Rethinking the Social Contract between Science and Society: Steps to an Ecology of Science Communication

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Foreword

I have for many years wanted to do a more comprehensive study of public communication of science and technology, which made it possible for me to learn something new and at the same time contribute to the field of science communication research. Thus, I decided to write a new article based dr.philos.-thesis that gave me an aim, room for exploration, and a good excuse to read interesting science and technology communication literature. If successful, so I thought initially, it would also make it possible to contextualize new research ideas about citizen science that I had been thinking about for some years.

As a dr.philos. thesis writer, I have no supervisors and no fellow students to thank. On the other hand, however, I have enjoyed being part of InterMedia/Change/Mediate research activities, so thanks to all my colleagues for the last six and a half years. Three collaborative projects have inspired my thinking and learning. First, *ICT and Learning* (Norwegian Agency for Digital Learning in Higher Education, 2013–2015); a special thanks to Jan Erik Dahl, Bård Ketil Engen, Monica Johannesen, Louise Mifsud, Anders I. Mørch, Ole Smørdal, and Leikny Øgrim. Second, *ENABLE: Higher Education and Multimedia in Special Needs Education and Rehabilitation* (Norwegian Agency for Development Cooperation, 2013–2018); a special thanks to Lawrence Eron, Suitbert Emil Lyakurwa, Proscovia Suubi Nantongo, Stackus Okwaput, Yngve Refseth, and Bjørn Skaar. And finally, *Cultural Heritage Mediascapes: Innovation in Knowledge and Mediation Practices* (The Research Council of Norway, 2015–2019); a special thanks to Line Esborg, Emily C. Oswald, Palmyre Pierroux, and Rolf Steier. Thanks also to Terje Thoresen for all his ICT support during this endeavor.

I am also tremendously grateful to Professor Sue Stocklmayer, who invited me to the Australian National Centre for the Public Awareness of Science (CPAS) at the Australian National University from the beginning of December 2015 until the end of June 2016, and her successor Professor Joan Leach, who took me on when Sue left her position as Director. Both Sue and Mike Gore were crucial in the planning phase, as was Mary Hooper, the administrator at CPAS. I have enjoyed talking with many members of the staff, and Sean Perera and Suzette Searle introduced me to the Multicultural Discussion Group and the many interesting discussions in that group. I have shared office with Bobby Cerini, before she moved to Questacon; David Kirby, visiting fellow from the University of Manchester; and Catherine Rayner. I have also enjoyed my discussions with Toss Gascoigne and Bernard Schiele, both longstanding members of the Network for the Public Communication of Science and Technology. Bobby Cerini and Annette Williams, Questacon, introduced me to the planned Citizen Science activities in the *Inspiring Australia programme*, Paul Flemons to the Australian Museum Centre for Citizen Science, and Peter Brenton and Stephanie von Gavel to Atlas of Living Australia. I am grateful to all of them for their hospitality and insight.

My stay at CPAS was made possible by the *Cultural Heritage Mediascapes: Innovation in Knowledge and Mediation Practices* project, funded by the Research Council of Norway (2015–2019), with Palmyre Pierroux as project leader, and research leave from the Department of Education. I am most grateful for all the support I have received. Only one of the studies received any form of external financial support. Study V was made possible through financial support from the Norwegian Centre for ICT in Education, and I appreciate this support. There is a general guideline of 50% teaching and 50% research time for academic posts at the University of Oslo, and after having been a "contract researcher" within the institute sector for many years, I appreciate this opportunity to select my own research topics within the security of an academic post.

In the finalization of the thesis, I asked three people to read the extended abstract: Joan Leach, Sten R. Ludvigsen, and Palmyre Pierroux. Their comments have been useful for finishing the thesis, so a huge thank-you to all three. Needless to say, I alone am responsible for what appears on the following pages. Any shortcomings or mistakes in the studies and the extended abstract are my own.

Academia is only a small but important part of life. Even more important are family and friends, so thanks to them all for being there, and a warm thank-you to Hilde, who has been my passionate companion through life for more than 41 years. Finally, my two grandchildren, Maya and Lucas—their smiles, questions, and comments are always enjoyable and sometimes puzzling!

Canberra/Oslo, June/July 2016

Per Hetland

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Study II:

Hetland, P. (2015). Popularizing the Internet: Traveling Companions Supporting the Good News. *Nordicom Review, 36*(2), 157–171.

Study III:

Hetland, P. (2012). Internet Between Utopia and Dystopia: The Narratives of Control. *Nordicom Review, 33*(2), 3–15.

Study IV:

Hetland, P. (2016b). Public Communication of Technological Change: Modest and Less Modest Witnesses. Submitted (later published in *Nordic Journal of Science and Technology Studies* 4(2), 5-16)

Study V:

Hetland, P. (2011b). The User Paradox in Technology Testing. *Nordic Journal of Digital Literacy, 6*(1–2), 7–21.

