies of the institution and the instruments to implement them. The question thus arises: 'what is their role in the governance of the science center?'. The anecdotal evidence thus far suggests that the public can contribute in meaningful ways by providing knowledge about specific content; formulating innovative approaches; expanding the points of view represented in the museum; enhancing the relevance of the museum for the community; and sustaining an open dialogue among visitors, to name but a few. The counterpart for the museum means surrendering control on some

decisions, and 'the exposure of the epistemological basis on which knowledge in museums is based, by the inclusion of information on methods, perspectives, and authoring' (Cameron 2005, p. 230).

For science centers, sharing the decision-making process with the public and building the necessary mutual trust cannot be achieved without a better understanding of who the public is that will engage in this process - what are the motivations, knowledge and skills required in order to make any output useful, and what is the relationship of the public with the science center, including visitors, non- visitors, stakeholders, etc.?

The research by Hood (1983) shows that social factors such as education, class, ethnicity and age group are central in making choices about leisure time, including visiting museums or science centers and the frequency of these visits. Hood found that frequent museum visitors (those visiting museums at least three times a year) select to visit a museum because they find that it fulfills three basic human needs they value most: (1) the opportunity to do something worthwhile; (2) a challenge for new experiences, and (3) an opportunity to learn.

Non-visitors, and to a great extent occasional visitors as well (visiting museums once or twice a year), do not visit museums because they value other criteria, such as being with people, feeling comfortable and at ease in one's surroundings and participating actively. Non-visitors and occasional visitors do not see the museum as a place where they can fulfill their needs. From the basic needs that Hood derived for frequent museum visitors, however, it may be argued that frequent visitors not only enjoy visiting museums, they are also committed to sustaining and supporting the museum as a public institution which plays an important social role in their lives. This assumption needs to be studied further in the case of science centers. Therefore, we need to study which publics can be involved in the governance of science centers, map the methodologies that can be used to engage the public and analyze what level of decision-making is granted.

2.7 Discussion

Governance systems in museums are typically static and traditional, and currently they do not grant the public a formal role in the decision-making process. The relationship between museums and the public is constantly changing, however, and museums nowadays are under increasing pressure to expose their epistemological process to public scrutiny and engage the public in this process. They need to do this to increase their inclusiveness, and also to preserve their reliability and trustworthiness when dealing with contemporary science and technology.

There are several instances where the public can inform the development of new exhibitions and programs, or contribute and comment on existing ones. We have argued that such activities, even when conducted in a participatory way, cannot be considered a form of public participation in the governance as they are often incidental and affect only specific developments within the institution.

The participation of the public in the governance of the museum, therefore, requires a change in the underlying structures that produce museum cultures (Mason and McCarthy 2006), and it is not simply a matter of changing access policies (McPherson

son 2006) or devising new programs and exhibitions. Structural consultation with the public has been recognized as a crucial issue for the management of a museum (Fleming 2006), although thus far only a few isolated cases have been integrating the public in the organization of the museum. Several experiences have remained at the level of anecdotal evidence, and it is difficult to consolidate their results despite the positive nature of these experiences.

We need to study how public participation can become a structural component in the science center in a similar way to what already happens with the scientific content - which is usually developed, tested and validated with the participation of scientific advisory boards, councils and networks of experts. Furthermore, science centers need to identify those decisions where they can relinquish control and share it with the public, and which level of authority can be granted to the public, including the rights, duties and tasks that can be shared alongside the potential threats that this process might uncover. That is, public participation must be consistent with the current governance structures of the museum, but it also needs a new model to describe the changed relationships between the active agents in the governance.

Currently, most governance models of science centers and museums are three-fold, with the board, the director or the staff, or a combination of these, being charged with decision-making power within the institution (see Figure 1). To keep our model simple, we assume that in the decision-making process there is one 'decision-maker', who is charged with the responsibility for a decision, and a series of 'stakeholders' who inform the decision maker but do not have ultimate responsibility for the decision.

The typical case for the 'board model' in Figure 1 is a capital campaign decision, such as the expansion of the science center; the long-term development planning for the institution with the choice of major themes to tackle and initiatives to promote, or the approval of the annual budget for the institution. The board is informed by its stakeholders and remains responsible for the decision. The 'director model' can be found in the case of fund-raising, in the establishment of partnerships with other institutions, or when authorizing significant expenses. In many cases, this is also the model that applies for all decisions related to implementing the strategy set out by the board. Finally, in the development of many exhibitions, the staff is in charge of the decision-making and the relevant choices (the director having only a formal role to sign-off the project or approve a framework beforehand). The staff is also in charge of many decisions in the area of education and, in this case, we speak of a 'staff model'.

We have discussed that there is a sufficiently developed body of knowledge supporting a more robust role for the public in shaping the science centers' methods of presenting and communicating science. In our view, the need to make science centers more inclusive, the focus on contemporary science and technology and the European policies on science governance are the over-riding factors that require a clearly defined role for the public in the governance of science centers. Thus, we believe that there is sufficient justification for the development of a fourth governance model, where the public is given a formal and integral role in strategic decisions about the institution (see Figure 2). In this instance, the public has a recognizable, non-negotiable role in making a decision that affects the science center. For example, the Native American communities have such a role in all decisions covered by the Native American Graves and Protection Repatriation Act (NAGPRA; see Scott and Luby, 2007).

Board Model	Decision-maker	B (board)					
	Informants/stakeholders	A	C	D	E	F	G

Director model	Decision-maker	A (director)					
	Informants/stakeholders	B	C	D	E	F	G

Staff model	Decision-maker	C (staff)					
	Informants/stakeholders	A	B	D	E	F	G

Figure 1. Current governance models. A: director; B: board; C: staff: curators/exhibit developers and educators; D: public; E: politics/public sector; F: industry/private sector; G: science institutions.

Public model	Decision-maker	D (public)					
	Informants/stakeholders	A	B	C	E	F	G

Figure 2. Public governance model. A: director; B: board; C: staff: curators/exhibit developers and educators; D: public; E: politics/public sector; F: industry/private sector; G: science institutions.

The actual definition of such a model for science centers requires a level of analysis which we have only started to uncover, however. For instance, before we can define such a model we need to know how science centers acknowledge and benefit from the shared authorship that derives from such activities, what are the risks entailed, and what are the interfaces between the public and the organization. An example of a public role which is close to being integral in the decision-making process can be found at the Dana Centre in London - the Science Museum's venue for scientific debate and discussion. The Dana Centre has pioneered audience-led projects where panels of people from specific communities in London (such as Chinese, African Caribbean and black) have been involved in an ongoing manner since the early stages. These panels worked together with the trustees and the staff of the institution to select and develop topics, formats and events to be produced at the Dana Centre.

By means of regular face-to-face meetings and online consultations, this process created a deeper relationship between the museum and its public which emerged as beneficial not only to the development of the programs, but also to position the Dana Centre as a partner for social projects in London. Thus, this approach contributed in a very concrete way to the inclusiveness of the institution. This ground-breaking approach, however, is currently limited to the Dana Centre activities and has not yet

found applications in other areas and programs of the Science Museum (Foggett 2008).

It is quite likely that the public that will be involved in structural and participatory activities will consist mainly of small groups of 'engaged citizens' (Einsiedel and Einsiedel 2004) - those who are committed to discuss and participate in the dialogue about science and society. Thus, we should determine whether these audiences represent existing museum visitors or new groups of people who are neglected by the traditional offerings of science centers, and whether they act on a volunteer basis or as paying members of the museum. In the case of the Dana Centre, for example, all the participants were new to the museum but were connected to one of the trustees.

Given the arguments presented in this paper, our next undertaking will focus upon current practices within the European context in order to assess to what extent public participation has been implemented in science centers, in what forms it takes place and what output it has delivered thus far. By means of qualitative, in-depth interviews with board members, directors and staff at leading institutions, we will test and refine the models in Figure 1 and 2 in order to explore how the public model combines most effectively with the existing models (i.e. board, director, staff) in the different activities of science centers. These results will be tested further - on the one hand with a larger sample of institutions representative of the science centers in Europe, in order to validate them across the field; and on the other hand, with the institutions' actual and potential publics in order to take into consideration their expectations and readiness to participate in the decision-making process of the science centers. At the end of this process, we aim to provide a coherent set of conditions that will enable science centers to include public participation within their governance structures.

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3.

Science Centers and Public Participation: Methods, Strategies, and Barriers³

3.1 Abstract

Science centers and museums are currently experimenting to strengthen the participation of the public in two-way conversations between the public and the institution. Eventually, these activities will lead to a stronger role of the public in the decision-making process of the museum. We analyzed the current situation faced by science museums in Europe in light of the recent discourse on public engagement with science and identified the main barriers and obstacles that prevent actual decision making of the public within the institutions. Finally, we discuss suggestions for solutions.

3.2 Introduction

Science centers and museums (referred to as SCMs in the rest of this article) have traditionally played an educational role offering their visitors opportunities for informal science and lifelong learning, and they are usually recognized as important players in the communication and dissemination of science to the larger public. The past decade, however, has been characterized by an increased professional interest in and development of activities where participatory techniques engaging the public directly with scientists, researchers, and policy makers are the key components of many public programs and exhibitions (S. R. Davies, 2009, 2011; Lehr et al., 2007). For example, projects like “Meeting of Minds” or “Polka” (I. Anderson et al., 2007; Parisse-Brassens, 2009) involved several SCMs where formal policy statements in the field of neurological and genetic research were formulated and subsequently brought to the European institutions. “Open labs” on the museum floor provide researchers a place to conduct their doctoral and postdoctoral research in open view of the public (Meyer, 2011). Increasingly popular are also the ‘science live’ programs, where the public serves as subjects for a wide array of scientific experiments. Currently such programs are running at the

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Science Museum in London, Science Center NEMO in Amsterdam, Science Gallery in Dublin, and other locations⁴. On a more general level, the international field of science centers has formally resolved to “further promote dialogue between scientists and the general public so that public opinions on science and technology can be heard and incorporated into decision-making processes.”⁵

SCMs aim therefore to be a direct link between the public and the “doing of science,” where the museum is in a key position to manage the interactions of the public with the stakeholders involved in the current practice of science (Bell, 2008; Chittenden, 2011; Chittenden, Farmelo, & Lewenstein, 2004). As a result, SCMs are effectively entering the field of science governance by shaping the relationships of the public with other stakeholders, by enabling the public to form images of science governance (Felt & Fochler, 2008, 2010), and by allowing the public to be directly involved in research activities, many of these of a controversial and innovative nature (Chittenden et al., 2004). Furthermore, SCMs perform another critical function: They enable scientists, researchers, and other stakeholders to shape and negotiate their own images of the public. SCMs have become places where the “understanding of the public by scientists” takes place (Lévy-Leblond, 1992, p. 20), thanks to the interactions between scientists and the public that they build and facilitate.

At the same time, SCMs are under pressure to develop new strategies to engage and involve the public in the development of their activities and programs, in order to strengthen their social relevance and become meaningful players in the dialogue between science and society (Rodari & Merzagora, 2007). SCMs are therefore currently developing new methods to share the traditional authority of the museum with the public and to achieve a more transparent epistemological process (Cameron, 2008, 2010). The transparency of such epistemological process, it has been argued, cannot be achieved however without a clear role of the public in the governance of the museum (Bandelli, Konijn, & Willems, 2009). The present article focuses on how SCMs see this role of the public and on the methods and strategies they employ to open up their decision-making process to the public.

Even if an increasing number of SCMs are thus becoming interfaces between science and society, there is so far little evidence that these crucial roles are effectively communicated to or negotiated with the public. The extensive literature on visitor and museum studies has traditionally focused on the relationship between museums and their public, with little attention so far about how public participation in the governance and decision-making process of SCMs affects the larger domain of science policy. At the same time, Science, Technology, and Society studies concerned with the public participation in science policy have usually confined the role of museums to the domains of education, dissemination, and communication of science, leaving a gap about the role of SCMs as platforms to support public participation in science policy.

⁴ More examples can be found at <http://www.ecsite.eu/activities-and-services/projects>.

⁵ As mentioned in the 2011 Cape Town Declaration, endorsed by all the science center networks worldwide, available online at http://media.fssc.se/2014/06/Cape_Town_Declaration.pdf.

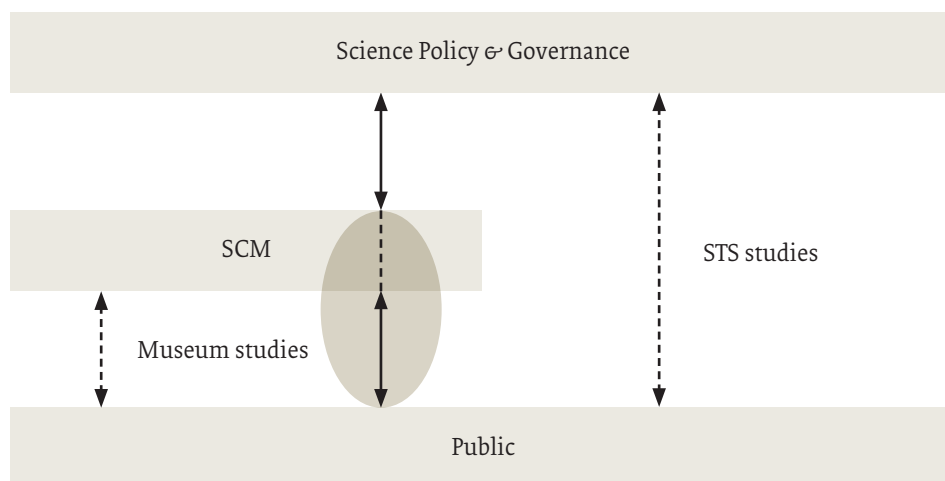


Figure 1. Context and focus of the present study: Public participation in SCM policy with outcomes that influence science policy and governance.

Note: SCM science centers and museums; STS Science, Technology, and Society.

The present article aims to fill this void, analyzing the mechanisms of public participation in the governance of SCMs from a perspective of public participation in science policy (see Figure 1). *Governance* is a term that lends itself to multiple definitions and interpretations (Jordan, Wurzel, & Zito, 2005). In this article, however, the concept of governance is used to describe the structures and processes where decisions and policy making take place, both at the institutional level (as in the governance of SCMs) and at the national or international level (as in the governance of science). Our focus in the following is mainly on the governance at the institutional level.

It seems that SCMs advocate (and in fact implement) two-way communication between the public and the various stakeholders involved in the governance of science, but it is still unknown to which extent the same two-way communication is implemented between the public and the museum itself. For instance, to what extent are the research experiments performed on the museum floor negotiated with the public? Are the public's ideas and concerns about the content of the programs taken into account? How are the dialogue events and the scientific citizenship they help establish (S. R. Davies, McCallie, Simonsson, Lehr, & Duensing, 2008) constructed? How do museum publics enact themselves during such events (Michael, 2009)?

These are some of the questions that need to be addressed in order to understand how SCMs perform their role as 'facilitators of engagement' between scientists and the public (Greco, 2007; van Dijck, 2003). There is no doubt that SCMs are good platforms to bring science to the public, but we still do not know if the opposite is actually true – that is, whether SCMs are able to include the public's voice in their activities and, therefore, in the science they construct and present. Science currently plays a critical role in the governance of SCMs. In many cases, science institutions are among the founders of science centers; the boards and trustees include scientists and representatives of scientific institutions; many directors are scientists; scientific advisory boards are either a per-

manent feature of SCMs or are set up when a new program is developed. Thus far, however, there is little evidence that the public plays any role in the governance and in the decision-making process of SCMs – at least not in the same structural and formal way. Public participation becomes effective when it is an identifiable and structural component in the decision-making process (Caron-Flinterman, Broerse, & Bunders, 2007) and in the governance of the institution. Moreover, it should be an ongoing activity, not an ad hoc exercise; participation should not be switched on only when it is convenient to the organization. It has to allow for unpredictable outcomes and real consequences and lead to some degree of power sharing among the parties involved (Seifert, 2006).

Nowadays, SCMs have all the potential to be ‘level playing field’ actors in the governance of science, that is, at the same level as research organizations, patients’ associations, industry, government and nongovernmental organizations, and so on. However, little is known about the mechanisms used in SCMs to make sure not only that the various stakeholders get equal opportunities to be heard but also that these mechanisms are transparent and adequate accountability systems are present (Macdonald, 1998, 2002, 2010).

It seems, therefore, that regardless of the ‘participatory turn’ of the past decade in the science and technology studies (Jasanoff, 2003), in their actual operations, SCMs still suffer from structural obstacles, which prevent them from effectively implementing public engagement and participation. As Chittenden (2011) puts it, SCMs still represent a system that is “ephemeral and unpredictable” (p. 1552).

Within the field of public engagement with science, there is a critical discussion about the existing gap between the public and science and the resistance of certain science structures to accept and acknowledge the difference that public participation can bring to methods, processes, and assumptions (Delgado, Kjolberg, & Wickson, 2010; Wynne, 2007). SCMs can be instrumental, therefore, in increasing public access to science and making public contributions to science governance more visible and meaningful.

If the public is involved in a structural way (i.e., participation becomes a regular, ongoing, and integral activity in SCMs), we need to address the position of the public in the decision-making process of the institution. Does the public remain an informant, or does this structural involvement lead to situations where the public not only is a full-fledged stakeholder but also holds decision-making power? How can we define the level of this involvement? In the present article, we address the question of how open are SCMs to public participation in their own governance, analyzing the current state in Europe in view of their methods to involve the public in their decision-making process and governance.

Museums already interact with several organizations that represent the public, like government agencies, civil society (Janes, 2007), and community organizations. These interactions often affect the museum governance, with seats in the board, advisory groups, and similar instances. However, these mechanisms are ruled by formal relationships at the institutional level between the museum and the organizations representing the public, and the interactions they entail are very different from those between the museum and the general public. Access to the museum governance is conditional to some form of ‘representation’ of the public involved – either in the form of belonging to an organization or bringing the agenda of a specific group to the museum.

In addition, several boards co-opt their members, reducing or in fact blocking the bottom-up participation of the public in these structures. This is the ‘institutional public’ in the governance of SCMs.

In the present article, we will focus instead on the public defined as individuals who interact with the museum or science center in their personal capacity, that is, not because of their institutional roles. In our study, the public may be visitors or users, members or tourists, or ‘nonvisitors’ who do not (yet) see the museum as a meaningful and relevant institution. The defining aspect is that we look at how a relationship is built between SCMs and individual members of the public. Participation in the governance requires building trust between the museum and the public – it is arguably not a role for the casual visitor who comes to the museum only once. There are several instances where casual visitors provide input to a museum though: Evaluation studies rely on this, and so do many ‘visitor voices’ projects (McLean & Pollock, 2007). But taking part in a structural way to the decision-making process and the governance of SCMs requires an understanding of the issues at stake, which can only be achieved with an ongoing interaction between the parties involved. Nevertheless, this relationship can start from a casual visit, if the visitor sees the museum as an open organization that supports and empowers the role of the public in the democratic society.

3.3 Method

To define the tools and mechanisms for public participation used in SCMs, we used in-depth, semi structured, qualitative interviews with four levels of museum staff: (a) board members, (b) directors, (c) middle staff (managers, content developers, education officers, etc.), and (d) floor staff/explainers. Each interview covered three areas:

- Who has decision-making power in the museum?
- Is the public involved in the decision-making process?
- Are there structural barriers and obstacles in implementing public participation in the decision-making process of SCMs?

Sample

We identified a theoretical sample (Strauss & Corbin, 1998) of five SCMs located in Western Europe (with a geographical distribution from Scandinavian to Mediterranean countries). In a theoretical sample, the cases are chosen to fill theoretical categories and to provide examples of extreme situations and polar types (Eisenhardt, 1989). We looked, therefore, for a broad variety in terms of the history of the institution, size, dominance position and competition, exhibition techniques, and funding mechanisms. Furthermore, we relied on the availability of additional documents and reports and on professional knowledge of the field to identify the institutions that would fit our purposes most. However, the institutions were not chosen to be representative of the science center field in Europe, nor do they represent “success stories” of public participation.

The institutions in the sample range from small (with less than 10 persons on staff) to very large (in excess of 500 staff members) and include very recent institutions

(2 years since opening to the public) to old ones (150 years). Four institutions have collections (historical objects, specimens, or exhibits), while one does not have any permanent collection and organizes only temporary exhibitions and programs. All the institutions in the sample have a board, which has been either publicly or privately appointed; have two or more levels of staff; and have one or more directors responsible for the management of the organization (when more directors were available, we interviewed those responsible for the public engagement or exhibitions).

In the following text, the five institutions selected (and the corresponding staff interviewed) are referred to with fictional names in order to guarantee the anonymity of the institutions and their staff. We named the institutions as follows: The Central, The Metropolitan, The Tower, The Grand, and The Rover.

Data Collection

The interviews (in all, 22 in-depth face-to-face interviews of about 1.5 hours duration each) were collected between September 2008 and December 2009, and all were recorded and transcribed. In addition to the interviews, other documents were used during the analysis:

- Mission statements
- Organization charts
- Annual reports, evaluation reports, press releases, and newsletter articles regarding the institutions
- Related personal communication with the interviewees and other members of the staff

The data were analyzed with techniques for developing grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1998), conceptualizing and reducing the results of the interviews into common categories, and finding relationships across them.

3.4 Analysis

Our analysis looks at how SCMs organize their decision-making process and the contributions from the public and provides an overview of the current barriers and best practices to include the public in the institutional decision-making processes.

In SCMs, there are multiple decision-making holders: Typically, this power is divided among the board, the director, and the staff (Bandelli et al., 2009). There are limitations to this model, however: For instance, institutions and decision makers will have their own decision-making style, affecting how decisions are taken, regardless of who takes them (e.g., autocracy, consultation, consensus, democracy, etc.). These styles are influenced by the organizational culture of each institution and by the personalities of the people involved in the decision-making process. There are also differences within each of the three categories in the model. On the one hand, for example, some institutions have more than one board (with separate responsibilities for legal and scientific issues) and more directors, often with unclear boundaries regarding the decision-mak-

ing power of these bodies. On the other hand, even within the staff, the level of decision-making power depends on many factors, some formal (e.g., hierarchical position or longevity in the institution) and some informal (e.g., the level of personal trust gained among colleagues or the person's acknowledged expertise in a specific domain). Finally, the legal status of an organization is reflected in its governance and therefore in its decision-making process. Nevertheless, this model captures the main categories of actors involved in the decision-making process and provides a level of abstraction suitable to be used as an analytical tool to describe an otherwise complex situation. We used this division to analyze the responses of our sample, looking at the role of the board, the director, and the staff as decision makers.

3.4.1 What Are the Current Processes of Decision Making in Science Centers?

The board. The board provides a general and strategic governance structure to steer the institution rather than acting as an actual decision maker. The board provides the legal framework for decisions that are already being taken by the institution and has, in fact, a role more often as informant than as decision maker. When it does take decisions, it is usually because of legal requirements. The board sets the 'boundaries' within which the institution operates and confirms (often for legal and financial reasons) the choices that the institution – mainly through its director – brings to its attention.