Study VI:

Hetland, P. (2011a). Science 2.0: Bridging Science and the Public. *Nordic Journal of Digital Literacy, 6*(Special Issue), 326–339.

For Maya and Lucas

Abstract

Three key questions guide this thesis.

First, how is public communication of science and technology (PCST) organized in different models of expert–public interaction?

Second, how do different models of science and technology popularization frame science and technology narratives?

Third, building on the first two questions, what are the implications of these models for the social contract between science and society?

This thesis involves both an exploratory cross-case analysis of PCST and a comparative mixed-methods study. The case studies were conducted using a broad array of methods: reviewing policy documents, articles from 3 newspapers over 12–18 years, and the study of participation in experiments and new infrastructures for doing citizen science through documents, observations, and interviews.

This thesis has eight crucial contributions to an improved understanding of public communication of science and technology.

By critically examining the three science communication models, dissemination, dialogue and participation, the thesis makes five contributions: 1) a study of how public appreciation of science and technology are promoted by the use of bias; 2) a study of how public engagement with science and technology are promoted by mediatization processes; 3) a study of how researchers in their popularization activities promote critical understanding of science and technology being modest witnesses; 4) a study of the dialogue models' room for participation in knowledge and policy construction processes; and 5) in studying the participation model, a better understanding of citizen science and boundary infrastructures.

Finally, the thesis has three more general contributions: 6) it represents the first comprehensive examination of science communication policy in Norway; 7) focusing on technology, it links science communication research and innovation studies; and 8) it contributes to a more analytical approach studying the three science communication models as trading zones within the context of the Nordic model of science communication.

The author is employed by Department of Education, Faculty of Educational Sciences, University of Oslo.

Norsk sammendrag

Tre overordnede forskningsspørsmål står sentralt i denne avhandlingen.

Først: hvordan er teknologi- og forskningskommunikasjon organisert i ulike modeller for samhandling mellom ekspertise og publikum?

For det andre: hvordan rammer ulike modeller for popularisering inn fortellingene innenfor teknologi- og forskningskommunikasjon?

For det tredje: hva er konsekvensene av disse modellene for den sosiale kontrakten mellom teknologi- og forskningsvirksomhet og samfunn?

Denne avhandlingen består av fem ulike casestudier av teknologi- og forskningskommunikasjon samt en komparativ studie på tvers av casestudiene. Casestudiene ble utført ved hjelp av et bredt spekter av metoder: studier av politikkdokumenter, artikler fra 3 ulike aviser gjennom 12-18 år og ved hjelp av observasjoner og intervjuer med deltakere i sosiale forsøk med ny teknologi og ny infrastruktur for å engasjere publikum som deltakere i forskningsaktivitet, eller det som også kan kalles, borgervitenskap eller folkeforskning.

Denne avhandlingen har åtte viktige bidrag til en bedre forståelse av teknologi- og forskningskommunikasjon.

Ved en kritisk studie de tre kommunikasjonsmodellene, den klassiske formidlingsmodellen, dialogmodellen og medvirkningsmodellen, har avhandlingen fem bidrag: 1) En studie av hvordan teknologi- og forskningskommunikasjon preges av klare skjevheter eller slagsider; 2) en studie av hvordan mediene gjennom teknologi- og forskningskommunikasjon er med på å "temme" eller domestisere teknologi og vitenskap; 3) en studie av hvordan forskere i deres direkte forskningskommunikasjon fremmer kritisk forståelse ved å være "beskjedne vitner"; 4) en studie av dialogmodellenes rom for deltakelse i kunnskapsutvikling og politikkutforming; og 5) ved å studere medvirkningsmodellen, en bedre forståelse av borgervitenskap eller folkeforskning og infrastrukturer for forskningssamarbeid.

Endelig har avhandlingen tre mer generelle bidrag: 6) Den representerer den første mer omfattende studie av politikkutvikling innenfor teknologi- og forskningskommunikasjon i Norge; 7) ved å rette blikket spesielt mot teknologikommunikasjon, kobler avhandlingen teknologi- og forskningskommunikasjon og innovasjonsstudier; og 8) den bidrar til en mer analytisk tilnærming til de tre modellene for teknologi- og forskningskommunikasjon ved å se på dem som utviklingsarenaer innenfor rammen av "Den nordiske modellen for teknologi- og forskningskommunikasjon".

Forfatteren er ansatt ved Institutt for pedagogikk, Det utdanningsvitenskapelige fakultet, Universitetet i Oslo.