The director. The role of the director as a decision maker on the other hand is much more variegated, and its actual role in the decision-making process of the institution varies considerably among the institutions surveyed. Small institutions allow for more democratic processes, whereas staff in large institutions tend to complain about the fact that these processes are often tactical (deciding who does what and when) rather than strategic. The director is seen as a broker for the different stakeholders and as the one who can give legitimacy to internal and external pressures. Directors, however, are not at all the unquestioned decision makers, and they can be bypassed in their decisions. The most frequently recurring reasons given are those of internal personalities that do not accept the institutional framework, time line, or protocol for the development of new initiatives and of conflicts with the budget constraints and control bodies.

The staff. In many respects, the staff has a weaker role in the decision-making process than the board or the director. One common observation across all institutions is the fact that staff decisions are easily overruled by opportunism decided outside of the process: The two reasons most often mentioned are political pragmatism and the influence of sponsors in steering the development of activities and projects. Two situations are reported in which the role of the staff in the actual decision-making process is clearer. One is the role of the staff as 'gatekeepers' of the contact with the public. When the public is consulted to provide input about a certain activity of the museum, the staff has in fact the power to 'frame' this interaction – even if it is not charged with actual decision-making power.

What we try to do is to bring to the table what [we think] the visitors need, not necessarily what they [say they] want. And this is an important thing. In the

decision-making process of the museum we are a powerful influential voice, but that's it, we are an influential voice but we are not making decisions. (Tower Manager 2)

The second case reporting a more clarified role of the staff in the actual decision-making process is when a member of the staff has an acknowledged 'independent' position within the organization. Usually, this means a certain expertise or a role that is well defined and can be carried out autonomously. In this situation, the staff is charged with a higher level of trust, and their decisions are easily implemented.

In conclusion, it appears that the staff is charged with decision-making power only when they have certain skills and competencies to lead a given process. In the other instances, the director acts both as a negotiator between the different informants/stakeholders and as a guarantor of the legitimacy of the decision-making process. The board provides mostly a higher level of guarantee and a framework for long-term institutional strategies. Of interest is that the decisions of both the staff and the directors are regularly bent in order to accommodate other decision makers; this is generally experienced as a frustrating 'bypass' of the procedure, because because it happens without transparency and argumentation.

3.4.2 Are There Methods and Strategies to Include the Public in the Decision-Making Processes in Science Centers?

The interviewees were asked to list the stakeholders of the institution where they work. Table 1 and Figure 2 show the percentage of the answers given by each category of respondents (in parentheses the number of respondents is shown – 18 out of the 22 interviewees answered this question).

The stakeholders most frequently mentioned are the public (intended as visitors to the science center), the national and local governments, universities, scientists, and the industry. Teachers and schools follow, together with associations and civil society, media, donors, and the trustees or board of the museum. The results suggest that the SCMs surveyed see as their stakeholders the very same actors that are most involved in the governance of science – notably the government, civil society, universities, industry, and the public – which reinforces the view that SCMs have all the potential to be active players in this arena.

As was expected, SCMs are currently still experimenting with strategies and methods to include the public in the definition of their activities and in their decision making. We did not find any well-worked out strategies in this regard, although the work done so far clearly highlights the priorities and the dilemmas faced when the public is included in a more structural way.

One common understanding across all the institutions interviewed is that adults are the key public who can contribute in a substantial way to a more relevant definition of the content and the role of SCMs. The knowledge that the adult public can provide must however fit within the mission of the institution and its responsibility to provide reliable information:

The whole institution is getting caught up in this sort of dichotomy, which is either they – the public – lead everything you do, and then we don’t have any voice, or “we have to tell” – but actually it’s a mix, people want to operate within the framework of an organization that they know is a voice of authority. Our responsibility is to provide authenticated information, good quality data, intelligent knowledge, facilitate all those things as well, but also to enable knowledge, experiences, and different perspectives to be applied, to ultimately build on the body of knowledge. (Rover Director)

Table 1. Museum stakeholders as mentioned by the interviewees (all values are in percentages).

	Schools	Trustees	Nat. Gov.	Local Gov.	University	Teachers	Public (visitors)	Media	Donors	Scientists	Associations Civil Society	Industry
Board (2)			100%	50%	50%	50%	50%					
Directors (5)		20%	100%	80%	60%	40%	60%	20%	40%	40%	40%	60%
Staff (11)	45%	10%	65%	55%	55%	35%	65%	20%	10%	35%	30%	35%

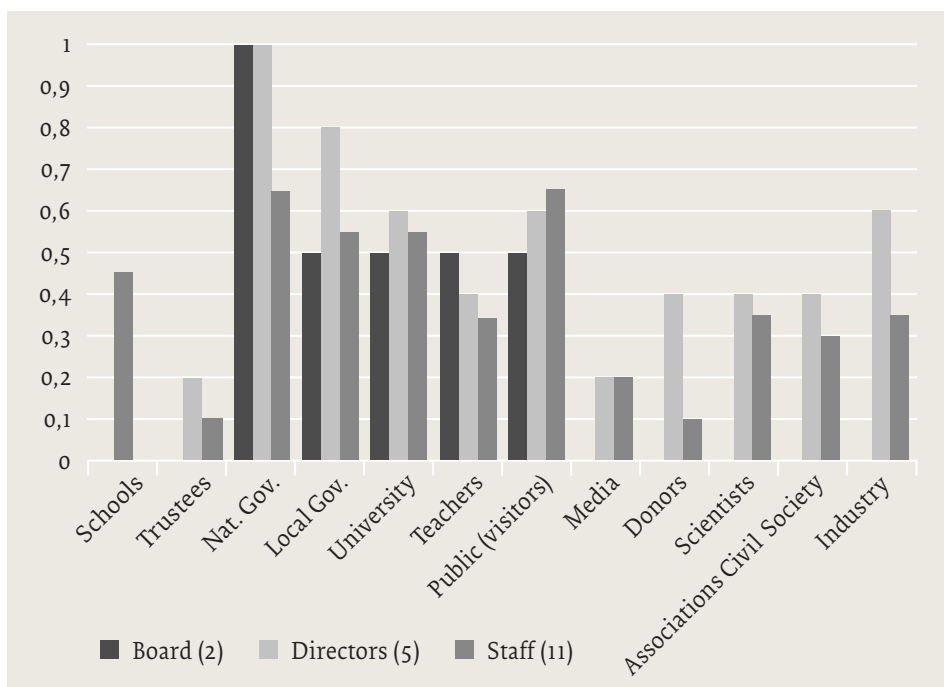


Figure 2. Museum stakeholders as mentioned by the interviewees.

At the same time, it is also clear that the public's contribution lies especially in the social and experiential domains; however, this creates a strategic problem with the way SCMs generate value. SCMs are still measured in terms of the number of their visitors, not because of the social value they help build together with their public. After a visitor pays the entrance ticket, he or she becomes a statistical number for the museum. The tools that can quantify what the public brings to the museum, such as comment cards, guest books, and the many tools described in the *Visitor Voices* literature (Gammon & Mazda, 2000; Livingstone, Pedretti, & Soren, 2001; McLean & Pollock, 2007; Pedretti & Soren, 2003), are not acknowledged outside the professional field of museums as instruments to assess the value of museums (M. L. Anderson, 2004): The leading indicator is usually the number of visitors and in some cases the income generated by the institution, or the number of temporary exhibitions.

One strategy that is being increasingly adopted is the direct involvement of the public in building alternative 'story lines' to an exhibition or a program. A structural way to do so is by exposing the epistemological method used by the museum to build an exhibition and 'co-develop' the exhibition from the beginning with the public:

While you're doing the research phase, you can encourage the audience to give their feedback and you can embed it in the exhibition. It's not like "here's the exhibition, we're finished, tell us what you think and leave your comments," it's more like "here's the research, tell us what you think while we're doing that," because that might be quite different from what you get once the exhibition is done. (Tower Manager 1)

A similar approach is also mentioned by another institution in the sample, with a specific mention of using web-based technology to “add a seat to the table” during the development process for a new exhibition. This kind of involvement seems to be more effective for broadening the relevance of the institution than for opening up the content already on the floor to the comments of the public. In both of these approaches, public participation becomes part of an integral method within the institution instead of being a ‘feature’ added at a later stage after the content has been researched and developed.

There is, however, a perceived limit to this approach: Sooner or later, the public involved in this early stage of development starts to assimilate the institutional culture of the museum and will lose the perspectives for which they were originally consulted.

The difficulty in the process is to ensure that the people you are talking to remain representative of the issues that you need to overcome for all the visitors and don’t become either individual advocates of what they would personally like, or become “museum people.” And I do think that by involving people in the process, there is a point where they become museum people. So that’s the difficulty. (Tower Manager 2)

The direct involvement of the public in the development process of programs and activities requires a more layered perspective to public segmentation, considering psychographic variables that are currently not exploited by SCMs. In addition to the demographic data about visitors currently available to museums, the interviewees mentioned the need to describe in more detail attitudes, values, interests, and lifestyle of their public in order to better understand the motivations and expectations of the public involved in this process.

In this way, it would be easier to identify and work together with the groups of collectors, scholars, and amateurs who want to share their passion for science, for instance, and to engage with the fast-growing field of citizen science (Bonney et al., 2009; Meyer, 2008). Furthermore, the role of the “friends of the museum” and members as brokers to reach new publics currently absent from museums (e.g., university students and immigrants) can be further considered. Members and friends are very committed publics who not only support the institution financially but are in most cases also ‘ambassadors’ of the institution within their circle of friends, colleagues, and acquaintances. They value the museum and are usually well informed about its activities. Our interviewees agreed that this is a public where SCMs could invest more, offering members and friends a more active role in the development of programs and activities in order to better address the needs of their circles of acquaintances.

Finally, another strategy that is being developed is the definition of professional profiles among the staff to include the public’s voice in the content of the museum. Two methods to do so emerged from our analysis. One is to have “audience advocates” who represent the public internally in the institution. This approach can allegedly be afforded only by large institutions and remains a project-based approach, and thus it is not structurally integrated (Koutsika, 2006).

The other method is to empower the staff to become social agents in order to harvest the political and social role that SCMs can play to strengthen the scientific citizenship of their public (Elam & Bertilsson, 2003; Irwin, 2001). This requires a consid-

erable effort on the side of the staff who must be able to access professional development opportunities in the field of science communication theory and social studies and translate this knowledge into programs and activities for the SCM.

We can refer to Bauman's concept of liquid society – in fact, we live in a world where everything is liquid, there are only fears, and you have to communicate that science doesn't give answers, but is a tool to give answers and live better. What is important for us is not the number of visitors or the exhibits, but the quality of the staff we have. Science centers, compared to traditional museums, changed a lot and became 'living' places. Today it's necessary to make a new step forward. Those who work in a science center must be able to build scenarios and projects about the future with a capacity to self-interrogate about what can be done. (Grand Board)

In conclusion, SCMs are trying out different strategies to move from being only content providers to being places that support the two dimensions of scientific citizenship: scientific competence and actual participation (Horst, 2007; Mejlgaard & Stares, 2009). While providing scientific competence to their public is a task SCMs have always embraced, implementing actual participation is seen as a necessary but still uneasy activity.

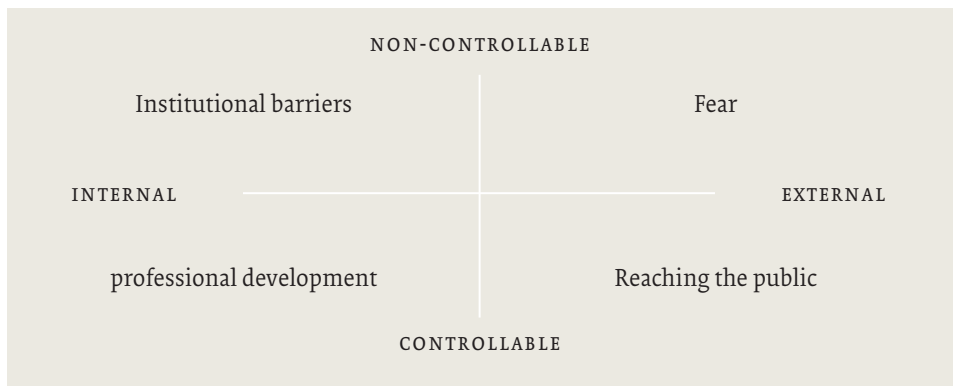


Figure 3. Barriers and obstacles to a structural participation of the public in the decision-making process of science museums.

3.4.3 What Are the Barriers and Obstacles That Limit or Prevent Public Participation in Museums?

The current barriers and obstacles that prevent a structural participation of the public in the decision-making process of SCMs are several, and all the interviewed subjects – with no exception – identified at least one that affects their work directly, and in many cases several more.

From the point of view of the staff and directors, the barriers and obstacles are

either internal (i.e., the source of the problem is identified and originating from within the institution) or external (i.e., public participation is made difficult or impossible by problems lying outside of the institution). At the same time, these barriers may be controllable (i.e., the staff has identified methods and solutions to address the problem, even if their implementation may be difficult) or uncontrollable (i.e., the solution to the problem is beyond the remit and possibilities of the staff).

We analyzed the stated barriers and obstacles alongside the two indicated axes: internal/external and controllable/noncontrollable. The resulting matrix (see Figure 3) allows us to define four categories of barriers.

Institutional barriers. Institutional barriers are conflicts between the established practices of the institution and the process of change necessary to include the public in the governance of the institution. These conflicts usually originate from different understandings within the institutions and in the field at large about the social role of SCMs. They are still commonly perceived as establishments where knowledge is displayed and offered to the public rather than places where knowledge is constantly generated, questioned, discussed, and improved. This is not only an internal institutional problem but also a consequence of a poor recognition and visibility of SCMs among other cultural institutions. The value of a museum or science center is still largely measured by the number of its visitors, but this measure obfuscates other important roles and functions. A board member's comment clearly describes the uneasiness of science centers in this regard, when the entertainment and leisure goals of the institution take over the concept of scientific citizenship that science centers aim to foster:

Science centers have betrayed Frank Oppenheimer's original idea when he founded the Exploratorium, which was to give everybody ownership of complicated science concepts, and have become instead places where there is an excess of simplification and popularization. Science centers must now regain a new level of experimentation, the science center as a place in the city, by the citizens, where serious things are done. In an entertaining and playful way, but doing serious things. (Grand Board)

The professionals in the field also share concerns on the lack of innovation in science centers and on the difficulties to capitalize on the experience of innovative projects:

Collaborative European projects have been opportunities to do something we would have never been able to do, in terms of themes or in terms of methodologies, like participatory tools where the public can contribute to our development. It's been a very innovative process, but we are not able to capitalize on this innovation to change our own programs. You need new competencies, new dynamics, which are different – and often absent – from the skills you normally have in an organization. (Grand Manager 1)

Another institutional barrier is the lack of transparency of the internal decision-making protocols and the opportunism of certain decisions, described above when referring to the 'bypassing' of decisions by the directors and the staff. This bar-

rier is twofold: On the one hand, it prevents the development of participatory methods for the public because it is unclear at which stage and with which actors within the institution the public can effectively interact; on the other hand, when the public is invited to contribute to the decision-making process, the lack of transparency creates internal opportunities to bypass or ignore the contributions of the public itself, weakening therefore the relationship and the trust between the institution and the public and confusing the roles of the public (and of the staff) in this process.

Lack of professional development. The lack of professional development about the methods, tools, and purposes to include the public in the decision-making process of museums is a major weakness on which all the staff interviewed agree. There is a lack of documentation and research on this subject, and the museums themselves rely mostly on anecdotal evidence and personal insights to better listen to and understand the public (Mayfield, 2004). A problem outlined by several staff is that it is still very difficult to get 'unbiased' feedback from the public: Usually, it is only the most enthusiastic public and the most disappointed one who take the effort to communicate their views with the museum. During a regular visit, the only member of the staff most people come in contact with is the ticket seller (when this function still exists). There is a structural lack of opportunities for the public to actually interact with the staff working at SCMs; and even when explainers or educators are available, they are not always well prepared to interact effectively with the public (Tran & King, 2007).

Alongside the problems of listening to the public, there is also the problem of making use of what is learned from the public, which means exposing the social and political values of that information:

We are struggling with how we represent the public's opinions on issues of contemporary science to other people so that it makes a difference. It's about whom you represent that viewpoint to, and get people to take it seriously. There's a nervousness about people's expectations of what actually happens with that information that at the moment doesn't get reflected back in the museum. We haven't found any real successful way moving that to a sort of political level saying "we've got so many people through the door and they are not happy with this sort of research or they are uncomfortable with that." How do you lobby that, or how do you get that taken seriously, if that is what we want to do? (Tower Manager 1)

This quotation exemplifies the stride between the ambition of SCMs as a field to bring public opinions into decision-making processes (as stated in the Cape Town declaration, see footnote 5) and the uncertainties when the institutions try to implement methods to incorporate these opinions into actual processes.

Quite often the activities where the public could provide feedback and interact with the museum (and its floor staff) are developed without a real consciousness of this process and a lack of knowledge of the current and potential interactions that take place between the public and the SCM:

the activities is a major problem. Their experience on the floor (of those who now sit in the office) is from 6-8 years ago, now the public is different, you can't develop the same things. You really need to observe what goes on. There isn't a real 'osmosis' between the management and the staff on the floor. Certainly, now some managers spend time on the floor, they see what goes on: But they don't wear our clothes, so to speak. (Grand Explainer)

This gap between those who develop the activities and those who implement them and interact with the public is also relevant to collection-based exhibitions:

Traditionally, there has been more of a "the curators are the font of all knowledge," you should be grateful that they've put something out there, the object is king, that sort of stuff. There has been a lack of understanding in that team that just putting something out there doesn't mean you are engaging in any way, you have to give it more work, and that the visitors genuinely are not like you, in lots of ways. (Tower Manager 2)

But it is not only the attitude of the staff or the cultural gap that constitutes a barrier for a deeper interaction with the public; the working methods of the staff, which rely almost completely on paper and written documents, are also responsible for this. One of the common concerns is that this way of working is unable to fully capture and describe the multiple and increasingly participatory languages (video, interactive and social media, etc.) that the public is used to nowadays in daily life.

Difficulties in reaching specific publics. Our interviewees all express that if science centers want to involve the public in their decision-making and governance process, they need to target and work with small groups, usually over a longer time than the usual interaction with an exhibit. The public that can be engaged with these activities is also a niche group, much more segmented than the 'general public' that museums broadly address. This is an issue that creates a series of barriers for the current way science centers operate. The first one is a stride between this definition of the public and the way the majority of visitors experience the museum:

Visitors don't want to spend one hour on an activity when there are other hundreds available. A science center is still seen by many people like a 'grab and go' activity, where you try something and you move to the next. (Grand Manager 2)

For many visitors, therefore, being involved in a deeper conversation about why and how the museum is dealing with a certain topic is something against their expectations of the visit. And when the public wants to be engaged in such an activity, it is the museum that struggles to frame this pursuit:

Events for small groups are expensive and we don't get any money, on the contrary, we have to spend money to support them. There is a big value in what we learn from these events—knowledge that we would have otherwise paid for. But we're not used to think this way yet. (Central Manager 1)

Audience-led programs are very staff intensive, and it is quite difficult to demonstrate whether they are making any real long-term difference. You may attract people and audiences for that event, I'm not sure there is any real evidence to show that when you've got them for that event they'll come back for anything else. (Tower Manager 1)

Another important barrier is the fact that not everybody wants or cares to engage with the museum. Or, even better, not everybody thinks they care to engage with the museum. There are still many misconceptions and false expectations (on both sides, museum staff and the public) about what SCMs should do and stand for that prevent potentially interested people to approach or be approached by the museum and establish a deeper interaction. For instance, many science centers are considered by the public opinion as places for children, where only a certain kind of simple and entertaining science is dealt with.

As explained above, selected publics are particularly suitable to be engaged in the decision-making process of SCMs – not only amateurs and collectors but also people who have gained formal or informal knowledge about certain issues (e.g., activists). However, the main concern expressed by the sample is that many of the 'triggers' that could engage these publics have a much lower visibility than the core activity of the museum, that is, the exhibition.

Fear of public controversy and of institutional change. The fear of changing existing practices plays a major role against the development of new participatory methods, according to the interviewed. Whereas other barriers and obstacles are rather well identified and can be addressed with experiments and exploratory actions, fear is an irrational block that can prevent further action and that is difficult to tackle directly. For most institutions, the major fear is of controversy in the public opinion:

We want to keep our existing public, kids, and we know what works for them, so we don't have an incentive to change. And then there is a fear of exposing yourself to criticism, discussion, reactions from the public opinion. The institution wants to avoid it. (Grand Explainer)

We need some way of representing, in a really obvious way, where different pieces of content are coming from. This is a piece that's been written by the museum, this is a piece that the public contributed, this is a piece that an expert in the field has written, but it's a personal opinion, it's not the museum's opinion. We are all thinking about how that might happen, we are all excited by the fact that it may be possible to do that, but also are worried that we might get it horrendously wrong, and that might be more damaging than not doing anything at all. (Tower Manager 1)

Internal fears also exist – internal opposition to changing the way of working, because people feel less secure when confronted with methods they are not familiar with. For example, when talking about the fact that scientists, developers, managers, and directors should spend more time in direct contact with the public, one director said,

My colleagues theoretically say it, but they don't do it. I want them out there on the floor, in direct contact, and it's not something they do. So our organization is interesting, intellectually all of this they will get, but in their heart sometimes it's a long way because it's a personal thing. (Rover Director)

Thus, just like scientists, who easily revert to a "one-way education to a deficit public" (S. R. Davies, 2008, p. 430), the museum staff tends also to fall back to one-way communication rather than challenging their established way of working.

3.5 Discussion

3.5.1 *Toward a Public Model of Governance?*

We do not claim that the results of our analysis can be generalized to the whole field of SCMs: Given the variety and diversity of institutions that belong to the field, it would be very hard to design a research project to sustain such a claim. However, we built our sample in such a way as to guarantee a wide applicability of the results, in terms of both institutional structures and range of activities. The organizations in our sample were carefully selected to portray a variety of approaches to public participation and of governance structures, ranging from small and dynamic organization to more traditional, big museums. Even across such diversity of institutional settings, we found several common issues, problems, and strategies that are indicative of a large part of the professional field of SCMs.

Our research highlighted a number of mechanisms for the public to be 'heard' by the decision makers. In all cases, however, the public appears to be an informant to the decision makers, who filter and act on the contributions of the public rather than negotiate such contributions with the public. There are instances where the public gives a direct and personal contribution to the decision-making process (e.g., by taking part to the co-development of exhibitions or audience-led projects). However, these situations do not lead to an actual sharing of authority with the public, since the contribution of the public is filtered and mediated by the staff or by reports, summaries of events, media reports, and so on. We found the most instances of unfiltered contributions by the public in the situations where the staff has decision-making power, and it can therefore hand it over to the public; however, as described above, these are not structural in the institution but are limited to one-off events and are incidental to the whole institutional decision-making process.