PART I:

EXTENDED ABSTRACT

Chapter 1 - Approaching the Ecology of Public Communication of Science and Technology

Thesis Background and Aims

Science, technology, and public enlightenment are crucial elements of the modern project. As a forerunner of the modern project, academia includes education, scientific research, and the communication of science and technology as its three most prominent assignments. In *Steps to an Ecology of Mind*, the anthropologist Gregory Bateson (1972) introduces the ecology of ideas. This thesis addresses the ecology of an element within the third assignment: public communication of science and technology.[1] One important aspect of the ecological approach is to uncover the multiple viewpoints that have enriched the debate over public communication of science and technology over the last decades, as there has been an increased focus toward first how different models of expert-public interaction frame public involvement (Bucchi, 2008; Trench, 2008b) and second how different models of science and technology popularization frame science and technology narratives (Perrault, 2013). This interest has emerged partly from the ongoing debate about science's new social contract[2] with society (Gibbons, 1999; Jasanoff, 2005; Nowotny, Scott, & Gibbons, 2001). Certainly this contract is not a legal contract in the usual sense, but a long-term social contract executed under the conditions of uncertainty (Williamson, 1979, p. 237) involving a number of aims, financial contributors, public and private institutions, mediators, publics, and other relevant stakeholders. In Norway, and to a great extent in all the Nordic countries, the concept of public communication of science and technology also encompasses the public communication of the social sciences and humanities. For the sake of simplicity, when referring to science communication research, the acronym *SCR* will be used, while the terms *public communication of science and technology* (PCST), *communication of science*, and *science communication* are used throughout the thesis to refer to all science and technology "mediation, interpretation, dissemination and explanation activities—the range of efforts, among others, to inform, sensitize and mobilize the public" (Schiele & Landry, 2012, p. 34).

[1] Maja Horst introduced me to the ecosystem of science communication and the ecological approach applied here.

[2] Some authors use the concept *compact* instead of *contract*; as I understand it, the difference it is basically loose versus strict. However, the very concept of a *social contract* is loose in itself. I therefore prefer to use *social contract* instead of *compact*, since it will—at least in a Nordic context—create less confusion.

The “energy” that flows through the Norwegian ecosystem of PCST comes partly from the unwritten and written social contract between science and society (Hetland, 2014; Løvhaug, 2011), and partly from a strong interest in developing new knowledge and understandings and communicating the findings to others (Searle, 2011; Steen, 2015). A large diversity of different publics engage in popularized science, but also in doing science, giving feedback directly or indirectly, facilitating a variety of communication forms with many possible outcomes, be it upstream and/or downstream mediating processes, knowledge dialogues, or building new knowledge. Consequently, the ecosystem of PCST may be studied along many dimensions. The present thesis focuses on the more overarching science communication policy in Norway (Hetland, 2014), the popularization activities within the deficit or dissemination model (Hetland, 2012, 2015, 2016b), the dialogue model (Hetland, 2011b), and the participation model (Hetland, 2011a). Earlier studies not included in this thesis analyzed narrators as journalists (Hetland, 2002b), along with their audiences (Hetland, 1999, 2002b). Although the deficit model has been much debated within SCR, the present study indicates that the deficit or dissemination model remains highly important in PCST, not the least because major stakeholders have clear interests in promoting technoscience by use of the dissemination model.

Recently, the journal *Public Understanding of Science* celebrated its 20th anniversary, featuring reflections on the past and future directions of the field of SCR. The first paper identified an increase in papers on public engagement, science communication, public perception, and scientists’ representations and forms of activism, while literacy, science museums, ethics, risk perception, science journalism, and the image of scientists received relatively less coverage (Bauer & Howard, 2012). The second paper identified five clusters of significant word associations in the vocabulary used (Suerdem, Bauer, Howard, & Ruby, 2013). Two clusters are of interest for the present thesis. The first maps a change from discussing public understanding to a concern with public engagement, or a shift in discourse from deficit to dialogue. The second cluster of special relevance maps a change in focus from media coverage to media framing. The third paper, which reviewed the 50 most-cited papers, identifies more discussions of public engagement and a turn in the academic approach to public dialogue “from a normative role advocating dialogue, towards a more critical stance, discussing why particular examples of public dialogue were or were not effective” (Smallman, 2016, p. 193).

The SCR field in Norway is not large enough to conduct a study that produces similar, well-founded conclusions. However, based on the content of three journals—*Public Understanding of Science*, *Science Communication*, and the Norwegian journal *Norsk Medietidsskrift*[3]—I have made a short study of which topics dominate Norwegian SCR since

[3] The journal was selected as the most-used Norwegian journal for SCR among the more than 50 journals published under Idunn.no.

1992. The first cluster can be called from public understanding to public engagement (Delgado, Kjølberg, & Wickson, 2011; Henriksen & Frøyland, 2000; Kallerud & Ramberg, 2002; Paine, 1992; Ryghaug, Sørensen, & Næss, 2011). The second cluster concerns framing and the dramatization of science and technology (Carver, Rødland, & Breivik, 2012; Delgado, Rommetveit, Barceló, & Lemkow, 2012; Magnus, 2010). The third cluster focuses on the implications of the third assignment and science–media interaction (Bentley & Kyvik, 2011; Carlsen, Müftüoglu, & Riese, 2014; Eide, 1997; Eide & Ottosen, 1994; Kyvik, 2005; Nag, 1997; Ottosen, 1996; Tøsse, 2013; Vettenranta, 2001).