Therefore, it is still very difficult to find a 'public model' of decision making, in which the public is charged with direct decision-making power and the other actors such as director, board, staff, and other stakeholders act as informants for the decisions that the public makes (Bandelli et al., 2009). Such a model can be found, thus far, only in the plans for a more transparent development process that opens up the epistemological nature of the process (as described in section "Are There Methods and Strategies to Include the Public in the Decision-Making Processes in Science Centers?"). The main question is therefore whether such a model can be implemented in a museum, and what would be the consequences. This question is particularly significant today

in light of the current developments in the field of science and technology studies and the public engagement with science that argue for a more direct and structural participation of the public in the governance of science (Horst & Irwin, 2009; Irwin, 2006; Wynne, 2007). Our interviewees, however, mentioned examples of mechanisms where the participation of the public is starting to become structural within the organization. Such projects and activities include 'discussion games' such as PlayDecide (Bandelli & Konijn, 2011; Parisse-Brassens, 2009), citizen science projects where the public contributes to scientific research with observations and simple analysis of data (Bonney et al., 2009), 'fair' or festival events that bring scientists and researchers in direct contact with the public, community-specific projects (e.g., the involvement of ethnic groups or teenagers in the planning and development of programs and exhibitions), forums and policy advice meetings (Bell, 2008), co-design of exhibitions (S. M. Davies, 2010), and 'science live' research experiments on the museum floor.

All these activities are fairly recent, and with the exception of science festivals and citizen science projects, they have been consistently employed only during the past 3 to 4 years. Even if no institution, to our knowledge, has a policy in place to use these approaches for the development of new activities and programs, all the organizations in our sample agree that these best practices constitute a solid base to become structural instruments.

3.5.2 Implementing Two-Way Communication in the Governance of Science Museums

The move from the 'public understanding of science' to the 'public engagement with science' has shown that, on the one hand, we have a much stronger integration between science, governance, and the public today than previously. On the other hand, there is still a wide gap between these new forms of scientific governance and the actual culture of science and the scientific governance (Irwin, 2006). Our research shows that in the case of SCMs too, there is still a disconnect between the rhetoric of public participation (arguing for a direct participation of the public in the choices and decisions processes) and the actual practice; about the same was observed by scholars such as Irwin, Wynne, and Hagendijk (Hagendijk, 2004; Hagendijk & Irwin, 2006; Irwin, 2006; Wynne, 2006, 2007). Also for SCMs, the main obstacle for a transformation from a 'deficit' model to a democratic one is the change of institutional practices and the cultural and epistemological assumptions behind them.

The key factor under the institutional control to achieve this change is the 'framing' of the interaction with the public, in terms of both reaching the public(s) to be engaged and having appropriate professional skills to manage such interactions. Wynne (2007) makes an important distinction between *invited* and *uninvited* publics: The former in fact usually suffer from a 'paternalistic' approach (or tokenism) from the side of the science institutions, which frame the dialogue leaving little room for actual contributions from the public that can challenge the top-down models of governance. It is our understanding that so far SCMs are mostly dealing with *invited* publics, framing the discussions in ways that are instrumental to maintaining established practices and approaches (Lynch, 2011).

However, *uninvited* publics can bring true innovation to the governance structures, even though they require new strategies to reach them and a new positioning of the museum in regard to its stakeholders, highlighting its role as a broker between different constituencies rather than as a content provider (Horst, 2011; Horst & Michael, 2011). It is in this new role that SCMs can demonstrate their (until now arguable) neutrality, not of the content they present but rather of the openness of a process that allows the questions of the public to be formulated and raised, questions that are often more far-reaching than those allowed or foreseen by the current engagement frameworks.

The current modalities of public engagement in SCMs that we found in our research also confirm the ambiguities that exist in describing and defining the publics in public engagement exercises (Felt & Fochler, 2010). Of relevance to museums is the fact that the ‘mini publics’ that do take part in the initiatives have an ambivalent relationship with the ‘general public.’ This means that depending on the design of the participation exercise, the representational value of these publics is dubious: They neither feel representatives of a general public nor feel even qualified to take part in such exercises. For SCMs, this means coming to terms with a modality of public engagement that values dissensus rather than consensus and the acceptance of inequalities of knowledge among the public (Tlili & Dawson, 2010).

Our research has identified two weaknesses that prevent public participation from happening: (a) the lack of appropriate evaluation and assessment methods to measure the contributions of the public to the decision-making process in SCMs and (b) the lack of recognition of SCMs as important players in the field of science governance. These two factors are intrinsically related: Because of the lack of reliable instruments to illustrate the importance of what the public can bring to the museum (rather than of what the public learns from the museum), SCMs are not able to demonstrate their role in the larger field of science governance. Furthermore, because SCMs are still seen only as ‘ancillary’ informal learning institutions, lacking recognition from the other stakeholders, they do not invest in methods to qualify (and possibly quantify) their role as brokers in mediating the science and society dialogue. This ‘impasse’ was recently experienced in the United Kingdom, when the formal exercise to assess the effectiveness of science centers in supporting the science and society agenda concluded that there was not enough evidence to draw a definitive conclusion (Frontier Economics, 2009). Additionally, the response from the field still lacks concrete methods and measures that help understand what the public can contribute to the science centers in particular and to the science and society agenda in general (U.K. Association for Science and Discovery Centres, 2010).

While the overarching problem of establishing a more trustworthy relationship between science museums and the public remains a complex one, there are some actions that museums can put in place to address it.

The first is the formulation and implementation of detailed psychographic indicators and activity and commitment indicators for the public. This would help identify the characteristics and needs of those publics that already see SCMs as institutions to interact with rather than as a leisure or learning destination.

The second is to grant more agency and support to those structures within the institution that are currently interacting with the public. We have observed that the

members of the staff in charge of the interaction with the public suffer from three main limitations: lack of knowledge of science communication theory, difficulty in properly exploiting the current exhibitions when they do not include participatory elements and tools in their design, and a lack of a clear position and mandate during the development process of new activities – they are usually presented with a ‘fait accompli’ on the museum floor with which they have to deal.

3.6 Conclusions

SCMs have been pioneers in exploring and implementing methods to engage the public with their programs and exhibitions. By communicating contemporary science and research, however, many of these methods and the underlying assumptions are challenged. The very nature of contemporary science requires new rules for the engagement with the public, and SCMs experience this change not only as an opportunity to strengthen their social role but also as a series of obstacles to their usual practices. The current study addressed several of them to increase the relevance of SCMs in the science and society arena.

The results of the current study highlight how several of these obstacles can be brought within control of the institution. In particular, decreasing institutional barriers and addressing the fear of negative reactions from external stakeholders would bring the obstacles under control of the staff working with the public, thus enabling a more systematic interaction between the public and the museum. Our study revealed a great awareness among the institutions surveyed to move in this direction, as well as the agreement that enabling a structural participation of the public in the museum’s governance would strengthen not only the relevance of the museum but ultimately also its success.

While the position of SCMs is therefore quite clear, the same cannot be said about the public yet. There are still many assumptions about the willingness of the public to participate in the science and society dialogue, and in particular through the engagement with SCMs. Therefore, we propose to focus on efforts elucidating the relationship between museums and the public. In addition to the existing studies on the learning and satisfaction of the public, we argue that it is necessary to understand the other side of this relationship – that is, the actual contribution that the public is willing to bring to the museum in terms of inputs, questions, proposals, and directions that fulfill and support a democratic science citizenship. Therefore, future research could focus on the publics that interact with SCMs and explore how scientific citizenship as proclaimed in current science and technology studies is constructed in these institutions. With such knowledge, science centers will be able to structure and define their role as active agents in the science and society arena.

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SCIENCE GALLERY

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4.

Public Participation and Scientific Citizenship in the Science Museum in London: Visitors' Perceptions of the Museum as a Broker⁶

4.1 Abstract

Science museums in Europe play an emerging and important role as brokers between the public and policy-making institutions and are becoming platforms that enable scientific citizenship. To do so, museums rely on the participation of their visitors. However, little is known about the relation between visitors' interest to participate, their engagement with science, and their perceptions of the museum as a platform of scientific citizenship. This study analyzes visitors' interest in 3 levels of participation: Sharing opinions and feedback (the museum as 'forum'); co-developing programs and activities; and participating in the governance of the museum. Quantitative analysis of the data from a survey conducted among 364 adult visitors to the Science Museum in London reveals that interest in the forum function of the museum does not depend on visitors' prior engagement with science, but rather on how the museum enables the scientific citizenship of its visitors. However, for interest in co-development the reverse was found – previous engagement and frequent visits are more important than scientific citizenship. The forum function of the museum and its perceived role in public policy further determine visitors' interest in museum governance.

4.2 Introduction

Science museums and science centers are increasingly profiling themselves as places where the public can participate in important discussions and debates about science, technology, and society. One of the resolutions of the 2011 Science Centre World Congress was for all science centers and museums to “promote dialogue between scientists and the general public so that public opinions on science and technology can be heard and incorporated into decision-making processes.”⁷ There are thus many activities in science museums where the public enters into a dialogue with scientists

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⁷ http://media.fssc.se/2014/06/Cape_Town_Declaration.pdf

and where visitors can discuss and also give feedback on different aspects of scientific research (Davies, 2011; Davies, McCallie, Simonsson, Lehr, & Duensing, 2008; Livingstone, Pedretti, & Soren, 2001; McLean & Pollock, 2007; Meyer, 2011).

In the last decade, the discussions and the feedback of visitors to science centers and museums in Europe started to have a direct impact on matters of science governance. For example, the outcomes of projects such as “Meeting of Minds,” “POLKA,” and “Nanodialogue” (Anderson et al., 2007; Laurent, 2012; Parisse-Brassens, 2009) were used by the European Commission to develop new policy documents on the subjects of neuroscience, health, and nanotechnology. More recently, in 2013, 33 science centers and museums in Europe were the hosts of the largest formal public consultation organized so far to inform the development of the European Commission’s new framework program for scientific research⁸. This activity has been fully integrated in the Horizon 2020 framework program. Another European initiative, the PLACES project⁹, has created a network of 70 partnerships between local administrations and science centers that develop science communication policies at local and regional levels throughout Europe.

We are witnessing therefore a new role for science centers and museums in Europe: They are increasingly offering their visitors multiple opportunities to participate in discussions and debates that will directly inform issues of science policy and governance. Museums thus become places where citizens can both increase their scientific competence and participate in discussions that affect society. The two concepts of competence and participation together constitute what is regarded as *scientific citizenship* (Horst, 2007; Irwin, 2001; Mejlgaard & Stares, 2009), a construct used to describe contemporary citizenship in the knowledge society (Arnason, 2013; Elam & Bertilsson, 2003). Scientific citizenship encompasses both the scientific competence needed in today’s society and the civic participation component of democracy. The new role that science museums are taking up makes them platforms that support or even enable the scientific citizenship of their visitors (Paquette, 2006).

In this regard, science museums are effectively acting as brokers between the public and science policy. They offer a broad range of activities and competences which span from the more traditional top-down approaches to highly interactive and sophisticated participatory procedures (McCallie et al., 2009). They are places of informal engagement with science that bridge informal, policy-free settings with politically motivated activities (Stilgoe, Lock, & Wilsdon, 2014). It becomes therefore important to understand to what extent the emerging role of science museums in policy is affecting public participation in the museum. Is the public aware of this role for museums? Does it affect visitors’ interest to take part in discussions, dialogues, and more generally to participate in the museum?

The literature on how the public perceives science museums as places that support public participation in science governance is limited. Although the institutional position of science museums with regard to public participation is the subject of a growing body of scholarly research (Bell, 2008; Chittenden, 2011; Chittenden, Farmelo, & Lewenstein, 2004; Davies, 2010; Delicado, 2009), the actual position of the public in this context remains largely unknown. Science, technology, and society studies have thoroughly analyzed issues of public participation in science policy, but they seldom

⁸ <http://voicesforinnovation.eu/>

⁹ <http://www.openplaces.eu>

focus on the role of science museums in this field. Recently, several studies have been published about the public audiences of science festivals (Entradas, Miller, & Peters, 2011; Jensen & Buckley, 2014) and temporary exhibitions (Felt, Schumann, Schwarz, & Strassnig, 2014; Horst, 2011; Horst & Michael, 2011). However, we were not able to find similar studies on the dynamics of museum visitors in this context.

In this article, we first discuss how science museums enable scientific citizenship by creating opportunities for visitors to participate in the museum, for instance in debates and discussions and in the co-development of activities. Second, we describe how we used the concepts of public participation and scientific citizenship to survey a sample of visitors at the Science Museum in London to examine the factors that affect participation in the museum. Third, we present the details of our methods and results of the data analysis. Finally, we discuss the results within the theoretical framework in view of future developments and research.

4.3 Public Participation in Science Museums

Public participation is usually described as a linear spectrum, with increasing levels of ownership and impact of the decisions taken by the public. The first model of public participation, called ladder of participation (Arnstein, 1969), consisted of eight levels; the current international standard is the Spectrum of Participation developed by the International Association of Public Participation (IAP2, 2014). This model describes five levels of increasing participation: inform, consult, involve, collaborate, and empower. Science museums can enable all five levels of participation through their activities. They can inform the public – this is probably the most well known function of museums; they can consult the public through research and evaluation initiatives; they can involve the public in discussions, debates, and conversations; they can collaborate with the public for co-curation and co-development purposes (Boon, 2011; Davies, 2010); and they can empower the public to participate in the governance of the museum (Bandelli, Konijn, & Willems, 2009).

At the first two levels, inform and consult, the public has a relatively passive role as receiver of information or as a sounding board, usually to comment on decisions already taken elsewhere. The last three levels require a more active role for the public and are the ones we consider in the present study. In this study, the level involve corresponds therefore to the idea that the museum is a forum where visitors exchange information and knowledge with each other and with the museum; the level collaborate corresponds to the museum as a platform where the public can co-develop programs and exhibitions together with the museum staff; and the level empower corresponds to the museum as an institution that includes the public in its governance. These three levels of participation require increasing levels of trust between the institution and the public. Therefore, although the forum function of museums is widely implemented, co-development activities are less frequent, and the empowerment of the public in governance remains rather elusive in practice.

Paradoxically, the emerging role of museums as brokers between the public and science policy, a role that is enabled by public participation activities, may also represent a barrier acting against participation itself: The fear of (negative) public opinion

is in fact one of the main obstacles faced by museums for implementing public participation (Bandelli & Konijn, 2012). When museums enable scientific citizenship by providing their visitors with opportunities to participate in policy-related discussions, they face the problem of maintaining a clear demarcation between their voice and the visitors' voice. Especially when dealing with topics of contemporary science, museums still feel uncomfortable about the consequences of these discussions. Most visitors, for instance, agree that science museums should take a critical stance on government policies about climate change; museum leaders and staff, however, are much more cautious (Cameron, 2011; Cameron & Deslandes, 2011). As a result, public participation in museums is often subdued and limited to small-scale initiatives. Museums also express difficulties in reaching specific publics to involve in policy-related participatory activities: These are usually thought to be publics who are already engaged with science to some degree (Bandelli & Konijn, 2012).

There are thus two kinds of factors that have an arguable effect on the public participation spectrum in science museums. On the one hand, the factors deriving from the capacity of museums to support scientific citizenship – namely, the fact that museums are providers of scientific competence and are platforms that can impact public policy. On the other hand, there are factors associated with the visitors – their own engagement with science, their sociodemographic background, and their relationship with the museum. In particular, visitation patterns and perception of transparency of the museum have been described as important factors related to the interest to participate: A positive relationship has been found between the frequency of visits to science centers and science literacy (Falk, Needham, Dierking, & Prendergast, 2014). In addition, many visitors regard openness and transparency about exhibition sources as necessary to facilitate critical thinking in science museums (Cameron, 2008). The current study analyzes how the factors described above are related to visitors' interest in the three levels of participation by means of empirical research conducted at the Science Museum in London.

The first research question analyzes the factors that affect the first level of participation in the museum, that is, the museum as a forum for discussion and feedback:

RQ1: How are scientific citizenship and visitors' background factors related to visitors' interest to give feedback and comments about topics presented in the museum?

The second research question examines the factors related to the second level of participation, that is, visitors' interest in co-development of programs and activities with the museum:

RQ2: How are scientific citizenship and visitors' background factors related to the interest of the public to participate in the co-development of museum activities?

A final research question investigates what factors affect the third level of visitors' participation, that is, their interest in taking part in the museum's governance. This question has a slightly broader formulation than the previous two. Recent science, technology, and society research (Bickerstaff et al., 2010; Callon, 1999; Elam & Bertilsson, 2003; Evans & Plows, 2007; Felt & Fochler, 2008) suggests that the public engaged in

participatory activities is actually not only interested in contributing their lay knowledge but also in sharing ownership for the decisions that are taken as a result of such participatory activities. This usually takes the form of co-production of knowledge, especially in the case of concerned publics such as patients or activists. In the case of more general audiences that do not have a specific agenda, such as most museum visitors, these results suggest that a more complex level of engagement leading to participation of the public in decision making processes might be possible. Therefore, we want to analyze if visitor participation in the museum combined with the broker role of the museum in policy may have an effect on the interest of the public to take part in the decision making process of the museum. Thus, the third research question is,

RQ3: Are visitor participation and the broker role of the museum related to the public's interest in museum governance?

4.4 Method

Participants and Procedures

We surveyed 364 adult visitors to the Science Museum in London. The Science Museum offers a variety of activities in which the public can directly engage with scientists and researchers, such as experiments in the "Live Science" area, debates and dialogue activities, and the special programs for adults at the monthly "Lates" events. Because the Science Museum has such varied and differentiated offerings for the different publics it serves, we built our sample from the public interested in activities targeting independent adults, that is, adults who visit the museum primarily for their own personal interest and not as chaperones for their family. The Science Museum has pioneered adult engagement through the activities of its Dana Centre since 2003. Nowadays this is an increasingly important public for many science centers and museums that want to offer more customized and tailored experiences to adult visitors. Therefore, the survey was advertised to the visitors attending the monthly "Lates" events and those who follow the museum's Twitter feed, a communication channel that the Science Museum uses to reach out to its adult public. At the time of the survey, it had more than 40,000 followers.

Visitors to the "Lates" events on June 27 and September 26, 2012 were asked to complete an online survey following their visit. On two nights, 250 cards with the web address of the survey were handed out. The Science Museum also advertised the survey 10 times on Twitter between June and September. We received 114 completed surveys (31.3% response rate) and 250 partial ones (68.7%). Of the respondents, 21.8% stated that their last visit was during a "Lates" event.

The total sample size was 364. Age varied between 20 and 62 years, with a mean value of 35.42 ($SD = 10.73$), and 62% ($n = 69$) were female. Education levels were 1% ($n = 1$) junior school; 12% ($n = 14$) high school; 69% ($n = 77$) bachelor/master degree; and 18% ($n = 20$) were Ph.D. level. Repeat visitors (i.e., people who had visited the museum at least once before) comprised 84% ($n = 213$) of the sample, and 39% ($n = 94$) had visited the museum in the previous 6 months.

Instrument

To answer our research questions, we developed a survey consisting mostly of 7-point Likert-type statements followed by rating scales from 0 (*do not agree*) to 6 (*fully agree*), except for one question (E3) for which the responses ranged from *very low* to *very high*. Because of the lack of a dominant approach in measuring scientific citizenship (Mejlgaard & Stares, 2009), we developed a series of empirical measures drawing on the available literature, and we subsequently revised the questions with the feedback from professionals working in the science museum and science center field. For several measures, we grouped multiple questions into single composite scales; in this case we report the item-total correlations and the Cronbach's alpha reliability value. For a scale to be considered reliable, the item-total correlations for each item should be above .30 and the Cronbach's alpha should exceed .65 (De Vaus, 2002).

Three variables measure the levels of participation in the museum: *forum-now*, *co-development*, and *public board*.

The scale *forum-now* consists of six items indicating the extent to which visitors currently see the museum as a place that supports expressing opinions and giving feedback (F1 to F6). All item-total correlations were above .30 and Cronbach's alpha of .72 indicated a reliable scale.

F1. There are enough opportunities to give my opinion and feedback in the Science Museum on matters of contemporary science and science policy.

F2. The Science Museum has made me aware of other organizations I would like to visit or to be in contact with.

F3. My point of view on matters of science, technology, and society is well represented in the presentations at the Science Museum.

F4. After the visit, I would have liked to add my point of view and/or personal experience to the programs and/or exhibitions at the Science Museum.

F5. I think other visitors would find it useful to know my point of view about the subjects of the programs and/or exhibitions I visited.

F6. The visit to the Science Museum made me realise that my point of view on science and technology is important.

The scale *co-development* consists of three items that measure the interest of visitors to participate in the development of activities for the museum (CD1 to CD3). All item-total correlations were greater than .30 and Cronbach's alpha was .81, thus indicating a reliable scale.

CD1. I think I have expertise, connections, or other skills, and know-how that could be useful to the Science Museum to develop new programs or exhibitions.

CD2. I would be interested to be involved on a voluntary basis (= not paid) in the development of new programs at the Science Museum.

CD3. I would be interested to be involved in the development of new programs at the Science Museum if my role were paid.

To measure whether visitors think that the Science Museum should introduce a *public board* in its governance (similar to the board of trustees or the scientific board, but composed of members of the public), a single item was included in the survey:

PB1. The Science Museum currently has a board of trustees and a scientific advisory board; should it also have a public board (composed of members of the public) to advise on how to represent science to the public?

We further defined a fourth variable, *forum-future*, which indicates how visitors would like to see the museum as a platform for feedback in the future. It is assessed through a subset of the items used in the scale *forum-now* (F1 to F5), but for this scale visitors were asked to state how they would like the situation to be in the future. All item-total correlations were above .30 and the scale was reliable with Cronbach's alpha = .75.

The *competence* aspect of the scientific citizenship enabled by the museum is assessed with a scale composed of four items (C1 to C4) that together measure the interest, engagement, and agency of visitors with the topics presented at the museum. All item-total correlations were above .30 and Cronbach's alpha was .69.

C1. The topics of the programs and exhibitions I saw at the Science Museum should be part of larger social and political discussions and debates.

C2. The topics presented in the programs and exhibitions I saw at the Science Museum are of special interest to me.

C3. The visit to the Science Museum strengthened my interest in science and technology.

C4. The visit to the Science Museum made me realize that I can use my knowledge and the information I gained during the visit in other contexts.

To assess the *participation* component of the scientific citizenship enabled by the museum, we measured the extent to which visitors perceive the museum as having a role in affecting public policy with two items:

P1. The Science Museum represents the public opinion in the national discussions about science.

P2. Institutions like the Royal Society, universities and industries regularly give advice to the government on matters of science policy. Should the Science Museum do the same?

For these two items visitors also were asked to rate the current and future (desired) role of the museum.

The variable *engagement* uses statements E1 to E6 to measure visitors' own assessment of their existing level of knowledge and engagement with science. All item-total correlations were above .30 and Cronbach's alpha was .81.

E1. There are many engaging and interesting ways to be more involved with the developments about the topics presented in the programs and exhibitions I saw at the Science Museum.

E2. I am interested in the social and policy discussions regarding science and technology.

E3. My level of knowledge about science and technology is . . .

E4. I am socially or politically active in a domain where science and technology are relevant (for example through my work or hobby).

E5. During the last 3 months I encountered a topic related to science and technology (for example, in conversations, in the media, on my job).

E6. I personally know people who are active (socially, professionally or politically) in science and technology.

One item was used to measure the extent to which visitors perceive the museum as being transparent in informing the public about who developed the exhibitions:

T1. It is easy to know who worked at the development of the programs and exhibitions at the Science Museum.

In addition, we collected the following demographic information from the sample: age, gender, and education. Visitors were also asked about their frequency of visits to the Science Museum and the dates of previous visits.

4.5 Results

Preliminary Analyses

All correlations reported in this article to test interrelations between variables were calculated using Pearson product-moment correlation coefficients with a significance level of $\alpha = .05$. To maximize the available data, missing data were excluded pairwise (i.e., the correlation coefficient was calculated using each pair of variables for which data were available). All regression analyses used Method Enter – that is, all variables are treated equally and entered at the same time – unless specified otherwise

(Green & Salkind, 2010). In this case, missing data were excluded listwise to include in the regression analysis only cases with valid data for all the variables.

Answering the Research Questions

RQ1: How are scientific citizenship and visitors' background factors related to the interest of the public to give feedback and comments about the topics presented in the museum?

Correlation analysis showed relatively strong and significant correlations between the variable *forum-now* and the variables related to the scientific citizenship enabled by the museum. That is, the more visitors agreed that the museum enables scientific citizenship, the more they agreed that the museum is a forum to exchange opinions and give feedback (and vice versa).

In addition, the analysis showed lower but significant correlations between the museum as forum and the variables describing visitors' engagement with science and their perception of the transparency of the museum (see Table 1). This means that visitors who reported a higher level of engagement with science tended to also have a higher opinion of the museum as a forum. Likewise, the visitors who think it is easy to know the names of who worked at an exhibition agree more, on average, with the idea of the museum as a forum. However, in both cases the relation is not as strong as between the museum as forum and scientific citizenship.

Table 1. Significant correlations between the variable *forum-now* and the variables related to scientific citizenship and visitors' background and perception of the museum.

Variable	<i>M</i>	<i>SD</i>	<i>N</i>	Pearson correlation with <i>forum-now</i>
Museum as platform for scientific citizenship				
Competence	4.14	1.03	116	.506**
The Museum represents the public opinion	3.64	1.37	154	.368**
The Museum gives advice to Government	3.23	1.40	154	.483**
Visitors' background and perception of the museum				
Engagement with science	3.45	1.41	113	.315**
Transparency	2.53	1.56	126	.283**
Note ** $p < 0.01$.				

Age, education, gender, and the number of visits per year were not significantly related to the idea of the museum as forum. There is however a significant difference between first time and repeat visitors. Those who were visiting the museum for the first time had a significantly higher opinion of the museum as a forum: $t(155) = -3.23, p = .002$ (first time visitors, $M = 3.85, SD = 1.18$; repeat visitors, $M = 3.02, SD = 1.13$). Thus, after visiting the museum once, visitors tended to have a lower opinion that the museum actually encourages feedback from them.

The next analysis aims at identifying how strong the influence is of scientific citizenship, engagement with science, and transparency on the visitors' interest to give feedback and comments. We do not imply direct causality of these factors, but we analyzed the strength of each factor on visitors' interest to exchange opinions and feedback. In addition, we analyzed how visitors' background (engagement with science and perception of transparency) affect their interest to exchange opinions and feedback above and beyond scientific citizenship. To do so, we used hierarchical multiple regression analysis, a statistical technique that estimates how the value of the target variable changes in response to a change of one of the factors, when all other factors remain fixed (Field, 2013). In this respect, we split the analysis in two steps. The first step included the factors related to scientific citizenship as predictors (i.e., competence and role of the museum in science policy – that is, the museum as an advisor to the government and the museum as a representative of the public opinion). The second step added the visitors' background (i.e., engagement with science and the perceived level of transparency of the museum) as a predictor for the visitors' interest to give feedback to the museum.

The results showed that the factors in the first step (scientific citizenship) accounted for a significant amount of variability: $R^2 = .48$, adjusted $R^2 = .46$, $F(3,90) = 27.55, p < .001$. The factors in the second step (engagement with science and transparency) did not explain much variability above and beyond scientific citizenship: R^2 change = .04, $F(2,88) = 3.46, p = .036$. The following predictors are significant: competence ($\beta = .32, p = .001$), museum as advisor to the government ($\beta = .26, p = .003$), and museum as representative of the public opinion ($\beta = .22, p = .013$).

To answer RQ1, the interest of visitors to give feedback in the museum is strongly influenced by how the museum enables scientific citizenship, that is, the extent to which visitors are interested in the topics presented at the museum and the perceived role of the museum in policy. Importantly, visitors' prior existing engagement with science is not a significant factor.

RQ2: How are scientific citizenship and visitors' background factors related to the interest of the public to participate in the co-development of museum activities?

The correlation between the interest in co-development and the scientific citizenship enabled by the museum is much weaker than in the case of the museum as forum. In fact, only the correlation between interest in co-development and competence is significant. Instead, the interest in co-development is significantly correlated with visitors' engagement with science, age, education level, and the number of visits per year. Table 2 contains the significant values.

These results suggest that the capacity of the museum to enable scientific citizenship is not very relevant for the interest in co-development, which is more strongly associated with the personal background of visitors. Furthermore, the participation dimension of scientific citizenship is absent from the factors associated with the interest in co-development.

Table 2. Significant correlations between the variable *interest in co-development* and the variables related to scientific citizenship and visitors' background

Variable	<i>M</i>	<i>SD</i>	<i>N</i>	Pearson correlation with co-development
Museum as platform for scientific citizenship				
Competence	4.14	1.03	107	.301**
Visitors' background				
Engagement with science	3.45	1.41	107	.376**
Education level	4.04	.58	108	.286**
Visits per year	1.19	2.84	110	.196*
Age	35.42	10.73	103	-.336**
Note. * $p < 0.05$; ** $p < 0.01$				

Similar to the previous analysis of the factors related to the visitors' interest to give feedback to the museum, we conducted a hierarchical regression analysis to evaluate how strongly each of the relevant factors identified above influence the visitor's interest to co-develop. Also in this case, the regression analysis was split into steps to assess how each group of factors affects the interest to co-develop above and beyond the others. The first step included the predictor competence (i.e., the only variable of scientific citizenship that significantly correlated to interest in co-development in Table 2); the second step included the factors related to visitors' background (engagement, education, age, and visits per year). A third step was added in this analysis to assess the strength of a possible influence of the factor forum-now above and beyond the previous ones. This analysis would provide insight into the strength of the first level of participation (interest in giving feedback to the museum) compared to scientific citizenship and visitors' background in predicting visitors' interest in co-development.

The results of these analyses indicate that the factor competence significantly contributes, yet accounts for a limited amount of variability, $R^2 = .10$, adjusted $R^2 = .09$, $F(1,98) = 10.57$, $p = .002$. All factors in the second step were also significant together, resulting in R^2 change = .24, $F(4,94) = 8.38$, $p < .001$. The results show that the variables related to the visitor's background (in the second step) explain a higher amount of vari-

ability above and beyond competence. The results of the third step show that R^2 change is not significant. Thus, the influence of visitors' interest in the museum as forum on visitors' interest in co-development can be neglected.

After the third step, the significant predictors for visitors' interest in co-development are engagement with science ($\beta = .27, p = .004$) and age ($\beta = -.28, p = .002$).

The answer to RQ2 is that visitors' interest in co-development is largely predicted by being already engaged with science and being of younger age. These results show a clear difference between the first level of participation, which is mostly related to how the museum enables scientific citizenship, and the second level, which is mostly related to personal characteristics of the visitors. Moreover, the results also suggest that the first level of participation – the visitors' interest to share opinions and exchange feedback – does not significantly affect the second level of participation – the interest to co-develop with the museum.

RQ3: Are visitor participation and the broker role of the museum related to the public's interest in museum governance?

To answer this question, we built a theoretical model based on the empirical observations thus far to analyze the extent to which the role of the museum as a broker (i.e., as a representative of public opinion and an advisor to the government) and the visitors' interest to share feedback and to co-develop affect visitors' belief that the museum should have a public board in its governance structure.

A public board is currently a hypothetical and future innovation in the governance of the museum. Thus, this analysis concerns the visitors' expectations of their ideal museum in the future. Therefore, the model describes how the expectations of the desired role of the museum as a broker, and the expectations about participation in the museum, affect the idea of instituting a public board. Consequently, the model includes the variables forum-future and the future values for the museum as broker. Because co-development already captures the future intentions of the visitors to participate, there was no need to introduce a different variable to describe the expectations for co-development. The model showing the relations among variables is shown in Figure 1.

To test this model, a structural equation model (SEM) analysis (maximum likelihood excluding missing values) was carried out using Stata software, version 12.0. SEM is a statistical technique to test and estimate the relative strengths of relations among variables and to construct latent variables, which are not measured directly but estimated from other observations (Kline, 2011). In our case, the variables forum-future and co-development are latent variables (i.e., theoretical constructs), which were measured (or observed) by the items in the questionnaire. The advantage of using SEM compared to regression analysis is that SEM allows researchers to develop more complex path models with direct and indirect effects, and it uses the actually observed variables to test relations among the latent variables. In Figure 1, directly measured variables are represented as rectangles and latent variables are represented as ellipses.

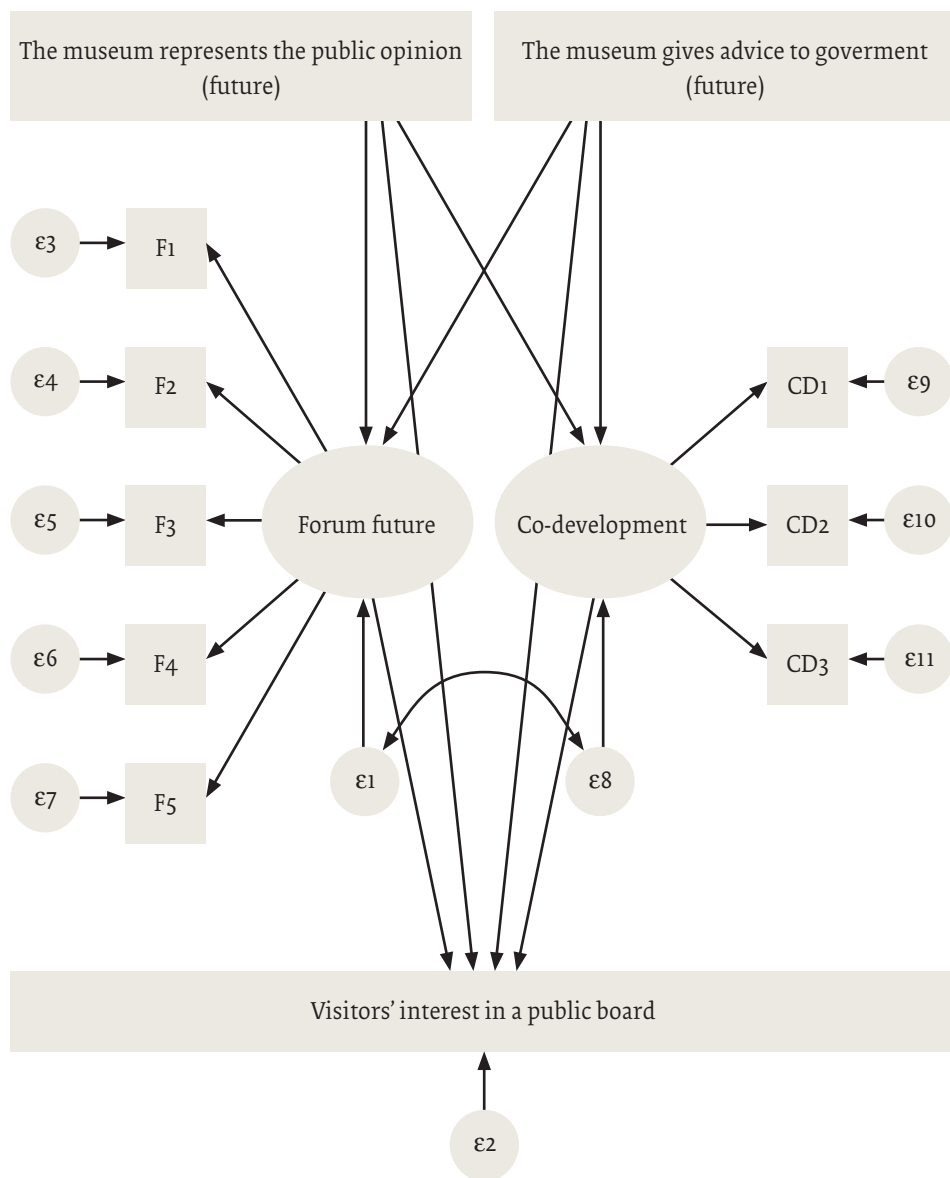


Figure 1. The complete theoretical model of visitors' interest in a public board, underlying the structural equation modeling.

The resulting SEM analysis produced a model with significant path coefficients showing an effect of museum as advisor to the government on forum, and of forum on public board, as shown in Figure 2. Table 3 reports the Goodness of Fit Indicators, showing that the model fits well to the data and therefore can be regarded as reliable.

Table 4 reports the significant path coefficients relative to the variable public board, showing that both forum and museum as advisor to the government have a significant effect on the interest of the public in a public board.

Table 3. Goodness of fit measures that indicate how well the model fits the data.

Indicators	χ^2	df	χ^2/df	CFI	RMSEA	SRMR
Science Museum visitors	51.94	37	1.40	0.948	0.067	0.063

Note. To test how well the model fits the data, a series of measures are commonly used. The χ^2 should not be significant in a good model, and this was the case for our model. The other commonly used indicators for the fit of the model to the data are the comparative fit index (CFI), root mean square error of approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). They need to reach the following values: χ^2/df values between 3 and 1 (Carmines & McIver, 1981); CFI values over 0.9 (Bentler & Bonett, 1980; McDonald & Marsh, 1990); SRMR values under 0.08 (Hu & Bentler, 1995); and RMSEA values under 0.08 indicate a good to reasonable fit (Browne & Cudeck, 1993).

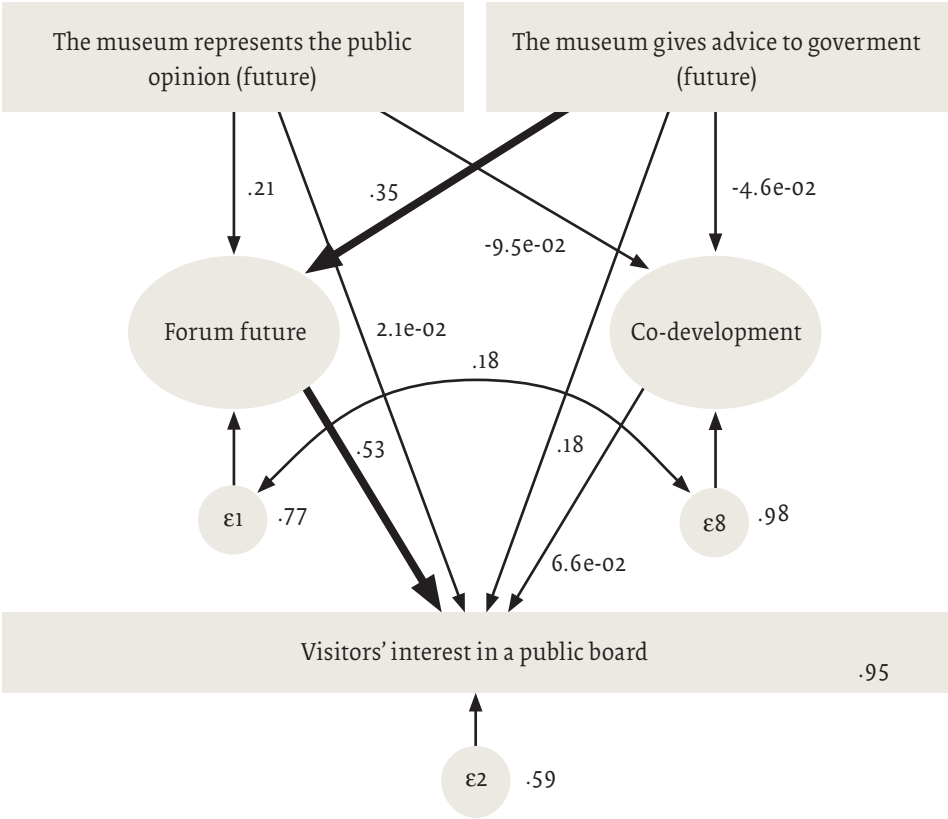


Figure 2. Structural equation model predicting interest in a public board at the Science Museum. Paths in bold are significant beyond the 0.01 level. Standardized coefficients are shown. For clarity, the observed variables for forum-future and co-development are not shown (see Figure 1).

Table 4. Direct and indirect effects on interest in a public board for the museum (standardized coefficients)

Variable	Interest in a public board		
	Direct	Indirect	Total
The museum represents the public opinion (future)	0.02	0.10	0.13
The museum as advisor to government (future)	0.18	0.18*	0.36**
Museum as forum (future)	0.53**		0.53**
Interest in co-development	0.07		0.07
Note: * $p < 0.05$. ** $p < 0.01$.			

The SEM analysis shows that the participants' ideal of the museum as an advisor to the government affects the perception of the museum as a forum. This, in turn, significantly affects participants' interest in a public board. That is, a stronger opinion that the museum should advise the government on matters of science policy corresponds with stronger expectations to share opinions and give feedback to the museum. At the same time, visitors who expressed stronger interest in this form of participation are also more interested in the museum having a public board. In contrast, the willingness to co-develop activities with the museum is not related to the interest in a public board.

To answer RQ3, the results show that the interest of the public in a participatory form of governance of the museum (i.e., a public board) is directly related to visitors' ideals of the museum as a forum, and also to visitors' ideals of the museum as an advisor to the government on matters of science policy.

4.6 Discussion

The purpose of this study was to investigate the factors that affect public participation in the Science Museum in London. In particular, the study examined how the role of science museums as platforms for scientific citizenship and visitors' engagement with science are related to three levels of participation: being involved in discussions and giving feedback (the forum function of museums); taking part in the co-development of activities with the museum; and public participation in the museum's governance by means of a public board. The study was conducted using a visitor survey at the Science Museum in London.

The results show a clear difference between the first two levels of participation. Although the forum function of the museum is primarily related to how the museum supports the scientific citizenship of its visitors, co-development is primarily related to the visitors' pre-existing level of engagement with science.

The perceived role of the museum as a platform that supports scientific citizen-

ship – increasing scientific competence and bringing the public’s opinions and points of view into larger discussions on science and technology – has a significant influence on how visitors see the museum as a forum, regardless of their existing engagement with science. The first level of participation, thus, is fairly horizontal among the visitors of the museum: It does not depend on whether visitors are already engaged with science, on their education level, or on demographic factors. In this regard, we observed a disparity between the perspective of museums and of the public. For museums, public participation is limited by the fact that it involves specific audiences who are already interested and engaged with science to some extent (Bandelli & Konijn, 2012). These results show instead that, if we consider the forum function of museums, there is no reason to consider visitors’ previous engagement with science, or the lack of it, as an obstacle to participation. These results should be interpreted taking into consideration that museum visitors have at least a basic level of engagement with science for the very fact that they are visiting a science museum; without further evidence, we cannot extend these findings to nonvisitors.

The findings of the present study further suggest that visitors will be more engaged in discussions if they think that the museum can convey their views, opinions, and concerns into higher conversations on science and technology that can have a policy impact. These results are in line with previous research (Cameron, 2011, 2012) showing that visitors expect a societal relevance and agency of science museums, especially on matters of contemporary and contentious science. This does not mean that the museum should take an activist role, or even an advocacy one. Rather, the findings underline that the public is sensitive to how the museum presents and negotiates with the public the societal and even political context of contemporary science and technology. The Science Museum has been a pioneer in presenting and discussing contemporary science with the public, with its innovative work at the Dana Centre and the Wellcome Wing. As it continues to develop, the Science Museum creates new opportunities for its public to appreciate and reflect about the role of science in society. These results show that for its visitors the museum is more than a place that exhibits science, and it has become a place where visitors also can talk science.

Visitors’ interest in co-development of activities with the museum is much more related to their existing level of engagement with science and their relationship with the museum than to how the museum supports scientific citizenship. Two observations can be made about these results. The first is that an interest in co-development is related to the trust established between frequent visitors and the museum. Although this is likely to be expected, it also means that this form of participation carries the danger of reducing the diversity of the contributions that the public can make, if it attracts a public that can “become museum people” (Bandelli & Konijn, 2012, p. 431). That is, a public that, because of its regular contact with the museum, will start to assimilate the institutional culture of the museum and stray from the perspectives it was originally consulted for. The second observation is that co-development depends significantly on the visitors’ existing engagement with science. In this regard, it is an activity where the museum is an outlet for a public that has a personal interest in science.

Finally, the forum function of the museum and its desired future role as an advisor to the government are significant factors that strengthen the idea that the public should participate in the governance of the museum. We interpret this result as a sign

that the public finds it important to claim some ownership in the decisions related to the forum function of the museum, where different opinions and points of view are exchanged and shared among the public and other stakeholders. Although the current study used the concept of a public board to capture the visitors' interest in the governance of the museum, there are likely other formats of participation that develop from the interactions of the public within the museum, and by the perceived public policy role of the museum. These emerging formats are especially important if museums want to increase their inclusiveness and engage the uninvited publics in addition to their existing audiences (Horst & Michael, 2011).

In addition to the strength of our empirical analysis, we also note some limitations to the present study. The sample was recruited from participants to specific events for adults and from those visitors who subscribe to the museum's online channels. Regardless of how the participants learned about the survey, they all had recently visited the museum, so the whole sample was composed of actual adult visitors. Furthermore, it had a large portion of visitors with a bachelor's-, master's-, or Ph.D.-level education. The participants are thus representative of a public that is interested and connected to the museum rather than of casual visitors. The study was not designed to measure differences between the visitors to the "Lates" events and visitors during the standard opening hours of the museum. However, as museums increasingly create tailored and differentiated experiences for their visitors, further research would be helpful to understand the extent to which specific programs such as the "Lates" (which are now common to many other museums) contribute to creating significantly different images and expectations of the museum among its public. We are also aware that there is a considerable feedback loop between the variables examined, and no strict causality among them can be established. Nevertheless, the regression analyses and the structural equation model allow us to identify the extent to which the variables considered in this study exert an influence on each other. In this regard, further research focusing on multiple forms of participation in museums, including online channels, would be helpful to better understand how these results can be generalized to a broader number of institutions and settings.

Despite these limitations, the results are consistent with the findings by Felt and Fochler (2008). They argue that participation exercises depend on the cultural, political, and technological context in which they take place. In particular, our results suggest that the context and framing of exhibitions and programs in museums (Macdonald, 2010) affect not only the engagement of visitors with the content, but also their interest to participate in the museum. More specifically, this study shows that public participation in the Science Museum is intrinsically connected with the perceptions and expectations of the museum's role in public policy, and in general with the scientific citizenship that is enabled by the museum. Future research seems necessary to gain insights on the variety and diversity of ways in which museums function as arenas of public participation, especially in contemporary science (Einsiedel & Einsiedel, 2004).

We intend to verify the extent to which these results can be generalized to other museums and science centers in Europe on a broader sample of institutions. For many science centers and museums, their role in policy remains enigmatic: On the one hand, it represents a source of income, given the growing number of European projects they are part of. On the other hand, museums tend to deny their involvement in policy and

claim a neutral position. In the end, it may very well be that, at least from the visitors' perspective, this contradiction is only spurious and that, in fact, the role of museums in policy should be acknowledged as an element of science engagement.