Comparing the international level with the national level, international and Norwegian SCR have much in common, except Norwegian SCR seems to be more concerned with the third assignment and science–media interaction. Therefore, this thesis studies the shifts in the Norwegian context from dissemination via dialogue to participation, especially the different approaches to dialogue and participation, and from media coverage to media framing within the larger context of science's new social contract. The present thesis also attempts to overcome one deficit in SCR, which has given "much less attention to technological developments than to those based on scientific research" (Trench & Bucchi, 2010, p. 2). Consequently, this thesis will study the popularization of a highly topical new technology, the Internet; experiments with information and communication technologies (ICT); and how citizen science (CS) can be facilitated by the development of new boundary infrastructures, such as the online portal Species Gateway[4], which launched in 2008.

In a review of how different models of expert–public interaction frame public involvement, Trench (2008b) found authors who identified three, four, and five different models. Studying the various arguments presented for these models, I concur with Trench (2008b) that three key models dominate SCR: the deficit, dialogue, and participation models. I, however, argue that *deficit* is a value-loaded concept that does not describe the model itself but, instead, makes assumptions about public knowledge that the communicators might have. Given that it is impossible to know for certain what assumptions about the different publics the communicators hold, I prefer to call the deficit model the dissemination model. Much evidence indicates that, even if outreach activities are intended to use other models, the dissemination model serves as their backbone (Brossard & Lewenstein, 2010). This trend is apparent in both policy and handbooks used within Norwegian PCST. One example comes from two handbooks suggesting science communication guidelines for Norwegian researchers. In 1982, Erlandsen published a book about how to popularize research, followed by a similar book by Farbrot in 2013. The more than 30 years between these two books are evident in the presentation of the three communication models by Farbrot (2013). However, he concludes that:

[4] In Study I and VI called Species Observation

> There is still reason to believe that one-way science communication will continue to dominate for the foreseeable future. It takes a long time to change established practices in a sector that carries a burden of traditions. But one-way science communication will gradually be supplemented by science communication which increasingly relies on dialogue and sharing. (Farbrot, 2013, p. 21, my translation)

Working from this perspective, Farbrot (2013) makes the dissemination model the backbone of his book. More surprisingly, critics of the popularization of science also use the dissemination model as a framework for their critiques (Öhman, 1993). Consequently, it is important to open up these three key models—dissemination, dialogue, and participation—for elaboration and discussion. Such an elaboration and discussion might also shed light on Irwin's question if we are "moving forwards or in circles" (2009, p. x).

All three key models of expert–public interaction and the variations within them are crucial to understand how science's social contract has evolved since 1945. Within a diversified media landscape, there has been growing interest in PCST, which plays an important role in how one understands science's social contract. The interest has its parallels in both science and technology policy and the sciences, including the humanities and social sciences. According to Vannevar Bush's 1945 report *Science: The Endless Frontier*, science can secure our health, prosperity, and security; higher education can expand the frontiers of knowledge; and the new frontiers of science should be made accessible to support the development of all citizens. Based on these ambitions, Bush (1945) formulated a program holding that improvement in the teaching of science is imperative and that it is important to maintain a proper relationship between science and other aspects of a democratic system. *Science: The Endless Frontier* became a manifesto for the support of basic science, and consequently the linear argument (Godin, 2006), although the relationship between basic science and innovation is rather complex (Stokes, 1997). Science was the "goose laying golden eggs." Following this metaphor, science and PCST were on the policy agendas of most aspiring economies after World War II, including Norway (Hetland, 2014; Løvhaug, 2011; Skoie, 2005), the Bodmer Report being especially influential in the late 1980s (Bodmer, 1985). Among others, Bush encouraged and developed the idea of a social contract for science (Guston, 2000; Stokes, 1997). The contract should ensure that the government funds basic science, while scientists provide discoveries that can be translated into new scientific and technological benefits. This social contract has long been under pressure, as "the old contract was made between a kind of government that no longer exists and a kind of scientific community that has long since disappeared" (Guston & Keniston, 1994, p. 17). Therefore, when Gibbons et al. introduce science's new social contract with society, it is to ensure the production of socially robust knowledge:

> A new contract will require more open, socially distributed, self-organizing systems of knowledge production that generate their own accountability and audit systems. Under the prevailing contract, science was left to make discoveries and then make

> them available to society. A new contract will be based upon the joint production of knowledge by society and science. (Gibbons, 1999, p. 17)

This new contract could serve to democratize science (Dickson, 1988) and move beyond the strong user involvement ideology that has been prevalent in Norwegian science and technology policy (Kallerud, 1996). A recent approach to democratize science and technology is found in what is called Responsible Research and Innovation (RRI), which describes a research and innovation process that takes into account effects and potential impacts on the environment and society (Von Schomberg, 2013). According to Stilgoe et al. (2013), RRI has four dimensions: a) anticipation, b) reflexivity, c) inclusion, and d) responsiveness. All the mentioned dimensions include different approaches to expert–public interaction. RRI is now part of both EU and Norwegian policy guidelines.