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5.

European Science Centers as Brokers of Public Participation¹⁰

5.1 Abstract

Science centers consider themselves as platforms of scientific citizenship, places where the public can increase their scientific competence and participate in activities that inform the policy of contemporary technoscience. However, there are conflicting views among scholars and professionals about the relationship between visitors' interest in participation and the scientific citizenship enabled by the science center, due in part to an overall scarcity of knowledge about this issue. This study addresses this problem analyzing the factors related to visitors' interest in three levels of participation: involvement in discussions and debates; collaboration in co-design of programs; and empowerment by participating in the governance. The study was conducted by means of a survey among 652 visitors of 6 national science centers and museums in Europe. The results show that interest in co-design depends largely on the visitors' pre-existing level of engagement with science, and reflects patterns of privilege for interest in science. The interest to be involved in discussions and debates instead is strongly related to how science centers enable scientific citizenship. The expected role of science centers in policy is also related to the visitors' interest to participate in the governance of the institution.

5.2 Introduction

Science centers and museums (referred to as SCM) contribute to create and to maintain scientifically and technologically informed, literate and engaged publics (Falk, Needham, Dierking, & Prendergast, 2014). To this end, they employ a wide range of methods such as exhibitions, educational programs, on-line and outreach activities, conferences, performances, workshops etcetera. They are often referred to as 'informal science education' (ISE) organizations, because they offer free choice, out of school opportunities for science learning (Falk & Dierking, 2000). In the last 15 years there

¹⁰ This chapter has been submitted to the journal *Science Communication*

has been a noticeable interest by several SCM to broaden their mission and include activities whose primary goal is to foster public participation on matters of contemporary technoscience (Bell, 2008, 2009; Cameron, Hodge, & Salazar, 2013). Without forgoing their educational function, these SCM develop and implement programs whose explicit aim is to contribute to public policy and decision-making processes relative to contemporary science and technology (SCWC, 2011). Some institutions explicitly mention this aim in their mission statement, like the Science Museum of Minnesota whose mission statement reads: “Turn on the science: Inspire learning. Inform policy. Improve lives.” (Science Museum of Minnesota, 2014, p. 2)

In Europe, several collaborative projects funded by the European Commission have given many SCM the opportunity to be part of policy making processes instrumental to define future policies in the field of health, environment, and nanotechnology (Laurent, 2012). Through these projects science centers collect, assemble and organize public opinions and concerns on science and technology, and they directly inform local, regional, national and European policies through participatory procedures¹¹. In this regard, thus, SCM are becoming platforms for scientific citizenship (Paquette, 2006): Institutions where visitors not only learn about science, but engage as citizens in the complex system of science governance. SCM act as brokers of public participation between citizens and policy making organizations (Cameron, 2012) and they support and often enable both dimensions of scientific citizenship, competence and participation (Horst, 2007; Irwin, 2001; Mejlgaard, 2009). Competence is enabled by providing visitors with the knowledge and skills necessary to deal effectively with the role played by science and technology in society; participation by acknowledging that the general public is a competent actor entitled to participate in the negotiations of science and technology developments. The balance between and the relative importance given to these two components, competence and participation, fluctuates according to social and political factors at a national level (Mejlgaard, 2009) and organizational culture, because the cultural norms of an institution frame and constrain the public dialogue that takes place inside (Bickerstaff, Lorenzoni, Jones, & Pidgeon, 2010). The scientific citizenship enabled by SCM depends therefore on the context in which they operate and the activities they offer to the public. In some cases the participation dimension is *indirect*: SCM mediate between the public and the policy-making domain, implementing public participation on their premises first, and then advising policy making bodies with the results of the participatory activities. Increasingly SCM provide their visitors with *direct* opportunities to make their voice and opinions ‘count’ at policy level. In this regard, SCM can be described as places of informal engagement with science which bridge informal, policy-free settings with politically motivated activities (Stilgoe, Lock, & Wilsdon, 2014).

¹¹ For example, the POLKA project defined new policies for the treatment of rare diseases with the input of more than 3000 citizens discussing issues of genetic research, access to treatments and genetic testing in several science centers (Parisse-Brassens, 2009). The European Commission has used the outcomes of the project “Nanodialogue”, which involved 9 science centers, to define its strategies for the communication of nanotechnology to the public (Laurent, 2012). In 2013, the European Commission funded the pilot project VOICES to formally involve 1000 citizens from all European countries in the definition of the research priorities for the new “Horizon 2020” framework program about urban waste. This initiative, the first one of its kind, was carried out in 27 science centers and museums. The four-year long project PLACES (Platform of Local Authorities and Cities Engaged in Science) is a platform where 69 European cities define local science communication policies and plans, with science centers as the main actors of this platform. Currently, several science centers are involved in a number of European projects to define and develop frameworks for implementing the European Commission’s RRI (Responsible Research and Innovation) policies across Europe.

Visitors' engagement and participation give SCM legitimacy for their role in policy. However, little is known about what visitors actually think about SCM as platforms for scientific citizenship. More specifically, there is a gap of knowledge about the visitors' awareness of the role of SCM in informing policy, and how this awareness is related to the visitors' interest to engage and participate at various levels in SCM. The aim of informing policy has traditionally been neglected by research on public participation in science centers (Davies, McCallie, Simonsson, Lehr, & Duensing, 2008) and there is no uniform or unequivocal view on this matter (McCallie et al., 2009). Science communication research has focused on the benefits of public participation for SCM audiences (Davies et al., 2008; Lehr et al., 2007) and on the dynamics of engagement of visitors (Davies, 2009, 2011; Einsiedel & Einsiedel, 2004; Mayfield, 2004), but thus far not on the relationship between public participation in SCM and the role of SCM in policy making. A recent empirical study conducted among visitors at the Science Museum in London suggests a positive relationship between the perceived role of the museum in public policy and the visitors' interest to participate in debates and discussions at the museum (Bandelli & Konijn, 2015). These results, however, cannot be generalized to other SCM. Moreover, visitors and SCM leaders have often radically different views on what the role of SCM in policy should be. Visitors are generally supportive of the direct agency of museums and science centers in controversial issues. Previous research conducted in Australia and the USA, for example, shows that a high proportion of visitors in those countries (76% and 68% respectively) think that science centers should facilitate collective action on matters of climate change by bringing together the various stakeholders. The expectations for an active role of science centers in policy is made even stronger by the fact that the vast majority of visitors (95%) feel that citizens in general have no influence at all on decision making about climate change (Cameron & Deslandes, 2011). SCM have thus the opportunity to be "a legitimate contributor to discussions within a deliberative process and may play a role as a 'secondary association' in 'institutionalizing deliberation'" (Cameron & Deslandes, 2011, p. 141). However, SCM leaders are much more cautious than their visitors: Several directors rule out that science centers should be involved in policy at all, because the diversity of stakeholders (government, corporate and community) and management forms mean that they are not equipped or intended for straightforward input into informing policy (Bandelli & Konijn, 2012; Cameron & Deslandes, 2011).

The conflicting views in the professional field underlie the motivation for this article. The general scarcity of studies on this specific issue make it is still unclear how the perceived role of SCM as sites for scientific citizenship at large – a role which seems to be favored by the visitors and is the rationale for several funding streams to the institutions – is related to how visitors engage and participate in the institution. Therefore, we conducted an empirical study among six European SCM to analyze the relationship between scientific citizenship and public participation in science centers and museums. In the following section we describe the theoretical approach chosen to analyze visitor participation and we present the research questions. The methodology for the quantitative analysis is described in section 3, followed by the presentation of the results. A discussion of the implications of these results for SCM and suggestions for further research conclude the article.

5.3 Three Levels of Public Participation in Science Centers and Museums

Public participation in SCM is not confined to the visitor experience; it affects also fundamental institutional aspects. When SCM implement any activity based on public participation, they not only give their visitors the opportunity to play an active role during their visit; they also explicitly or implicitly affect the way they operate internally and make decisions¹². Public participation therefore changes the institution where it is implemented (Simon, 2010). In the specific case of SCM, presenting contemporary, ‘unfinished’ science changes the relationship between SCM and their public (Hine & Medvecky, 2015). Visitors are not anymore only recipients of knowledge but they become also inquiring experts (Einsiedel & Einsiedel, 2004); SCM can no longer pretend to “have all the answers” but instead they expose their “ignorance” and empower in this way the visitors to participate and contribute their knowledge (Durant, 2004 p. 58). Audience-led programs appear alongside the traditional museum-led presentations (Science Museum Visitor Research Group, 2004), and visitor participation thus becomes an integral part of the epistemological process of the institution. Public participation in SCM, therefore, affects not only the development of exhibitions and programs; it affects how the institution creates and shares knowledge; it determines what is being told or even displayed in the institution; it exposes the decision making process of SCM to public scrutiny. Therefore, it has been argued (Bandelli, Konijn, & Willems, 2009), SCM also have the potential of giving the public a role in the governance of the institution.

To describe how SCM implement public participation we use the theoretical framework provided by the spectrum of public participation (IAP2, 2014). This model, derived from the seminal work “A ladder of citizen participation” (Arnstein, 1969), describes five levels in which the public can participate in the institution: *inform*, *consult*, *involve*, *collaborate* and *empower*. Museums enact all five levels of participation with their visitors (Runnel & Pruulmann-Vengerfeldt, 2012). In the first two levels the role of the public is passive or reactive, and the institution maintains complete control over the participation process. In the three levels *involve*, *collaborate* and *empower*, instead, the public has an active role and it has the possibility to directly shape the outcomes of the participation process. The level *involve* captures the modalities of participation where visitors share opinions and feedback about the content presented in the museum with other visitors and with the staff; the level *collaborate* describes the modalities of co-development of content by the public and SCM; and the level *empower* captures public participation in the governance of the institution.

In general, the levels *involve* and *collaborate* are widely implemented in SCM; the level *empower* remains still elusive in practice, and is, with a few exceptions, a possibil-

¹² In her book “The Participatory Museum”, Nina Simon identifies three rationales that make visitor participation an essential characteristic of museums (Simon, 2010). The first rationale is that participation is necessary in order to create an “audience-centered” institution which is responsive to the needs of its visitors and is inclusive and relevant to more diverse audiences (Bunning, Kavanagh, McSweeney, & Sandell, 2015; Dana, 1917; Weil, 2006). The second rationale is that audience participation is at the core of the constructivism theories that inform much of the work done by museums to support learning (Falk & Dierking, 1992, 2000; Hein, 2000). The third rationale is that visitor participation is necessary for purposes of participatory design and evaluation, in order to include visitors in the development process of museum exhibitions and programs (Dierking & Pollock, 1998; McLean & Pollock, 2007; Taxén, 2004). According to these three rationales, therefore, public participation is entrenched in the very essence of SCM.

ity for the future as far as SCM are concerned. It is important to state that although the hierarchy of these three levels implies higher degrees of public participation in the decision making process of SCM, 'higher' does not necessarily mean 'better'. Different levels of public participation can in fact co-exist within an institution (Simon, 2010) and there is no consensus about the relative value of the various ways in which the public can participate in museums (Govier, 2009). At each level, however, visitors engage with a different constituency: at the *involve* level, visitors mainly engage with the public of the SCM; at the *collaborate* level, with the staff of the SCM; and at the *empower* level, with the governance of the institution.

The first part of the current study examines the relationship between the two levels of participation currently implemented in SCM, *involve* and *collaborate*, and the visitors' perception of SCM as places of scientific citizenship. The existing engagement with science of the visitors and socio-demographic factors are also considered in this analysis. The museum visitor experience model (Falk, 2009, 2011) shows that visitors' prior knowledge, experience and interest strongly influence their experience in the museum. Even if we are not considering the complete museum experience of the visitors but only their interest to participate, we draw on this model and assume that the visitors' existing interest and engagement with science is also related to their interest to participate in the museum or science center. Socio-demographic factors have been shown to have an effect on access to SCM (Dawson, 2014a, 2014b), on science knowledge (Falk & Needham, 2013) and in general on participation (Musick & Wilson, 2008): Being male and higher education are usually predictors of higher levels of interest in science and in participation. The first research questions for our empirical assessment is thus:

RQ1: How are scientific citizenship, existing engagement with science and socio-demographic factors related to the visitors' interest to be involved and to collaborate in SCM?

The second part of the current study examines how the emerging role of SCM in policy is related to all three levels of participation *involve*, *collaborate* and *empower*. While both *involve* and *collaborate* are common forms of participation in several SCM, *empower* is currently a hypothetical form of participation for the adult public. There is currently no SCM in Europe with a governance structure where the public is part of the decision making process (Bandelli et al., 2009). Such structures do exist for younger audiences though: for instance, in 2004 the science center in Granada ("Parque de las Ciencias") has implemented two permanent councils of children and youngsters, which give advice and comment on all aspects of the science center. A similar structure exists at the Museum of Natural History of Barcelona, where the children's council is a permanent advisory body of the museum and "has the same consideration as any other advisory body that the museum may have" (Museu de Ciències Naturals de Barcelona, 2015, para. 5). There are signs, however, that institutions are willing to formally include the adult public as well in their governance enabling therefore the *empower* level of participation. For example, Pavilhão do Conhecimento, the science center in Lisbon, is currently working to implement a 'public board' composed of adult members of the public which will have an advisory function similar to that of the scientific board of the science center. Some SCM are thus beginning to equip themselves with governance structures where the public has a formal role, and implement therefore all three levels of participation.

At the same time there is another development taking place in the field of SCM which is further shaping their role in policy. Many European funding streams available to SCM nowadays explicitly mention the impact on policy making as one of the expected results of the activities to be funded (European Commission, 2013). The European Commission, thus, explicitly assigns a role to inform policy development to the recipients of its grants, making therefore the role of SCM in policy more explicit and direct. The second part of the analysis aims thus at understanding how visitors experience these two developments, and in particular if there is a relationship between the visitors' expectations of the role of SCM in policy and the interest in all three levels of participation, *involve*, *collaborate* and *empower*. The second research question is:

RQ2: How are the visitors' expectations of a role of SCM in policy related to their interest to participate in the institution?

The following section outlines the methodological approach in answering these research questions through a survey conducted among visitors to a sample of six European SCM.

5.4 Methodology

To answer the research questions, we first identified a sample of SCM which have recently taken part in European projects about contemporary science. Although this study does not focus on any European funded project in particular, this requirement was necessary in order to select institutions which are knowledgeable and sensitive to the current European policies regarding SCM and public participation. We then developed and administered a survey to a sample of adult visitors at each selected location.

Selection of science centers

The following criteria were defined in order to identify a group of institutions for analysis. The science centers to be selected:

- are established in a country of the European Union;
- have a national relevance, either by statute (i.e., being defined as “the national center/museum”) or by visitation (attracting a substantial number of visitors from the whole country);
- have a significant number of exhibitions and ongoing programs on issues of contemporary science and technology;
- have taken part in at least 2 collaborative projects funded by the European Commission in the past 5 years.

The 14 institutions which fulfilled the criteria were further classified according to their geographical location, i.e. East/West and North/Centre/South Europe. The institutions were also classified according to the national context in which they operate in regards to science communication culture and public participation, using the classification of consolidated, developing and fragile state of national science com-

munication culture (Mejlgaard, Bloch, Degn, Nielsen, & Ravn, 2012); and high or low level of public involvement in science and technology (Rask, Maciukaite-Zviniene, & Petrauskiene, 2012).

We formed a sample of 6 institutions, ensuring a broad and balanced geographical spread (two thirds of the sample from Western Europe and one third from Eastern Europe), an equal representativeness of public involvement in science and technology (three institutions from countries with high levels of participation and three with low levels of participation), and a representative spread in terms of science communication culture: four institutions established in countries with a consolidated culture, one each in countries with developing and fragile cultures. The selected institutions are reported in Table 1. While this sample does not pretend to be representative of the whole field of SCM in Europe, it is a diverse and broad subset of institutions with a leading role in their field, and it represents therefore a suitable base for this analysis.

Table 1. Institutions surveyed and country characterization.

Country	Institution name	West, East	North, Centre, South	Science Communication culture	Public involvement in S/T
Czech Republic	Techmania Science Center	East	Centre	Fragile	Low
Poland	Copernicus Science Centre	East	Centre	Developing	Low
Portugal	Pavilion of Knowledge	West	South	Consolidated	Low
Italy	Museo Leonardo da Vinci	West	South	Consolidated	High
Finland	Heureka – the Finnish science center	West	North	Consolidated	High
Netherlands	Science Center NEMO	West	North	Consolidated	High

Respondents

The survey was administered with a paper form to a sample of adult visitors selected according to the museums' standard evaluation procedures, between the months of March and August 2014.

The total sample size (N) was 652 (between 95 and 150 respondents per institution). Age varied between 18 and 87; $M=38.45$; $SD=11.85$. 56% of the respondents ($n=355$) were female, 44% ($n=284$) were male. The education level of the visitors was quite high: 39% ($n=251$) reported having a masters/bachelor degree, followed by 32% ($n=205$) with a high school degree, and only 3% ($n=18$) with primary school qualification; Figure 1 shows the education levels of the sample. 55% ($n=354$) of the respondents were repeat visitors, that is, people who had visited the science center at least once before the current visit.

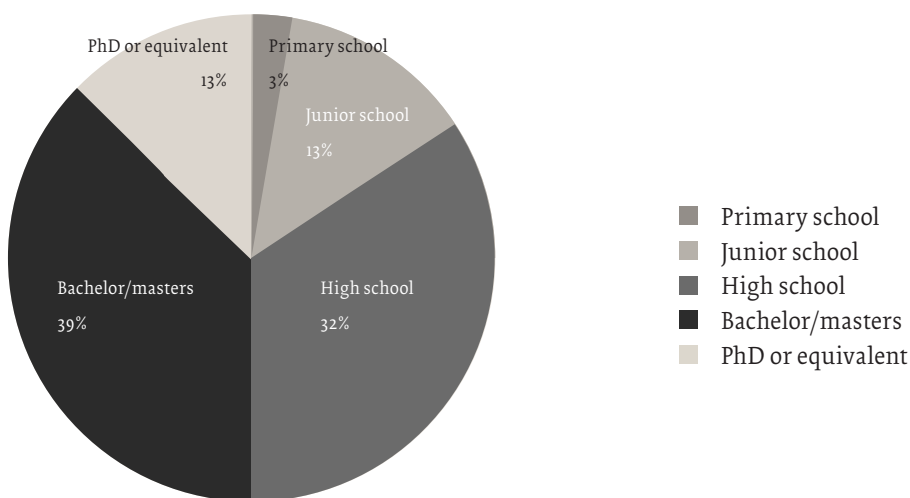


Figure 1. Education levels of visitors

Measurements

The survey contained 22 questions with a 7-point Likert-type rating scale ranging from 0 (completely disagree) to 6 (fully agree). The questions are listed in the appendix.

The visitors' interest in the participation level *involve* was measured with 6 items (I1 to I6) indicating to which extent visitors currently see the SCM as a place that supports expressing opinions and giving feedback. The Cronbach's alpha was .78 and all item-total correlations were above .30. An additional variable *involve-future* was defined, to measure how visitors would like to see the SCM as a platform for involvement in the future. It was assessed through a subset of the same items used in the scale *involve* (I1 to I5) but for this scale visitors were asked to state how they would like the situation to be

in the future. All item-total correlations were above .30 and the Cronbach's alpha was .79.

The variable *collaborate* consists of three items that together measured the interest of the visitors to participate in the co-development of activities for the SCM (CO1 to CO3). The Cronbach's alpha was .79 and all item-total correlations were above .30.

The interest in the level *empower* was measured with one item asking visitors to what extent they agreed with the idea that the science center or museum should introduce a *public board* in its governance, similar to the board of trustees or the scientific board, but composed of members of the public (EM1).

The *competence* aspect of the scientific citizenship enabled by the SCM was assessed with a scale composed of four questions (C1 to C4) that together measured the interest, engagement and agency of the visitors with the topics presented at the SCM. The Cronbach's alpha was .68 and all item-total correlations were above .30.

To assess the participation component of the scientific citizenship enabled by the SCM, two questions (P1 and P2) were used to measure how visitors perceive the museum acting as a bridge between the public and public policy: specifically, the SCM as a *representative of the public opinion* in national discussions about science and technology, and the SCM as an *advisor to the government* for matters of science communication. Visitors were asked to what extent they agreed that SCM play these roles now, and to what extent they would like to see SCM playing these roles in the future.

Finally, the variable *engagement* uses questions E1 to E6 to measure the visitors' own assessment of their existing level of knowledge and engagement with science. Cronbach's alpha was .82 with all item-total correlations above .30.

In addition, the survey asked for the following demographic information: *age*, *gender*, and *level of formal education*. Visitors were also asked about their *frequency of visit* and *date of previous visit*.

All correlations reported in this paper to test interrelationships between variables are calculated using Pearson product-moment correlation coefficient with a significance level of $\alpha = .05$. All regression analyses use Method Enter (Green & Salkind, 2010) unless specified otherwise. Both were performed using SPSS v. 22. Structural Equation Model analysis was carried out using Stata v. 13.

5.5 Results

RQ1: *How are scientific citizenship, existing engagement with science and socio-demographic factors related to the visitors' interest to be involved and to collaborate in SCM?*

Visitors are in general positive towards being involved; on a scale from 0 to 6, with 3 as the middle value, $M=3.37$, $SD=1.07$. Interest in co-development is on average lower ($M=2.20$, $SD=1.59$). Education levels play a significant difference in the responses related to involvement ($F(4,636)=5.76$, $p<.001$) and collaboration ($F(4,631)=3.48$, $p=.008$). The relationship between education levels and the variable *involve* follows an inverted "U" shape, where the interest is at its peak for visitors with junior school education, and then decreases for high school, master's and PhD levels. For the variable *collaborate* instead the opposite is true: interest decreases until the bachelor/master degree, and then goes distinctively up for the PhD level. These patterns are quite different from

the relationship between education and *engagement*, where higher levels of education correspond to higher levels of engagement (see Figure 2). Gender is a significant factor for collaboration, where males show on average a higher level of interest than females ($M_M=2.44$, $SD_M=1.52$; $M_F=2.00$, $SD_F=1.62$; $t(631)=-3.51$, $p<.001$). The results from our sample show also that males declare a higher engagement with science than females ($M_M=3.96$, $SD_M=1.14$; $M_F=3.57$, $SD_F=1.21$; $t(637)=-4.19$, $p<.001$), whereas there is no significant difference between males and females for *involve*. Frequency of visit was found to be a significant factor for *collaborate*, with increasing levels of interest in collaboration corresponding to more frequent visits in a year ($F(4,638)=11.17$, $p<.001$), whereas it was not significant for *involve*. Similarly, there was a significant difference between first time and repeat visitors for *collaborate* but not for *involve*. Age was not a significant factor for *involve*, and there is only a small correlation between age and *collaborate* ($r(624)=-.112$, $p=.005$).

The analysis of the socio-demographic factors reveals that education, gender and frequency of visit play a remarkably different role for the two levels of participation: while *involve* is highest for lower education levels and does not significantly change in relation to the other factors, higher interest to *collaborate* is instead associated with frequent visits, with a higher education level, and with being male. *Collaborate* follows a pattern which is in many respects similar to *engagement* with science, which this analysis confirms being higher for males, well-educated frequent visitors.

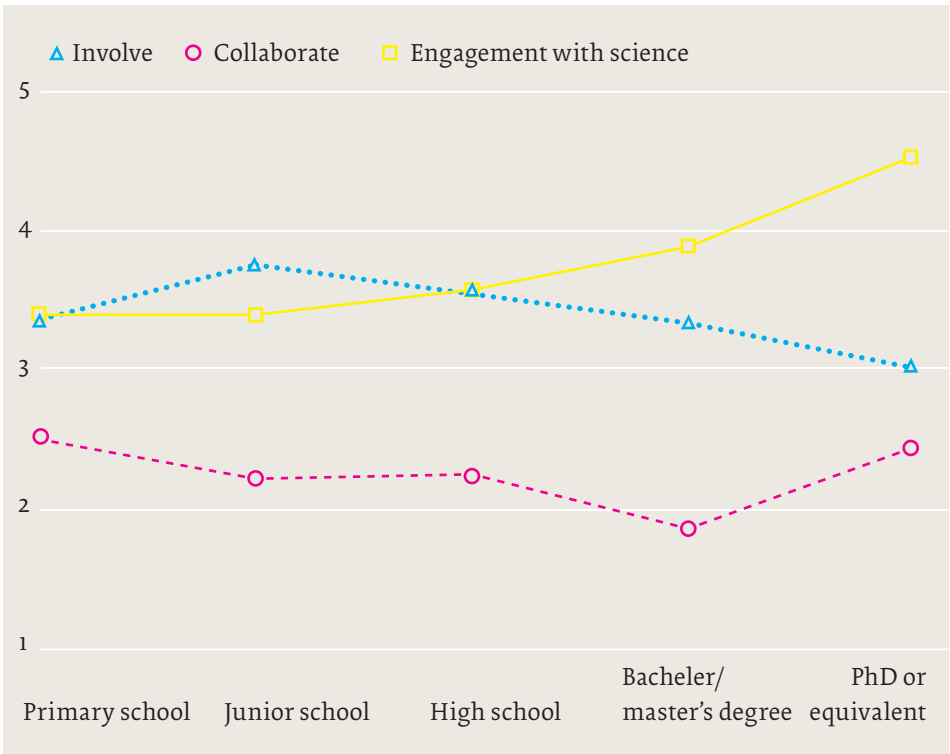


Figure 2. Visitors' interest in involvement and collaboration in SCM and self-reported engagement with science by education level.

Correlation analysis (Table 2) shows that the variables relative to scientific citizenship, i.e. competence and the role of SCM in policy, are significantly and quite strongly correlated with *involve*, much more so than the existing *engagement* with science of the visitors. For *collaborate* instead, the strongest correlation is with *engagement*, and the correlations with scientific citizenship are weak. This suggests that the more the visitors are engaged with science, the more they see SCM as places where they can contribute their knowledge in the form of co-development; a higher engagement with science, however, is considerable less related to an increased interest to be involved in the SCM. A higher engagement with science does not correspond to a much higher appreciation of SCM as places for scientific citizenship either. Instead, the visitors' interest to be involved in the SCM is much strongly related to their appreciation of the SCM as platforms for scientific citizenship.

Table 2. Correlations between the main variables of the study.

	Collaborate	Empower	Competence	SCM represents the public opinion	SCM as advisor to Government	Engagement	Age
Involve	.369**	.312**	.519**	.400**	.288**	.194**	.015
Collaborate		.362**	.103**	.122**	.211**	.462**	-.112**
Empower			.121**	.233**	.257**	.115**	-.068
Competence				.277**	.204**	.168**	.171**
SCM represents public opinion					.274**	.033	.012
SCM as advisor						.112**	-0.65
Engagement							.115**
Note. Significant at the level *0.05; **0.01							

Regression analysis was used to assess the relative importance of *competence*, *role in policy* and *engagement* on the visitors' interest in participation in SCM. While it is not possible to determine the directionality among these factors which are very likely associated in mutually reinforcing ways, regression analysis gives a measure of how the scientific citizenship enabled in SCM and the visitors' engagement with science, when considered together, affect the visitors' interest to participate.

Table 3. Hierarchical regression analysis of participation in SCM

	<i>Involve</i>		<i>Collaborate</i>	
First block	$R^2=.04$ adjusted $R^2=.04$ $F(1,622)=23.58, p<.001$		$R^2=.22$ adjusted $R^2=.22$ $F(1,622)=172.46, p<.001$	
	β	p	β	p
Engagement	.19	$p<.001$	.47	$p<.001$
Second block	$R^2 \text{ change}=.33$ $F(3,619)=107.11, p<.001$		$R^2 \text{ change}=.03$ $F(3,619)=8.42, p<.001$	
	β	p	β	p
Engagement	.10	$p=.002$	.45	$p<.001$
Competence	.41	$p<.001$	-.02	$p=.55$
SCM represents the public opinion	.24	$p<.001$	.06	$P=.10$
SCM as advisor to Government	.13	$p<.001$	.15	$p<.001$

The results of the analysis are presented in Table 3. The most significant factors for the interest to be involved are competence and the perceived role of the science center in policy – that is, the scientific citizenship enabled by the SCM. Visitors' engagement with science is instead the weakest factor. This result suggests that visitors regard SCM as places for discussion and debate in large measure regardless of their existing engagement in science; and that the visitors' opinions about the role of the science center in policy play an almost equal role to the competence enabled by the SCM. In the case of the interest to collaborate, instead, the existing engagement with science is the strongest factor; this suggests that the interest to collaborate is much more related to external factors (namely, the visitors' existing engagement with science) than to how SCM support scientific citizenship.

In conclusion, the interest in the two forms of participation *involve* and *collaboration* present very different characterizations. *Involve* is not related to age, gender, frequency of visit; it is only marginally related to the visitors' existing engagement with science, and is slightly higher among visitors with a lower education. Interest in *collaboration* is instead higher among males, frequent visitors with higher education, and vis-

itors who are in general already engaged with science. The scientific citizenship enabled by SCM is strongly related to the interest to be involved, whereas it plays a small role in the interest to collaborate.

RQ2: How are the visitors' expectations of a role of SCM in policy related to their interest to participate in the institution?

Visitors in the sample are generally positive about the *empower* level of participation. For the question whether SCM should have a board composed of members of the public in addition to the existing trustees and/or scientific boards, $M = 3.58$ and $SD = 1.70$. Visitors are also expecting a stronger role of SCM in policy in the future, both to represent the public opinion and as advisors to the government. For SCM as representatives of the public opinion, $M_{now} = 3.48$, $SD_{now} = 1.41$, $M_{future} = 3.95$, $SD_{future} = 1.46$; for SCM as advisors to the government, $M_{now} = 3.23$, $SD_{now} = 1.55$, $M_{future} = 3.69$, $SD_{future} = 1.68$. In both cases the difference is statistically significant; for SCM as representatives of the public opinion $t(603) = -10.56$, $p < .001$ and for SCM as advisors to the government $t(602) = -9.20$, $p < .001$.

To answer RQ2 we used an empirical model to analyze whether the expected policy role of SCM in the future is significantly related to the interest in participation in science centers at all three levels, *involve*, *collaborate* and *empower*. Because in this case the analysis revolves around expectations for the future rather than current values, the model includes the variable *involve-future* in order to capture the expected level of interest in involvement; *collaborate* and *empower* instead already capture the future intentions of the visitors in the formulation of the questions (Figure 3).

The future role of science centers in policy are treated as exogenous (i.e. independent) variables, in order to measure to which extent they influence the interest in participation. Like in the previous analysis, also in this case there is likely a mutual influence of the variables considered. However, with this model, we can test if the expected role of SCM in policy, as required for instance by the European grants, is related to the interest of the visitors to participate at various levels in the SCM.

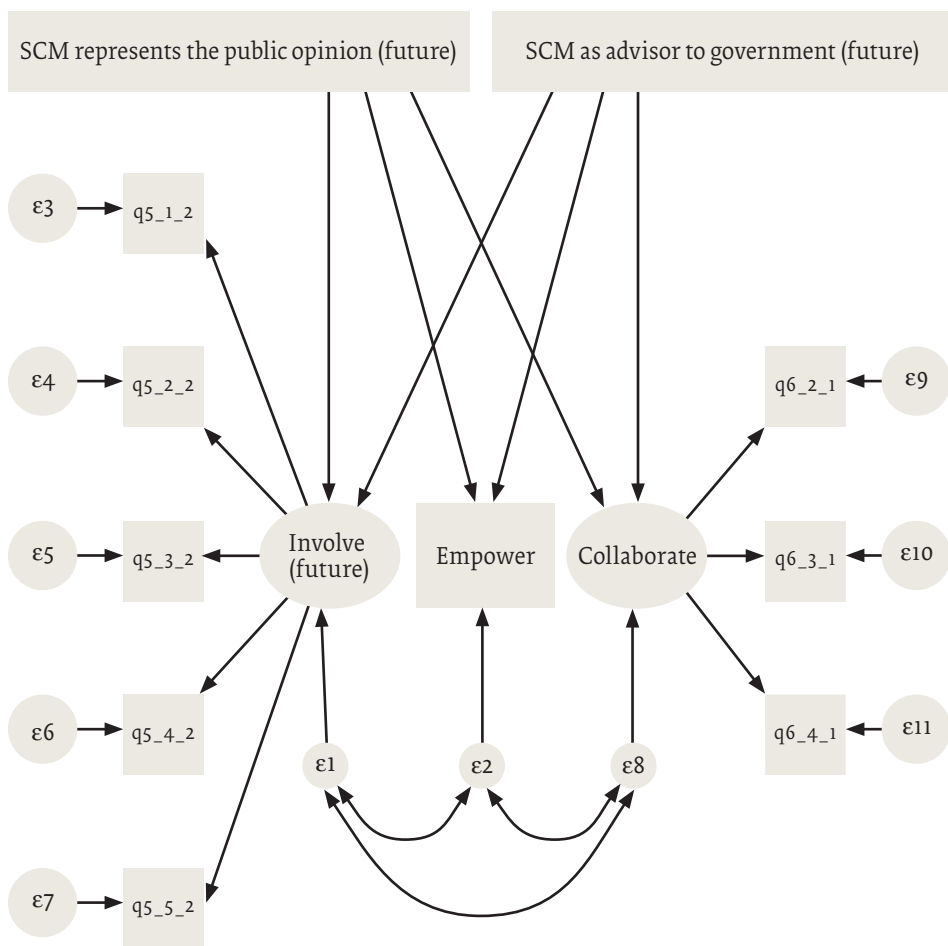


Figure 3. Structural equation model to measure the effect of the expected role of SCM in policy on participation.

To test this model, a maximum likelihood Structural Equation Model (SEM) analysis was carried out. SEM is a statistical technique which allows to test and estimate relationships between variables and to construct 'latent' variables which are not measured directly but estimated from other observations (Kline, 2011). In our case, the variables involve-future and collaborate are latent variables, measured by several items of the survey. In Figure 3, rectangular variables are directly measured, whereas elliptical variables are latent ones.

The resulting SEM-analysis produced a model with a good fit and significant path coefficients as shown in Figure 4. The CFI (Comparative Fit Index) is 0.958; values over 0.9 indicate a good fit (Bentler & Bonnett, 1980; McDonald & Marsh, 1990). RMSEA (Root Mean Square Error of Approximation) is 0.059; values between 0.05 and 0.08 indicate a good to reasonable fit (Cudeck & Browne, 1992). SRMR (Standardized Root Mean Square Residual) is 0.036; values under 0.08 (Hu & Bentler, 1995) indicate a good fit.

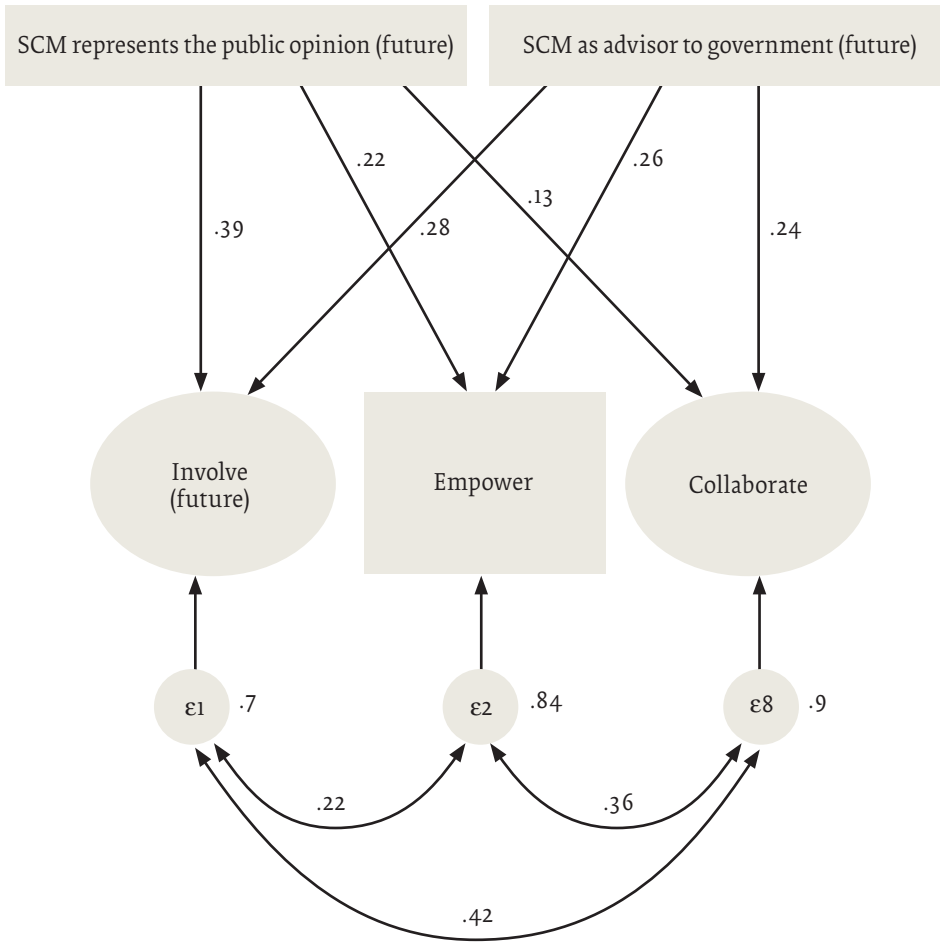


Figure 4. Structural equation model for interest in a public board showing significant paths.

Note: All paths are significant beyond the 0.01 level. Standardized coefficients are shown. For clarity, the observed variables for “Involve (future)” and “Collaborate” are not shown (see Fig. 3).

Results show that in general the expected role of SCM in policy is significantly related to the visitors’ interest to participate. The expected role of SCM in the future as advisors to the government on matters of science policy affects *involve* ($\beta = .28$, $p < .001$), *collaborate* ($\beta = .24$, $p < .001$) and *empower* ($\beta = .26$, $p < .001$) in an almost equal way. Instead, the expected role of SCM in the future to represent the public opinion in national and local discussions about science affects the interest in involvement three-fold compared to the effect on interest to collaborate (for *involve*, $\beta = .39$, $p < .001$; for *collaborate*, $\beta = .13$, $p = .004$). The effect on *empower* sits approximately in between, $\beta = .22$, $p < .001$.

This analysis reveals therefore that the visitors’ expectations of a role of SCM in policy are related to their interest to participate in the SCM. The level of participation

most strongly affected is *involve*, followed by *empower* and *collaborate*. The expectations that SCM can be advisors on matters of science policy equally affect all three levels of participation, whereas the role of SCM as representatives of the public opinion is relatively stronger for *involve*, followed by *empower*, and weaker for *collaborate*.

5.6 Discussion and conclusions

The purpose of this study was to analyze how the emerging role of European SCM as platforms for scientific citizenship is related to visitors' interest in participation in the institution. The analysis focused on visitors' interest in three levels of participation: Involvement in discussions and debates; co-development of programs and activities; and public participation in the governance of the institution. A survey conducted among 652 visitors to 6 European SCM was used to measure how these three degrees of participation are related to the visitors' perception of SCM as institutions supporting scientific competence and having a role in policy; to the visitors' existing level of engagement with science; and to socio-demographic factors.

The first part of the analysis focused on visitors' interest in two forms of participation currently implemented in SCM: the involvement of the public to share opinions and feedback about the content of the exhibitions and programs, and the co-development of activities with the institution. The interest to be involved was highest for visitors with lower education, and did not significantly vary with the other socio-demographic factors considered (age, gender, frequency of visit). It was strongly related to how visitors perceive the role of SCM as platforms that enable scientific citizenship, and it was only marginally influenced by the existing engagement with science. The interest in co-development instead was found to be higher for visitors with either very low or very high education, male, who keep returning to visit the institution. It was strongly influenced by the level of existing engagement with science, and only in minimal part related with the perceived role of SCM as platforms scientific citizenship (specifically, only with the role of SCM as advisors to the government).

We can notice therefore that as far as the interest to be involved is concerned, SCM are 'democratizing' public participation for visitors with lower education levels, who usually do not have access to the same opportunities as visitors with higher education. Furthermore, the fact that the interest to be involved depends in minimal part on the existing engagement with science and that it does not depend on visitation patterns, suggests also that in this regard SCM do not necessarily "preach to the converted". That is, the capacity of the SCM to be a forum for discussion does not depend much on how engaged with science visitors are, but rather on how visitors perceive the SCM as being a platform that enables scientific citizenship. The interest in co-development, instead, seems to be a way for visitors to enact their existing engagement with science, regardless of how they consider SCM platforms for scientific citizenship. This level of participation reflects also entrenched patterns of higher interest in science by a well educated, male public (Falk & Needham, 2013; Takahashi & Tandoc, Edson C., 2015).

The second part of the analysis shows that visitors expect SCM to play a stronger role in policy in the future compared to today, and that these expectations are significantly related to their interest to participate at all levels. Two broadly defined roles

of SCM in policy where considered: the expected role of SCM to advise the government on matters of science policy, and the expected role of SCM as representatives of the public opinion in local and national discussions about science. The former is related to all three levels of participation in a very similar way; the latter shows a much stronger relationship with the interest to be involved, followed by the interest in public participation in the governance of the SCM, and lastly by the interest in co-development. This result suggests that the interest to be involved is quite strongly related to the expectations that SCM will bring the opinions and conversations of the visitors into larger national and local discussions regarding science and science policy. To some extent these expectations are also related to the interest in a direct participation of the visitors in the governance of SCM, and less so with the interest in co-development.

Two observations can be made from these findings. The first one is that the “broker” role of SCM acting as interfaces between the public and policy-related discussions is intrinsically related to how visitors participate in the institution. Even if differences exist between different levels of participation, visitors associate a higher interest to participate in SCM with a higher awareness of the role that SCM play in policy, and as platforms of scientific citizenship in general. Furthermore, visitors are interested to meaningfully take part in activities where they can “have their voice heard” regardless of their existing degree of engagement with science. This is even more noticeable for visitors with a lower education level. Therefore, being brokers of public opinion can be a positive factor for visitors’ participation in SCM. This is in contrast to the fact that such a role is still considered problematic by SCM (Bandelli & Konijn, 2012; Cameron, 2012).

The second observation is that forms of participation based on co-development pose the risk of maintaining certain established inequalities in science engagement (Dawson, 2014b). Not only is the interest in this form of participation stronger in certain privileged groups, but it appears also that it is not related to the capacity of SCM to stimulate and enable scientific citizenship. The risk of these forms of participation is that they are susceptible of reflecting existing social unbalances in science engagement, and visitors may not see them as activities related to building scientific citizenship in SCM.

These results raise a question about the effectiveness of co-development as a strategy to engage diverse audiences with science. There is a possibility that inviting the public to co-develop implicitly selects a public which participates out of a pre-existing interest and desire to be engaged with science. This kind of participation displays the weakest relationship with the context of the science center as a place for scientific citizenship. At the risk of oversimplifying, we might conclude that science center visitors interested in debates and discussions engage with the ‘center’ through ‘science’, whereas those interested in co-development engage with ‘science’ through the ‘center’. For the former, scientific citizenship as enabled by SCM is the most important factor to participate; for the latter, the most important factor is a pre-existing interest and engagement with science.

There are a number of limitations in this study which we want to point out. The quantitative approach followed in this study, while allowing for uniform measures across institutions and comparative analysis for the different kinds of visitors’ interests, provides only a coarse level of sophistication when dealing with complex issues such as participation and scientific citizenship. When interpreting the results, we should

therefore keep in mind that they provide broad indications rather than specific measures. This study also focuses on visitors' statements about their interest in different forms of participation; the propensity to participate, or the actual participation effort, might be different from their interest. These findings do not allow to unequivocally justify causality or directionality between the various factors. It is in fact reasonable to think that these factors are associated in mutually reinforcing ways; and that the reciprocal influence is not exerted only during the visit to a SCM but likely over a much longer period of time. Therefore, this study provides only a 'snapshot' of what visitors think at a precise moment – during the visit. Finally, these results are obtained from a large sample across several institutions; the reality of any single science center or museum is likely to be different depending on local, cultural and organizational aspects.

Despite these limitations, the study clearly shows that SCM fulfill the role of 'brokers of participation', acting as an interface between visitors' participation at various levels in the institution, and participation in policy. This role suggests a principle that could find application in the design of exhibitions and programs: Giving more visibility to the role of the museum in policy in order to strengthen the forum function of the museum. Further research designed around the specific situation of each institution using both quantitative and qualitative methods is of course required to support this principle. But the evidence so far shows that in order to increase interest in discussions and debates, how visitors think the museum influences public policy might play a more important role than the visitors' own engagement with science or with the content of the exhibitions.

5.7 Acknowledgments

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5.8 Appendix

Survey questions

Involve

- I1 There are enough opportunities to give my opinion and feedback in the Science Center on matters of contemporary science and science policy
- I2 The Science Center has made me aware of other organisations I would like to visit or to be in contact with
- I3 My point of view on matters of science, technology and society is well represented in the presentations at the Science Center
- I4 After the visit, I would have liked to add my point of view and/or personal experience to the programs and/or exhibitions at the Science Center
- I5 I think other visitors would find it useful to know my point of view about the subjects of the programs and /or exhibitions I visited
- I6 The visit to the Science Center made me realise that my point of view on science and technology is important

Collaborate

- CO1 I think I have expertise, connections or other skills and know-how that could be useful to the Science Center to develop new programs or exhibitions
- CO2 I would be interested to be involved on a voluntary basis (=not paid) in the development of new programs at the Science Center
- CO3 I would be interested to be involved in the development of new programs at the Science Center if my role were paid

Empower

- EM1 The Science Center currently has a board of trustees and a scientific advisory board; should it have also a public board (composed of members of the public) to advise on how to represent science to the public?

Competence

- C1 The topics presented at the Science Center are of special interest to me
- C2 The visit to the Science Center strengthened my interest in science and technology
- C3 The visit to the Science Center made me realize that I can use my knowledge and the information I gained during the visit in other contexts
- C4 The topics of the programs and exhibitions I saw at the Science Center are part of larger social and political discussions and debates

Participation

- P1 The Science Center represents the public opinion in the national and local discussions about science

- P2 Institutions like the National Science Academy, universities and industries give regularly advice to the government on matters of science policy. Should the Science Center do the same?