As stated, PCST has been understood as a crucial part of a long-standing, unwritten social contract between science and society. This social contract has in Norway increasingly been made explicit and written; e.g., in the laws governing higher education institutions in Norway: first, in the law governing the University of Bergen (1948), followed by the revised law governing the University of Oslo (1955), the law governing all public higher-education institutions (1995), the revised law governing both public and private higher-education institutions (2005), and, finally, in the expanded and strengthened 2013 *Act Relating to Universities and University Colleges*, which declared that higher education institutions have three assignments: education, scientific research, and science and technology communication.[5] Consequently, science and technology communication is sometimes called the third assignment, which should: 1) contribute to public communication of science and technology, 2) contribute to innovation, and 3) ensure the participation of higher education staff in public debate.[6] One important condition for undertaking the third assignment is academic freedom (Underdal et al., 2006), and this was from 2007 included in the *Act Relating to Universities and University Colleges*. The Norwegian National Research Ethics Committees have since 1990 given advice on research ethics, and, according to the Norwegian *Guidelines for Research Ethics in the Social Sciences, Law and the Humanities* (NESH, 2006),

> Science communication involves communicating insights, ways of working and attitudes (the ethos of science) from specialised fields of research to individuals outside the field ('popularisation'), including contributions to social debates based on scientific reasoning' (p. 32). And further on; 'Communication is also an expression of one of the requirements for democracy: Communication shall contribute to the

[5] http://www.lovdata.no/all/nl-20050401-015.html

[6] Consquently, I will make a distinction between science and technology communication (containing the mentioned three elements) and public communication of science and technology (beeing one of the three elements).

> maintenance and development of cultural traditions, to the informed formation of public opinion and to the dissemination of socially relevant knowledge. (p. 33)

It is, however, unclear if this responsibility is primarily an individual responsibility, primarily an institutional responsibility, or a combination of both.

In Norway, PCST has its historic roots in the Danish–Norwegian Enlightenment tradition from the end of 1600 and beginning of 1700 (Engelstad, Grennes, Kalleberg, & Malnes, 1998). The third assignment, therefore, has been perceived as an important part of the Humbolt legacy of *Bildung*, or liberal education and civic character formation (*danning*) (Kalleberg, 2011). Kalleberg (2012, p. 48, emphasis in original) draws a clear distinction between two academic roles: "one as experts with *clients*, the other as public intellectuals with *citizens*." The translation of science in a highly specialized language to general knowledge for the public has long concerned intellectuals (Dewey, 1927; Fleck, 1935/1979; Öhman, 1993). Studies of the third assignment in Sweden show that it was understood within a dissemination model and in more dialogical models (Kasperowski & Bragesjö, 2011). In Denmark, Horst (2012) claims, the participatory governance of science and technology is founded on cultural traditions of dialogue. An important figure in this long tradition in Scandinavia is Danish-Norwegian professor Ludvig Holberg (1684–1754), who was deeply concerned with the emerging publics in the early Danish–Norwegian Enlightenment (Kalleberg, 2008).

From 1800 and to 1980, concepts such as popularization (*popularisering*) and public enlightenment (*folkeopplysning*) dominated discourse, while concepts such as science dissemination (*forskningsformidling*) and science communication (*forskningskommunikasjon*) came into usage from the 1980s through the early 2000s. Their popularity over the past 30 years is illustrated by their appearance in two large Norwegian newspapers (*Aftenposten* and *VG*)[7]. The term *popularization* was also used over these three decades, but generally fell out of use in the early 2000s. *Public enlightenment*, however, remains in use. *Science dissemination* emerged in the 1980s and became the dominant concept in the early 2000s. *Science communication* came into use in the early 2000s, but whether it will overtake *science dissemination* remains to be seen. Especially in the Norwegian context, *science communication* is sometimes understood as public relations (PR). PR are an important part of the history of SCR, as the field encompasses scientific institutions' PR concerns (Bauer & Bucchi, 2007). These four concepts—popularization, public enlightenment, science dissemination, and science communication—illustrate changing understandings within science and the news media in Norway. A similar search on regjeringen.no, which contains most relevant policy documents since the late 1990s, returned *public enlightenment* as the

[7] This assertion is based on a search in the electronic database Atekst/Retriever. The two newspapers were selected, as they are available in digital format for the mentioned period: *Aftenposten* from 1 January 1983 and *VG* from 1 January 1945.

most-used term, while *science dissemination* was used almost as frequently. However, policy documents provide a different context for the use of concepts than the news media.

Thesis Design

Within the three key models of PCST, there is, however, a continuum of variations. For example, it is necessary to study the dissemination model closer when it comes to popular science and technology communication. Bech-Karlsen (1996) and Perrault (2013) provided directions for doing so. Bech-Karlsen suggested how the Enlightenment tradition can be understood in different contexts. In defense of the Enlightenment tradition, Bech-Karlsen (1996) points to the basic distinction between the Nordic and continental European traditions: "The Nordic variant is based upon a dialogue and respect for the recipient's values, while the European model regards the recipient as 'an empty container' which shall be filled with knowledge" (Bech-Karlsen, 1996, p. 22). Bech-Karlsen (1996) described the classic European tradition as a transfer of knowledge from the expert to the layperson. In the Nordic tradition, though, the expert enters into a dialogue with the layperson. Bech-Karlsen maintains that there is nothing inherently authoritative within the Enlightenment tradition; its authoritative aspects are temporary and circumstantial.

Perrault (2013) develops this argument by identifying three sub-models of science and technology popularization: public appreciation of science and technology (PAST), public engagement with science and technology (PEST), and critical understanding of science in the public (CUSP). The PAST sub-model is characterized by a one-way flow of information from the scientific sphere to the public in which science is a black box, reading is uncomplicated, knowledge is boosted, and the deficit exists only on the reader's side. The PEST sub-model conceives of science communication as a conversation open to dialogue; however, this sub-model still separates science and society, and locates the center of gravity in science. The CUSP sub-model of science communication considers all the elements of science-in-society, including their interactions, to be worth scrutinizing. The CUSP sub-model offers four advantages: first, it has a "relational" focus; second, expertise is multiple; third, it focuses on the twin duties of science communication to inform and educate while probing and criticizing; and fourth, it matches the reality of the public's views of science, which combines public enthusiasm and public criticism (Perrault, 2013, pp. 12–17). Consequently, in this thesis, I structure my understanding of science and technology popularization around these three sub-models.

In addition, I argue that the dialogue model varies depending on the extent to which participants contribute to the knowledge and policy construction processes (Hetland, 2011b). Finally, within the participation model, one finds a similar variation (Socientize, 2015), which is not explicitly discussed in Study VI (Hetland, 2011a), but is included in the present extended abstract. The emergence of Web 2.0 has ushered important changes over the past

10–15 years, as “new media technologies have redesigned the relationships we have with one another and with organizations” (Brabham, 2013, p. xv). Significant consequences of these changes are apparent within all three key models of PCST.

Figure 1.1 illustrates how the case studies are integrated, and consequently, how the thesis is designed. The upper and lower parts of the illustration mirror each other in involvement or engagement. The upper side of the line goes from low levels of participation to high levels of participation, and consequently, to the dissemination, dialogue, and participation models. The lower side of the line goes from PAST to CUSP with the three roles of popularization: boosters, translators and critics.