Engagment

- E1 In addition to the Science Center, I know other engaging and interesting ways to be involved with the developments of science and technology
- E1 I am interested in the social and policy discussions regarding science and technology
- E3 My level of knowledge about science and technology is...
- E4 I am socially or politically active in a domain where science and technology are relevant (for example through my work or hobby)
- E5 During the last 3 months I encountered a topic related to science and technology (for example in conversations, in the media, on my job)
- E6 I personally know people who are active (socially, professionally or politically) in science and technology

Note: in all survey questions, "the Science Center" was replaced with the name of the institution where the survey was being conducted.

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6.

General Discussion

The main aim of the research reported in this dissertation was to better understand how visitor participation is contextualized in European science centers and museums. This exploratory research analyzed visitor participation from three perspectives. The first perspective reviewed how public participation affects the epistemological process of science centers and becomes thus an integral part of the decision making process of the institution. The second perspective analyzed how science centers and museums in Europe enable public participation and what are the opportunities and obstacles they experience in this process. The third part analyzed the interest of the visitors in actively participating in science centers to share opinions, to co-develop exhibitions and programs, and to participate in the governance. The empirical research for the second and third part of the research project involved 12 institutions and 1016 visitors.

This final chapter first presents a summary of the findings. Subsequently, our findings will be reflected upon and interpreted to provide further insights on the role that public participation plays in science centers and how science centers can position themselves in the larger field of public participation in science governance. In this chapter we discuss also the limitations of the current study and we suggest a number of new research directions to further advance the knowledge in this field. Finally, the implications of our findings for policy and practice will be discussed, presenting three areas of intervention which are supported by the results of this study.

6.1 Summary of the Main Findings

In **chapter 2**, “The Need for Public Participation in the Governance of Science Centers”, we describe how a renewal of the institutional governance of science centers is made necessary when they present contemporary science to the public. By its nature, contemporary science is unfinished and controversial. Unfinished because the findings are tentative and fluid, and are likely subject to change, often drastically, with any new discovery. Controversial because there is no agreement within the scientific community itself on the meaning of the findings, and because the ethical and societal implications of the research expose the broad diversity of views and interests of the stakehold-

ers involved (Durant, 2004). Science centers and museums, traditionally involved only in disseminating established and accepted knowledge, have now a new role as negotiators of tentative knowledge “in the making” between the public and several other stakeholders involved in the scientific process. Listening to the public and mediating different kinds of expertise becomes therefore critical; science centers shift their role from being authorities on a given subject to being brokers of situated knowledge. This means that science centers need to share some of their authority with the public, and that the public becomes a crucial contributor to the epistemological process of the institution, and therefore of its decision making process. We concluded that public participation in science centers implies an additional governance model where the public is one of the decision makers, and not only an informant. This model is not supposed to replace the current governance models, but to co-exist alongside the more traditional ones.

The study presented in **chapter 3**, “Science Centers and Public Participation: Methods, Strategies, and Barriers”, analyzed how science centers enable public participation within their organizations, and to which extent a public-led model of governance is attainable. The research was conducted on a sample of five institutions which provided a wide variety in terms of institutional history, size, dominance position and competition, exhibition techniques, and funding mechanisms. We interviewed 22 members of staff, directors and board members using a grounded-theory methodology (Strauss & Corbin, 1998, 1997). We found that science centers currently rely on conventional governance structures based on the board, director or staff as decision makers. These structures co-exist within each institution, and even though they are long established, there are repeated instances where they lack in transparency. Science centers are also trying out different strategies to enable public participation in their activities and to share some forms of decision making with the public. We identified the main practices so far and four types of obstacles that were encountered in this process. The obstacles reported in the interviews were either internal to the organization or external to it; and they could be either controllable by the staff, meaning that the staff was able to provide a solution, or outside of the control of the staff. The internal barriers were: 1) institutional obstacles, such as lack of institutional interest and poor transparency, which were not controllable; and 2) the lack of professional development, which was a controllable obstacle. The external ones were: 3) the fear of negative public opinion, a non-controllable obstacle; and 4) the difficulty in reaching specific publics interested in participation, a controllable one. Furthermore, all the interviewees agreed that the lack of evaluation and research on public participation in science centers and museums prevents science centers from being recognized as effective players in the field of science governance. We further identified two actions that science centers can undertake to reduce the barriers in implementing public participation. The first is the development of more detailed visitor studies and indicators to better understand the interests and needs of the public in regards to participation. The second is to grant more agency to the staff who is currently interacting with the visitors, so that they can enable and support the participation of the public.

In **chapter 4**, “Public Participation and Scientific Citizenship in the Science Museum in London”, we describe the development and testing of a quantitative approach to study the factors related to visitors’ interest to participate in science centers and museums. We applied the ‘ladder of citizen participation’ by Arnstein (1969), in the format used by the International Association of Public Participation (IAP2, 2014), to define three levels of visitor participation: a) involvement in conversations, discussions and debates; b) co-development of exhibitions; and c) public participation in museum governance. The factors considered were 1) socio-demographic (including frequency of visit to the museum); 2) visitors’ existing interest and engagement with science; and 3) visitors’ perceptions of the museum as a place that supports scientific citizenship. We applied the definition of scientific citizenship put forward by Horst as a combination of two dimensions: Scientific competence and public participation in science (Horst, 2007; Irwin, 2001). The competence dimension of scientific citizenship was assessed measuring the interest, engagement, and agency of visitors with the topics presented at the museum. The participation dimension by measuring to what extent visitors perceive the museum as having a role in affecting public policy.

The results of a survey among 114 adult visitors to the Science Museum in London revealed that visitors’ interest in being involved in conversations, discussions and debates was not related to their prior engagement with science, but rather to how the museum enables scientific citizenship. However, for the interest in co-development the reverse was found to be true: previous engagement with science and frequent visits were more important than scientific citizenship. Being involved in conversations and the perceived role of the museum in public policy were also significantly related to the visitors’ interest in the governance of the museum. Therefore the results of this study suggest that the expectations that the museum will act as a ‘broker’ between the public and policy making are significant factors to predict visitor’s participation in conversations, discussions and debates, and in the governance of the museum. At the same time, other forms of participation, such as the co-development of activities, might reproduce patterns of ‘engaging the already engaged’.

In **chapter 5**, “European Science Centers as Brokers of Public Participation”, we present the results of a European-wide study that analyzed how scientific citizenship is related to visitors’ interest in participation in science centers and museums. In this study we refined the approach developed in chapter 4 and broadened the scope. We conducted a quantitative research on a sample of six science centers chosen to represent the different levels of science engagement and culture in Europe. Building on the results presented in the previous chapter, we analyzed three levels of visitor participation: 1) involvement in conversations, discussions and debates; 2) co-development of exhibitions and programs; 3) public participation in the governance of the institution. The results of this study, conducted among 652 visitors (all locally gathered on-site, N-ranges from 95 to 150), showed that the interest to participate in conversations, discussions and debates was highest for visitors with lower education and was strongly related to how visitors perceive the role of science centers as platforms that enable scientific citizenship. Higher levels of education corresponded to a higher level of previous engagement with science. However, engagement with science was a weak predictor of the interest to participate in discussions and debates. The interest in co-development

instead was strongly influenced by the level of existing engagement with science, and only minimally related to scientific citizenship. Interest in co-development further appeared higher among males and frequent visitors with a higher level of education. The results further indicate that all levels of visitors' interest to participate in science centers were related to the expectations that the science center will bring the opinions and conversations of the visitors into larger national and local discussions regarding science and science policy – thus acting as a 'broker' of public participation in science. The level of participation most strongly affected by the 'broker' role of science centers was the interest in participating in conversations, discussions and debates, followed by the interest in public participation in the governance, and lastly by the interest in co-development of exhibitions and programs.

6.2 Discussion of the Results and Theoretical Implications

The findings of these studies lead to four considerations which we discuss in this section highlighting their theoretical and empirical relevance for the field of public engagement and participation in science.

6.2.1 Democratizing Public Participation

The first implication concerns the visitors' interest to participate in discussions and debates (chapters 4 and 5). These are structured and unstructured activities where the public can express their opinions about the topics presented in the programs and exhibitions, contribute their points of view to the narrative(s) presented in the science center and share them with other visitors. The results show that the interest in this kind of interactions is unrelated to gender and visitation frequency and only minimally related to previous interest in science. The interest to participate in discussions and debates is instead positively related to how science centers enable the scientific citizenship of their visitors. That is, the more the visitors recognize the science centers' role in public policy and appreciate the relevancy of the content presented in the exhibitions and programs, the more they are interested to participate in discussions and debates. Moreover, visitors with a lower education level (junior or high school) express a higher interest to share their opinions and feedback in science centers than those with a higher education level (bachelor, master or PhD).

These findings point to an important democratic potential for science centers. The interest of visitors to participate in discussions and debates regardless of gender, visitation patterns, and to some extent previous engagement with science, suggests that locating public participation in science centers can facilitate the engagement of the often assumed 'disinterested', or less engaged, publics (Evans & Plows, 2007). More specifically, the context of the science center, which stimulates and supports the scientific citizenship of their visitors, can elicit a higher interest to participate in audiences with lower education levels, who otherwise express a lower level of engagement with science than visitors with higher education levels (see Figure 1).

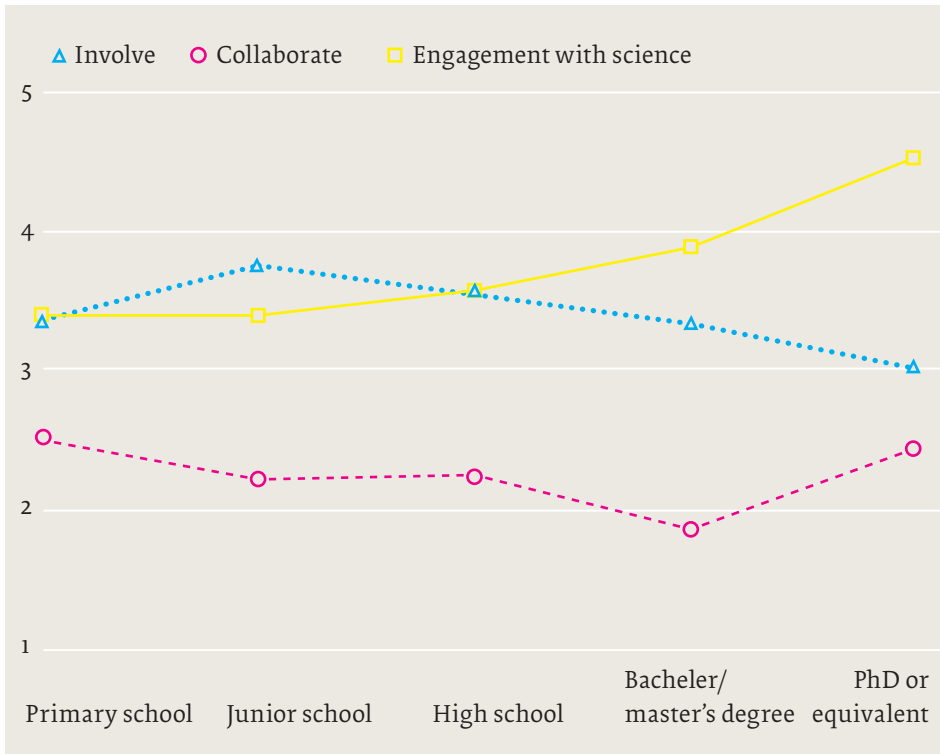


Figure 1. Visitors' interest in discussions and debates, co-development, and self-reported engagement with science by education level.

Science centers, thus, have the potential to reduce some of the current limitations of public participation initiatives, where traditionally the protagonists are small, invited publics (Goodin & Dryzek, 2006). Often, these mini-publics voice a “deeply felt uneasiness” during engagement activities (Felt & Fochler, 2011, p. 498) because they do not consider themselves ‘the’ representatives of the public. They are also aware that by being involved in these exercises they may prevent other voices and opinions to be heard as well. While science centers cannot lay any claim about the overall social equity or representativeness of their visitors (Dawson, 2014), this study shows that they may be able to democratize the interest to participate of their public and therefore engage large audiences who would otherwise be absent from participatory opportunities.

Clearly, these findings apply only to those people who already made the decision to visit the science center. In this regard, thus, visitors act as ‘self-invited’ participants to engagement opportunities. However, among these visitors are also publics who would otherwise escape other opportunities to be engaged with science – for instance, parents and chaperons who visit the science center ‘only’ to accompany younger visitors (Falk, 2009). Engaging with these otherwise ‘unengaged’ publics has been shown to be critical to identify and reflect on the assumptions made in the theory of science communication (Horst & Michael, 2011). In this light, thus, visitor participation is a reflexive practice for the professional development of the science communication capacity of science centers.

Finally, the interest of visitors to participate regardless of gender, visitation patterns and previous engagement with science reinforces the findings of chapter 3. One of the barriers to implement public participation as reported in the interviews, which is the difficulty to reach specific publics, might not depend on the characteristics of the public, but on the business models of science centers. Visitors appear to be overall interested to participate in discussions, whereas science centers are still unable to conceive a business model that works with participatory activities. As reported by a number of participants in the study presented in chapter 3, the current business model of science centers, based on ticket sales and large visitor numbers, is not yet able to capture and capitalize on the knowledge that visitors bring to the science center. Therefore, discussion activities, which are resource intensive, are seen as a costly way to engage visitors, rather than as a method to generate value.

In conclusion, science centers are shown to be effective platforms to encourage all visitors, and in particular those traditionally less engaged with science, in discussing about contemporary science and technology. They lower some of the traditional barriers to science engagement, such as level of education and gender, and empower all visitors to contribute their views and opinions on the content of exhibitions and programs.

6.2.2 Engaging the Already Engaged

The other form of visitor's interest in participation measured in this dissertation, the interest to co-develop exhibitions and programs together with the staff of the science center, follows instead quite a different pattern than the one described in the previous section. The interest in co-development, which is enabled by opening up the exhibition design process to the public as explained in chapters 2 and 3 (see also Boon, 2011; Bunning, Kavanagh, McSweeney, & Sandell, 2015; S. Davies, 2010) is higher in frequent visitors, males, visitors already interested in science and those with higher education levels. It tends therefore to reproduce patterns of privilege for interest in and access to science (Falk & Needham, 2013). Interest in co-development is also weakly related to how science centers support scientific citizenship. Thus, in contrast to the interest to participate in discussions and debates, in this case science centers tend to perform an instrumental role for already engaged audiences to enact their (existing) interest in science, rather than a substantive role in widening interest and engagement.

From the study presented in chapter 3, co-development emerges as one of the preferred ways for science centers to enable public participation, mainly because it is an effective instrument to bring external knowledge into the institution (see also Bunning et al., 2015). However, the staff is also concerned that at a certain point the public involved in co-development becomes 'museum people'. This term was used to explain how at a certain point the input provided by the public aligns and overlaps with that of the staff, and does not contribute substantially to broadening the narratives and the interpretation of the institution. The pattern of privilege visible in the visitors' interest in this kind of participation provides a possible explanation for this phenomenon. The reason may lie in how science centers implicitly shape the public that is invited to participate in co-development activities. A recurring example of co-development that

emerged in chapter 3 is including members of the public in the consulting bodies set up to advise the science center for the development of a new exhibition. While in principle this is a way to engage a larger number of stakeholders, in practice the public would sit (often literally) at a table among 'experts' of various disciplines. This situation may easily lead to a perceived unbalance of expertise and the reoccurrence of difficult relationships between the public and the other stakeholders, as observed in other studies (Felt & Fochler, 2008, 2010; Felt, Schumann, Schwarz, & Strassnig, 2014; Michael, 2009; Wynne, 2006). It may also prevent certain members of the public from participating, because they do not feel qualified to take part in the process (Powell, Colin, Lee Kleinman, Delborne, & Anderson, 2011). This would explain the lower interest in this kind of participation from less privileged members of the public. Eventually, the implicit pre-selection of a certain kind of participants combined with the role of the institutional culture in framing participatory activities (Bickerstaff, Lorenzoni, Jones, & Pidgeon, 2010) flattens the diversity of opinions and makes it easier for visitors to stop performing as 'the public', and revert to more conventional and assimilated views (see also Michael, 2009).

In practice, the formats for co-development employed by science centers are more varied than the example reported above, and the threshold to participation for the public therefore potentially much lower. However, the results of this study are compatible with the findings (Lynch, 2011a) that there are entrenched assumptions regarding participation in general, and co-development in particular, both on the side of the science centers and of the public, that affect the visitors' interest in this form of participation.

In conclusion, participation activities presented to the visitors as co-development of exhibitions and programs carry the risk of being more interesting to a privileged audience who has some level of previous engagement with science. In this regard, such activities might hinder the potential of science centers to stimulate and support the diversity of views and contributions from their visitors.

6.2.3 The Political Agency of Science Centers

The third implication concerns the relationship between the perceived role of science centers in public policy and the visitors' interest to participate at various levels in the institution. As described in chapters 4 and 5, science centers implement various activities where they assemble public discourses and opinions on matters of contemporary science and technology, and they relay these opinions to other stakeholders. By acting as mediators between their visitors and science policy, science centers enable the participation dimension of scientific citizenship (Horst, 2007; Mejlgaard & Stares, 2009), giving their visitors the possibility to inform and sometimes even influence public policy.

The two empirical studies presented in chapters 4 and 5 show a significant relationship between the visitors' expectations of the role of science centers as mediators in public policy and the visitors' interest to participate in the institution. The strongest relationship can be found for the interest to participate in discussions and debates, followed by the interest in participation in the governance of the science center and lastly

the interest in co-development. These empirical results confirm, from a visitors' perspective, the argument put forward in chapter 2: The role of science centers as knowledge mediators is intrinsically related to how visitors participate in science centers. Visitors are more interested to participate, and in particular are more interested to share their opinions about the content presented in the science center, when they expect some agency of the science center in public policy. The two forms of agency considered in this study are the science center as a representative of the public opinion in larger discussions about science, and as an advisor to the government on matters of science communication and policy.

In other words, the expected political agency of the science center contributes to how visitors enact 'being the public' in science centers. There is usually a wide gap between the public and what happens with the input it provides during dialogue and participation activities. Some practitioners go as far as reporting that the feedback to participants and to wider society about how public input is used is absent from virtually any dialogue initiative (Sutcliffe, 2011). More generally, the awareness about how public input is going to be used in policy is an essential aspect of effective participation (Rowe, 2004). Our results show that the visitors' awareness of the political agency of science center is a positive factor to raise interest in all forms of participation inside science centers. Combined with the knowledge that visitors expect an increased policy role of science centers in the future (Bandelli & Konijn, 2015), these results suggest that when science centers are open and explicit about their role in science policy, they fulfill not only a normative requirement of public participation, but they also play an instrumental role to increase the engagement of their visitors.

In sum, the agency of the public in participating in science centers is related to how visitors perceive the agency of science centers in public policy. Visitor participation within the institution reflects therefore to some extent how the institution itself participates in the system of science policy.

6.2.4 *Re-aligning Science Centers with their Public*

With this last consideration we want to reflect on two misalignments, or gaps, between the assumptions of the staff working in science centers and the experience of the public. The first one is that science centers tend to conceive public participation as an activity which engages limited audiences (chapter 3), whereas we found that a large number of visitors regardless of age, education and prior level of science engagement, are interested to participate by sharing their feedback and opinions (chapter 5). Instead, the assumptions of the science centers are reflected in the interest to co-develop, which is confined to more specific audiences, and follows more traditional patterns of privileged access (males, frequent visitors, highly educated).

The second gap is between the uneasiness of science centers to acknowledge their political agency, that is, their capacity to influence the political field and the importance of this role in engaging the visitors. Science centers tend to define themselves as neutral places (see chapter 2) where conversations on contemporary science and technology can take place. Recent research on how science centers represent climate change (Cameron & Deslandes, 2011; Cameron, Hodge, & Salazar, 2013; Cameron, 2012) has shown that sci-

ence centers and museums are considered by the public trusted information sources, rather than neutral organizations. Science museums and science centers still struggle between the roles of “stewards” and “spectators” (Janes, 2009, p. 169), that is between taking an active stance on issues of societal concern (such as climate change) or remaining indifferent in the name of neutrality.

Implications of the first gap include important consequences for how science centers frame the conversations that take place on their premises. There is a risk that by targeting participatory activities only to specific audiences (when in fact our research showed that this is not necessary), science centers implicitly and unconsciously create a context which is dominated by certain views about science, society, and culture which exclude other audiences (Dawson, 2014), and become self-referential. This potential for self-referentiality is expressed for example in the evaluation of the VOICES project (Rowe & Watermeyer, 2013, p. 12), which has pointed out how the context of science centers can influence the discussions that take place in the institutions: “The location of focus groups within science museums/centres/galleries would provide an important contextual reference, reminder and prompt for dynamic, imaginative and interactive work”. Therefore science centers need to be careful not to create a vicious circle where the assumptions about their public end up affecting the context in which participation takes place, and eventually creating barriers for a broader engagement of the public.

Implications of the second gap highlight the importance of the political agency of science centers for their visitors. Despite some resistance to acknowledge this role in the professional field, from directors and staff who prefer to keep the political agency of science centers and their public activities separate (Cameron & Deslandes, 2011; Janes, 2009), the role of science centers as a political instrument at the service of society has been present since the first science centers were founded. The Exploratorium, the science center in San Francisco founded by Frank Oppenheimer in 1969 and regarded as the first and most influential science center, was built in fact as a “political institution [...] to change the way people feel about nature, about each other, about war” (Cole, 2009, p. 233).

Today science centers can play an important role in reducing the barriers to engagement with science by creating opportunities for the public to interact with those political stakeholders who are normally ‘off-limits’ to a large part of the public. In a society where citizens are normally prohibited from engaging with “science-protected politics” (Wynne, 2007, p. 103), many visitors consider science centers as institutions that can help them to make their voices be heard. Acknowledging a political agency for science centers means being aware that the discussions and the conversations that take place inside the science center are meaningful because they contribute to shaping the role of science in society. The political agency of science centers is particularly relevant in countries where the science communication structure is not yet consolidated, or where formal possibilities to participate in science and technology are more limited, such as Portugal, Poland and the Czech Republic (Mejlgaard, Bloch, Degn, Nielsen, & Ravn, 2012). In these countries visitors are more positive of the brokering role of science centers in policy, as well as of a stronger role for the public in the governance of the institution (Bandelli & Konijn, 2015). When science centers take the responsibility for this process, they open up new “spheres of influence and relevance” to support more effective policy making (Cameron et al., 2013, p. 15). While there is no easy answer on how to reduce these two gaps, our research shows that they can be measured, leading

thus to increased awareness within the institution about their effects and hopefully to possible solutions.

To conclude, this research was based on an innovative approach, which combines the reflective discourse on the agency of science museums in the governance of science with descriptive studies to measure how this discourse is actually related to visitor participation. The results highlight that visitor participation in science centers and museums is a complex phenomenon which varies considerably depending on how it is framed and contextualized. The staff working in science centers and museums and the visitors hold implicit and explicit assumptions and expectations which have been shown to play a determinant role in how public participation is performed. At the same time, science centers and museums have a clear potential to act as 'brokers' of participation between the public and the other stakeholders that they engage with, enabling forms of participation which are otherwise limited and not widely accessible.