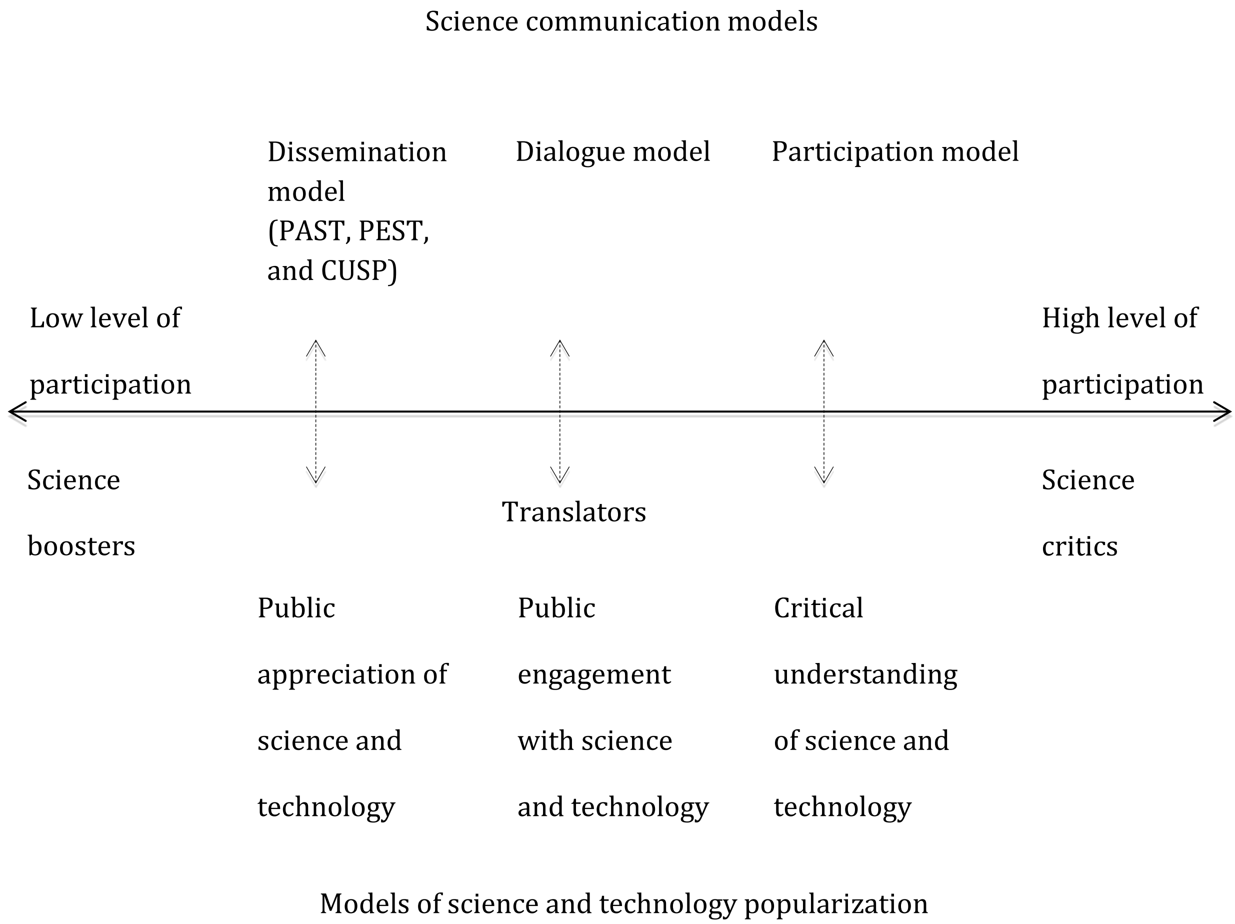

Figure 1.1. Thesis design.

Main Research Questions

Three key questions guide this thesis. First, how is public communication of science and technology organized in different models of expert–public interaction? Second, how do different models of science and technology popularization frame science and technology narratives? Third, building on the first two questions, what are the implications of these models for the social contract between science and society?

This thesis involves both an exploratory cross-case analysis (Flyvbjerg, 1991, 2006; Yin, 2014) of PCST and a comparative mixed-methods study (Creswell, 2014). The case studies were conducted using a broad array of methods: reviewing policy documents, articles from 3 newspapers over 12–18 years, and the study of participation in experiments and new infrastructures for doing CS through documents, observations, and interviews.

The thesis is divided into two parts: the extended abstract (Part I) and the studies (Part II). The extended abstract has six chapters, including this introduction. Chapter 2 addresses how expert–public interaction frames public involvement and how science and technology are popularized, with the social contract between science and society as a backdrop. This general background allows for describing the analytical framework in Chapter 3 and methods in Chapter 4. Chapter 5 presents a summary of the results of the empirical studies included in this thesis and explains the empirical, methodological, and theoretical contributions of the studies. Finally, Chapter 6 concludes the thesis, making particular reference to the social contract between science and society; outlines some limitations; and gives directions for further work.

Part II consists of the six studies on which the thesis is based. In Study I, the focus is on presenting how Norwegian policy for science communication has been formulated since 1975. Three communication models (dissemination, dialogue, and participation) and three sub-models of science and technology popularization (PAST, PEST, and CUSP**)** are identified. Referring to Figure 1.1, study II investigates how the PAST sub-model is promoted by science and technology boosterism, and consequently, the strong pro-innovation bias in PCST. Study III examines the PEST/CUSP sub-models and how the narratives of control contribute to the domestication of ICT, including how expectancy cycles related to the Internet fluctuate in the mass media. This relationship is an important element linking PCST with innovation studies, and also opens up for different forms of public engagement. Study IV explores the CUSP sub-model and how researchers popularize the Internet in comparison to the popularization activities of Norwegian journalists. Most researchers, taking the role of the modest witness (Allan, Anderson, & Petersen, 2005; Dunwoody, 1999; Gunter, Kinderlerer, & Beyleveld, 1999; Haraway, 1997; Shapin, 1984; Shapin & Schaffer, 1985), aim to curb mediatization processes or the constant growth of the media's influence in contemporary society. As such, this study is also interesting in a context where the news-gathering in both new-media and traditional-media landscapes face financial pressure.

Study V analyzes how the dialogue model is applied in design and policy experiments and uses three concepts (authoring, positionality, and improvisation) to probe the room for dialogue. The study structures the room for dialogue along two axes: the intensity of participation in knowledge and policy construction processes. Finally, Study VI probes the participation model through a case study of CS and important processes in building boundary infrastructures. Successful boundary infrastructures presume two levels of boundary objects. The first level facilitates communication and trust. The second level of boundary objects facilitates activities that reach out to different communities and society at large.

The Nordic Model of Science Communication

Are the above-mentioned research questions important, or are they and similar questions already overstudied? Well, as mentioned before, the questions are certainly not studied in excess in Norway, despite the strong policy focus on science communication. Reading the international literature, there are also certain biases, emphasizing some aspects, while leaving other aspects little discussed. This is apparent when discussing the deficit model of the journal *Public Understanding of Science*, which ran an essay competition with the following title: “Why does the ‘deficit concept’ not go away?” (Bauer, 2016). Reading the six essays, I will claim that something is still missing (Cortassa, 2016; Ko, 2016; Meyer, 2016; Raps, 2016; Simis, Madden, Cacciatore, & Yeo, 2016; Suldovsky, 2016). The deficit model is discussed mainly from three angles: (1) public understanding of (the) science(s), (2) scientists’ understanding of the public(s), and (3) the relationships between these two groups of actors. In my studies, I have decided to open up the deficit or dissemination model and critically examine what is actually going on by studying the relevant texts. Consequently, instead of black-boxing the deficit model, it is necessary to open it up for more detailed and critical studies. Perrault (2013) has been very useful in this respect.