6.3 Methodological Considerations

The qualitative and quantitative approaches used in our studies hold both strengths and limitations, which have implications for future research.

6.3.1. Methodological Strengths

The grounded theory approach allowed us to identify the opportunities for public participation in science centers and the underlying barriers and fears. Ensuring the anonymity of the institutions and the people interviewed allowed for a great level of transparency and openness by the interviewees. Conducting individual interviews was particularly appropriate considering the sensitive nature of the issues that emerged, such as lack of internal transparency and staff dynamics. We recommend designing future research in a way that can guarantee the anonymity of the institutions where possible. In case the institutions are named, we recommend to conduct anonymous one-to-one interviews with the staff (Lynch, 2011b).

The quantitative approach using on-site visitor surveys ensured homogeneous and comparable results across a broad number of institutions. Quantitative methods are well suited to identify the relative strength of contributing factors in cases where the nature of the phenomenon to study – in this case, public participation – is complex and cumulative and where no clear path of causality can be established. In this regard, advanced techniques such as structural equation modeling offer the level of sophistication necessary to manage the complexity of the factors at play.

On a pure functional level, structuring the questionnaires with closed questions made it possible to efficiently manage the responses in many different languages. Overall, the high response rate confirms the functional viability of this method to survey museums visitors. Electronic and online methods should be however considered; a considerable number of visitors across all institutions were in fact surprised to fill in a paper survey instead of an electronic one. However, the paper for-

mat allowed for a precise distribution of the survey among visitors, and did not require any technical infrastructure or equipment from the institutions or the visitors.

6.3.2 Limitations and Weaknesses

In chapter 3, anonymous staff interviews allowed for a great level of transparency. However, it meant also that less information could be used and disclosed regarding the social and cultural context in which the institutions are located. If future research focuses on how institutions implement public participation in policy at local or regional level, particular care should be given to the level of anonymity that can be guaranteed in these circumstances. Our results show that science centers and museums experience a distinct fear of adverse public opinion on matters related to public participation. If the institutions can be identified by contextual references, they might express more conventional positions to avoid changes in the current status-quo of relationships with other stakeholders and the public.

The theoretical sampling method (Eisenhardt, 1989) relies on a broad variety of cases, including extreme and polar ones, to build theoretical categories. We relied on published sources and professional expert consultations to identify the group of institutions for our sample in chapter 3. Theoretical sampling presents, however, the inherent possible weakness to ignore relevant cases, resulting in incomplete categories for analysis. The general scarcity of published literature on science centers means that professional knowledge and access to unpublished literature play an important role to ensure that sampling can be performed adequately.

In regards to the quantitative methodology, cross-institutional studies usually rely on local staff and volunteers to collect data. While in principle standardized procedures and training are put in place to ensure consistency across institutions, differences in data collection are possible. The wide variety of configurations and sizes of science centers and museums requires also to carefully consider how a “visit” is defined. In some (smaller) institutions it means visiting all exhibition areas, in others (such as large museums) it means at best a visit to some galleries or to a temporary exhibition. Furthermore, filling in a visitor survey may interrupt the visit experience or disrupt social patterns among groups, possibly influencing the answers to the survey questions. To minimize this problem, visitor data collection could be embedded in the visit experience, using computer based exhibits for instance.

Finally, to study and understand the many issues related to public participation, a combination of quantitative and qualitative methods is required. However, cross-institutional qualitative research can easily become financially challenging due to the training and translations required. The methodological and functional limitations of both approaches should be therefore carefully balanced for consideration in further studies.

6.4 Directions for Future Research

Our research started as a broad quest to better understand how public participation is contextualized in science centers. The need to study how visitors participate

in these institutions originates from the observation that science centers usually fall into a 'gray area' in regards to public engagement with science. On the one hand they have played a marginal role in the research about public participation so far, while on the other hand they have gained a substantial role in informing and implementing policies about public engagement. The lack of evaluation studies, and more general of visitor research, was identified as one of the reasons for the difficulties that science centers face when they want to broaden their reach (chapter 3). Recent research has highlighted how evaluation studies in museums suffer from institutional frameworks and constraints that undermine the impact of the findings (M. Davies & Heath, 2013). Moreover, the lack of research on how science centers and museums perform their activities may have negative consequences for the institutions themselves, because it restricts access to funding and it undermines the work of the many professionals in the field. Therefore, we propose the following lines of research to strengthen the position of science centers and museums in the field of public engagement with science.

6.4.1 Study Relevance at Local Level

In our study we focused on institutions that have a national role or mandate, and our questions to the visitors regarded the agency of science centers in national policy. However, the relevance of science centers is in many cases higher at local level than at national one. The role of science centers as intermediaries of public participation and as interfaces for new forms of social engagement (Cameron et al., 2013) is deeply rooted in the local policy context, at the city and regional level. This is also the level where the potential for public engagement to influence policy is highest (Emery, Mulder, & Frewer, 2015). Therefore research could focus on how science centers are able to support scientific citizenship in their local communities, and most importantly, how they do so in partnership and collaboration with other partners. Initiatives such as the PLACES project¹³ have shown that there is a considerable variety in the local ecosystems of science engagement. Each locale has different priorities, dynamics and communities to engage. Moreover, science center visitors are not exclusive: They visit and interact with several other institutions and organizations that contribute to shaping their scientific citizenship. Therefore a priority should be to better understand how science centers can best leverage on the interconnected systems that are being shaped by their visitors.

6.4.2 Include Non-visitors

The capacity of science centers to democratize public participation should be tested with audiences that normally do not visit science centers. The present study shows that there is a positive relationship between the scientific citizenship that science centers support and the interest of their visitors to participate, and that this is particularly true for visitors with lower education. It would be useful to understand if this relationship exists also in the case of the public who does not (yet) visit a science cen-

ter. Future research could focus on the interest to participate in science by audiences who do not visit science centers and study how non-visitors perceive the opportunities offered by science centers to fulfill their interests. In particular, it would be useful to study to which extent non-visitors perceive science centers as places that support scientific citizenship.

6.4.3 Study the Impact of Science Centers on Scientific Citizenship

This study has highlighted a relationship between the expected political agency of science centers and the visitors' interest to participate. Further research could qualify this relationship and study what forms of political agency are possible and desired by both science centers and their visitors. In particular, it is important to extend the studies on the impact of science centers (Falk, Needham, Dierking, & Prendergast, 2014; Frontier Economics, 2009) to issues of public participation and scientific citizenship. Recent research conducted on the representation of climate change in museums and science centers (Cameron et al., 2013; Cameron, 2012) has shown that science centers need to switch from a vertical dissemination of information and data to a horizontal process of dialogue and participation. They need to equip their public with the tactical knowledge necessary to enable participation in actions and debates (Salazar, 2011). Future research should focus thus on understanding how science centers build this tactical knowledge among their public, and what is their impact on the participation capacity of their public.

6.4.4 Study Broader Concepts of Participation

Helga Nowotny, president of the European Research Council, recently argued that one of the main challenges of public engagement with science is its political dimension (Nowotny, 2014). To align public engagement with the political reality of science, explains Nowotny, it is necessary to study inclusive practices such as citizen science. These practices, together with scientific games and participatory experiments, may hold clues about the new emerging political realities that are taking shape among the public. Other influential scholars have also argued for the need to understand how informal science engagement platforms, among which science centers, increasingly "break down any clear distinction between informal, policy-free engagements and politically motivated activities" (Stilgoe, Lock, & Wilsdon, 2014, p. 9). What these authors describe is a situation where informal science activities, traditionally considered "peddling deficit model approaches" (Stilgoe et al., 2014, p. 9) are in fact being appropriated by new generations of citizens and organizations and are being tested as new participatory and political platforms. However, there is currently very little research to understand what are the mechanisms and the motivations to do so. What we know is that many of the evaluation indicators used in public participation are inadequate to account and describe the personal motivations of those who participate (Harvey, 2008), and therefore are not able to capture the processes that Nowotny and Stilgoe et al. suggest. The

present study shows how science centers are still uncomfortable with the political consequences of the activities they promote. At the same time, it shows that the political agency of science centers is an important factor that affects the interest of visitors to participate. Further research focused on identifying broader concepts of participation and political agency of science centers and their public would be desirable to reduce the institutional uncertainties and advance the understandings of public engagement.

6.5 Implications and Recommendations for Practice and Policy

This research was born out of a personal and professional curiosity to better understand what public participation entails in a science center. In many respects, ‘public participation’ has been, and still is, a buzzword in the professional field of museums and science centers (Sani, Lynch, Visser, & Gariboldi, 2015). It embodies optimism and purpose, but also a considerable normative power (Cornwall & Brock, 2005). Science centers, like many other public cultural institutions, are de facto required to ‘do’ public participation by their stakeholders, even if there are still significant uncertainties about the purpose, the modalities, and the expected and unexpected consequences of it. The results of this research can be used to reduce these uncertainties and help science centers to better integrate public participation in their activities. We propose three recommendations for policy and practice based on the findings of our research.

6.5.1 Broaden the Scope of Co-development

The first recommendation is to make co-development more ‘horizontal’, that is a process which includes also non visitors and that becomes co-production of knowledge rather than co-development of exhibitions or programs. This study points out that engaging visitors in the co-development of activities in science centers might reproduce existing patterns of access and privilege in science engagement. Two strategies can be implemented to reduce this risk. One is to involve non-visitors who can bring new perspectives and question the assumptions that science centers have about their public. Large institutions such as the Science Museum are already doing this (Bunning et al., 2015). Even if it remains a difficult and costly endeavor for smaller institutions, online technologies such as Google Cultural Institute (Google, 2015) can help science centers to interact with a much wider public without the constraints of the physical location. The pervasiveness of online technologies means that these can become a powerful instrument to engage with under privileged audiences which would otherwise never come in contact with science centers and museums. The second strategy is to leverage on the ‘democratic potential’ described in section 6.2.1 to co-produce knowledge with all visitors. It means developing an organizational culture where the focus of co-development is not on the exhibits or programs, but on the meaning-making that takes place in the science center. To make sense of contemporary science and technology, people tend to use narratives to envision the future(s) that these technologies will entail (Macnaghten, Davies, & Kearnes, 2015; Paquette, 2006). The opportunity for science centers is to leverage on their capacity to engage horizontally those visitors who are not already

engaged with science in order to create robust narratives which represent the ideals, concerns and visions of citizens. This may seem a subtle or an easy step to take, but it means re-framing the purpose of the instruments and methods that science centers use. It means opening a discussion on the purpose of the learning that takes place in science centers, and understanding how this purpose can be negotiated with the public (see also Hein, 2012).

6.5.2 Focus on Adult Visitors

Science centers traditionally focus on younger audiences, and direct their efforts on educational and learning activities for children. Adult visitors, which represent on average about two thirds of the visitors to science centers, partake in these educational activities either accompanying younger visitors or as independent visitors. Learning, however, is usually not the most prominent or desired activity for adult visitors. Personal growth, thoughtfulness, deepening purpose in life are instead the primary outcomes which adult visitors seek when visiting museums (Packer, 2008). Our research builds on previous studies (Cameron et al., 2013; Cameron, 2012; Meyer, 2010) that show how adult visitors are conscious of the societal relevance of the topics presented in science centers. Often, reaching out with the same exhibitions to both young and adult audiences means that the topics and the issues at stake are simplified and the ensuing debate is limited.

We recommend investing in adult visitors research in order to reduce the assumptions and stereotypes that science centers have about their visitors. It is not only to avoid the ‘dumbing-down’ of science for which science centers are being periodically criticized. The public expects science centers to be also a place for adults who do not want to be (only) ‘children of all ages’, as many science centers use to describe their visitors. Dealing with serious topics does not mean that the visitor experience is boring or not exciting. Similarly, presenting a topic in such a way to be appreciated by a child does not mean it has to be overly simplified. However, there are several design implications, both in terms of exhibition design and programmatic design, to consider in order to make science centers more meaningful for independent adult visitors. Some institutions such as Copernicus Science Center in Warsaw, Poland, and the Science Museum in London, are already moving in this direction and are developing monthly events for adults to understand what are the ambitions, expectations and requirements of catering to a whole different audience than families with children. Other institutions, such as Science Gallery, focus entirely on adults and young adults. We recommend that the knowledge gained by these institutions is shared in the professional field and that more incentives are given to develop long term programs with adults.

6.5.3 “Bring the political back in”

We recommend that science centers and their funders invest in innovating both the formats and the processes to interface with politics and policy making. From within the professional field, there is a call for science centers to develop projects that “feed back

into science policies and/or research and innovation endeavours” (Troncoso & Becker, 2015, para. 45). More generally, the scholarly field of science communication advocates for new methods of public engagement to pluralize practice (Irwin, 2014), to bring “the political back in” (Nowotny, 2014, p. 20), to build trust with policy makers using informal settings (Emery et al., 2015; Stilgoe et al., 2014). These reflections express a need to create new institutional interfaces between the public and the realm of science governance. Interfaces which broaden access and inclusion in the discourse of science policy and that offer new instruments to (re)define what public interest means (Nowotny, 2014). Our study shows that visitors actually expect a role of science centers in policy. It seems therefore clear that there is an opportunity for science centers to be players in the governance of science. Building on their potential to interest the ‘unengaged’ public in discussions about contemporary science and technology, science centers can actively contribute to develop innovative participatory mechanisms that challenge the current, formal processes. It requires a lot of effort and capacity to make mistakes, but there is a concrete opportunity for science centers to start shifting the meaning of ‘engagement with science’ to ‘engagement with the role of science’ in society.

This shift is particularly important at a time when European policy makers define research and innovation as ‘responsible practices’, that is practices where all the stakeholders involved take responsibility for the process and outcomes of their endeavors (Stilgoe, Owen, & Macnaghten, 2013). Science centers can play in this regard an important function. They can integrate public engagement in the practice of ‘responsible research’ by enabling conversations and discussions between multiple stakeholders. Usually, these conversations and the issues for public debate are decided by ‘experts’, not by the public (Wilsdon & Willis, 2004). Science centers offer instead horizontal access to discussions related to the role of science in society, regardless of the expertise of the participants. Furthermore, visitors expect that science centers play a role in policy based on the knowledge that is discussed and exchanged with the public. These are two important ingredients to create an infrastructure where the public has the possibility to decide which issues are important to discuss, and science centers can be the platforms to bring these issues to political attention.

6.6 Final conclusions

From this research, the following final conclusions can be drawn:

- When science centers present contemporary science to the public, they shift their role from being authorities on a given subject to being brokers of knowledge;
- Because of this shift, public participation becomes an integral component of the process to construct and negotiate knowledge in the science center;
- Science centers are experimenting with several formats of public participation, but they are also wary about the consequences of these experiments, and in particular about the negative public opinion that might ensue;
- Visitors' interest to participate in discussions and debates in science centers does not depend on their age, gender, frequency of visit, and it is only in minimal part related to their existing interest and engagement with science.
- Visitors with a lower level of formal education express a higher interest to participate in discussions and debates than visitors with higher levels of education;
- Interest in the co-development of programs and exhibitions is higher among visitors who are male, higher educated, already engaged with science and frequent visitors to the science center;
- Scientific citizenship is strongly related to the interest to participate in discussions and debates in science centers; it is only marginally related to the interest in co-development.
- Visitors are aware of the role of science center in public policy, and this awareness positively affects their interest to participate in discussions and debates.

6.7 References

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Summary

A visit to a science center today is not only an opportunity to learn about science; it becomes an opportunity to participate in how science is communicated and reflected in society. Science centers and museums can be considered places where visitors become scientific citizens, that is, places where the public is qualified to participate in conversations and societal discussions related to scientific knowledge. This dissertation examines what happens when the public participates in a science center, how institutions manage participation and how visitor participation is related to scientific citizenship.

The General Introduction (chapter 1) describes the scientific and societal background for this research. The engagement of citizens with science is currently a cornerstone of European science and innovation and it has become an indissoluble component of science policy. In this context, science centers and museums represent a unique platform to develop and implement innovative public engagement opportunities for a wide public. They communicate current science and technology with millions of visitors every year, and at the same time they play a strategic role in European policy, thanks to their active role in several policy-oriented European initiatives. However, there is little available research on how science centers support visitors' participation, and more specifically on what role scientific citizenship plays in this context. The current research aims at furthering the knowledge about public participation within European science centers by focusing on three main questions:

- What is the role of public participation in the institutional structure of science centers?
- What are the opportunities and barriers in European science centers to enable public participation?
- What is the relationship between scientific citizenship and visitor interest to participate in science centers and museums?

Answering these questions is necessary in order to contextualise the opportunities for participation in science centers, and to understand which kind of public(s) – or better, scientific citizens – science centers are in fact shaping. Are science centers

a locus of participation by themselves, or are they a broker of participation, fulfilling an instrumental role to connect the public to a more complex system of science governance?

This research draws on two academic fields of study, namely museum studies and science, technology and society (STS) studies. The former provides the framework to understand museums and science centers as institutions with a strong civic component and as public institutions where the public can reflect about societal developments. The latter provide the theoretical structure to study how the situated knowledge of the visitors becomes a substantive factor in the process of public engagement with science and science policy.

Three methodological approaches are used. In the first part of the research (chapter 2), literature review is used to develop a conceptual understanding of the institutional effects of public participation in science centers. The second part of the research (chapter 3) aims at strengthening the theoretical understanding of how science centers enable public participation, and in particular of what are the barriers and obstacles to its implementation. A grounded-theory approach was used, based on a series of case studies and in depth interviews. The third part of the research (chapters 4 and 5) focuses on visitors' interest in public participation and the factors affecting such interest. For this section a quantitative approach was used, with a survey administered to visitors to seven national science centers and museums in Europe. Structural equation modelling (SEM) was used to analyse the relationships among the factors contributing to visitors' interest in public participation.

The study presented in chapter 2 discusses current practices of public participation in European science centers and museums and argues that a new governance model is necessary in order to engage the public in the processes of: (a) developing museum activities, (b) making decisions about museum operations and (c) participating in museum governance. The study presents a review of the process of change that has characterized the museum field in the past century, looking at how the current governance structures of museums have been identified as possible barriers to effective public engagement. Drawing on recent literature, the study presents the argument that because science centers produce and mediate scientific culture with the public, they are subject to the policy recommendations that call for a thorough participation of citizens to contribute to and inform the direction and development of scientific research. This argument leads to the formulation of a governance model with the direct participation of the public.

The empirical study presented in chapter 3 analyses the opportunities, barriers and obstacles to public participation in European science centers and museums. In-depth interviews were conducted with 22 members of staff from a sample of five institutions, to identify who has decision-making power in the institution, whether the public is involved in the decision-making process, and what are the barriers to implement public participation in the decision-making process of science centers and museums. The results show that decision-making in science centers and museums is a complex process, and it is only partially structured according to clear procedures. There are currently several initiatives to involve the public in activities that include some level of decision making, even though these are incidental and not yet integral to the governance of the institution. The analysis shows also that there are four kinds

of structural barriers and obstacles that prevent a structural participation of the public in the decision-making process. These are institutional conflicts, lack of professional development, fear of public controversy, and difficulty in reaching specific publics. To address these barriers, science centers should consider strengthening their evaluation and assessment practices, as well as granting more agency to the staff currently interacting with the public.

The study presented in chapter 4 analyses the relation between visitors' interest to participate in the museum, their engagement with science, and their perceptions of the museum as a platform of scientific citizenship. Three levels of participation are addressed: Sharing opinions and feedback (i.e. considering the museum as a 'forum'); co-developing programs and activities; and participating in the governance of the museum. Quantitative analysis of the data from a survey conducted among 364 adult visitors to the Science Museum in London reveals that interest in the forum function of the museum does not depend on visitors' prior engagement with science, but rather on how the museum enables the scientific citizenship of its visitors. However, for interest in co-development the reverse was found – previous engagement and frequent visits are more important than scientific citizenship. Both the forum function of the museum and its perceived role in public policy further determine visitors' interest in museum governance. The results of this study suggest that the expectations that the museum will act as a 'broker' between the public and policy making are significant factors to predict visitor's participation in conversations, discussions and debates, and in the governance of the museum. At the same time, other forms of participation, such as the co-development of activities, reproduce patterns of 'engaging the already engaged'.

The study presented in chapter 5 improves the quantitative approach introduced in chapter 4 and applies it to a sample of 652 visitors to 6 national science centers and museums in Europe. The results show that interest in co-design depends largely on the visitors' pre-existing level of engagement with science, and reflects patterns of privilege for interest in science. The interest to be involved in discussions and debates instead is strongly related to how science centers enable scientific citizenship. The expected role of science centers in policy is also related to the visitors' interest to participate in the governance of the institution.

The findings of these studies lead to four considerations which are discussed in the final chapter of the dissertation.

The first consideration is that science centers play an important role to democratize public participation in science. The interest of visitors to participate in discussions and debates regardless of gender, visitation patterns, and to some extent previous engagement with science, suggests that locating public participation in science centers can facilitate the engagement of the often assumed 'disinterested', or less engaged, publics. More specifically, the context of the science center, which stimulates and supports the scientific citizenship of their visitors, can elicit a higher interest to participate in audiences with lower education levels, who otherwise express a lower level of engagement with science than visitors with higher education levels.

The second consideration is that the co-development of exhibitions and programs by the public together with the staff of the science center tends to reproduce patterns of privilege for interest in and access to science. There is a risk that in this case science centers tend to perform an instrumental role for already engaged audiences

to enact their (existing) interest in science, rather than a substantive role in widening interest and engagement.

The third consideration is that visitors are more interested to share their opinions about the content presented in the science center when they expect some agency of the science center in public policy. That is, the expected political agency of the science center contributes to how visitors enact 'being the public' in science centers.

The fourth consideration is that there are currently two misalignments between the assumptions of the staff working in science centers and the experience of the public. The first misalignment is that science centers tend to conceive public participation as an activity which engages limited audiences (chapter 3), whereas the studies in chapter 4 and 5 show that a large number of visitors regardless of age, education and prior level of science engagement are interested to participate by sharing their feedback and opinions. Instead, the assumptions of the science centers are reflected in the interest to co-develop, which is confined to more specific audiences, and follows more traditional patterns of privileged access (males, frequent visitors, highly educated). The second misalignment is between the uneasiness of science centers to acknowledge their political agency, that is, their capacity to influence the political field, and the importance of this role in engaging the visitors.

This research suggests additional lines of research to better understand the role of science centers and museums in the field of public engagement with science. 1) Studying the relevance of scientific citizenship at city and regional level; 2) include non-visitors in future studies of how science centers support scientific citizenship; 3) research the forms of political agency that are possible and desired by both science centers and their visitors; 4) researching new forms of public engagement, in particular inclusive practices such as citizen science.

The dissertation offers three recommendations for policy and practice based on the findings of the research. The first recommendation is to make co-development more 'horizontal', that is a process which includes also non visitors and that becomes co-production of knowledge rather than co-development of exhibitions or programs. The second is to focus on adult visitors in order to reduce the assumptions and stereotypes that science centers have about their visitors. The third one is that science centers and their funders invest in innovating both the formats and the processes to interface with politics and policy making.

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When I decided to start this PhD research, a dear friend of mine warned me that it will be a solitary experience, and that I should be prepared to be alone in a challenging and hard process.

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