Often when reading about the deficit model, dialogue and participation are promoted as a strategy to overcome the flaws of the deficit model. However, dialogue and participation are not solutions without problems. Consequently, it is necessary to critically examine these two models as well. What do dialogue and participation actually imply? I have chosen to distinguish between knowledge and policy construction processes, and will critically examine how the different publics are included in experimental activities. Finally, the participation model is a rising star in the firmament of science communication. This newly won status makes it even more important to critically examine the participation model. Several concepts are used to describe the participants, like *amateurs*, *laypeople*, and *volunteers*. In this thesis, I will use *amateurs* or *volunteers*, since laypeople usually are defined as persons who do not have specialized or professional knowledge of a subject. I prefer to focus on participation and the development of expertise, not on the participants’ assumed knowledge. However, in this thesis, I am only able to study the preconditions for these crucial learning processes. A more detailed study of the actual learning processes will be done in the new, expanded version of this case study, called *Natural History Museums and Citizen Science*, within the framework of the *Cultural Heritage Mediascapes: Innovation in Knowledge and Mediation Practices* project,[8] funded by the Research Council of Norway (2015–2019).

By focusing on Norway, I will claim that one sees the contours of a Nordic model of science communication (NMSC). SCR in the Nordic countries is strongly influenced by the Anglo-American tradition. However, I will claim that there is a specific NMSC that is often overlooked within SCR. The NMSC rests on four pillars:

1) Science communication is almost always understood broadly, including the social sciences and humanities (Hetland, 2014).
2) The very concept of the third assignment underlines the strong contractual element. This contractual element is emerging as a crucial element of the Nordic welfare societies, emphasizing free access to higher education (Ahola, Hedmo, Thomsen, & Vabø, 2014; Christensen, Gornitzka, & Maassen, 2014), including easy access to the benefits of scientific research.
3) Science communication in the Nordic countries builds on a long tradition of dialogue, irrespective of which science communication model is in play (Bech-Karlsen, 1996; Hetland, 2014; Horst, 2012; Kasperowski, & Bragesjö, 2011, Tydén, 1993).
4) The Media Welfare State emphasizes "*universal services*, *editorial freedom*, *a cultural policy for the media*; and last, but not least, a tendency to *choose policy solutions that are consensual and durable, based on consultation with both public and private stakeholders*" (Syvertsen, Enli, Mjøs, & Moe, 2014, p. 2, emphasis in original). The Media Welfare State is in relation to NMSC visible in several collaborative projects, such as forskning.no, forskning.se, and videnskab.dk, just to mention three examples.

These four pillars, I will claim, are the core constitutional elements of NMSC. There are, of course, important variations between the Nordic countries, NMSC is consequently an ideal type. The NMSC constitutes an important context for studying the science's new social contract with society.

To conclude, this thesis aims to study how science communication is practiced by studying the actual communication activities, their contents, and the room for dialogue and participation within a Norwegian/Nordic context.

[8] http://www.uv.uio.no/iped/english/research/projects/mediascapes/index.html

Chapter 2 - Prior Research on Public Communication of Science and Technology

Over the past 20 years, SCR has been dominated by a successive number of themes and models (Suerdem, Bauer, Howard, & Ruby, 2013). Three key models of expert–public interaction are central to PCST: the dissemination, dialogue, and participation models. Together, these three key models provide a multi-model framework for studying public communication of science and technology, and are often described along an evolutionary continuum, from dissemination to dialogue, and then to participation. Underlying this description is an evaluation that the latter two are better than the first. However, I claim that the totality of the three key models is important for how each has developed over time. Science and technology popularization is an important part of the dissemination model and is explored in the PAST, PEST, and CUSP sub-models. Finally, the discourse on changing science systems involves publics differently. Consequently, this review on prior SCR focuses on three topics: first, how expert–public interaction frames public involvement; second, how different models of science and technology popularization frame science and technology narratives; and third, the evolving understandings of the social contract between science and society by exploring hybridity and the evolution of trading zones. The two first parts of the chapter should be regarded as an overview of the review sections in the six studies, while the third part is specific for this extended abstract. However, when Study VI was done, CS was only emerging, and the study does not include a good review on CS; this is compensated for in this extended abstract.

Expert–Public Interaction and the Framing of Public Involvement

I have found three elements that are crucially important for developing an analytical framework of PCST models. First, what are the primary aims of the models including their broader ideological context? Second, what is the format of public participation? Finally, what kinds of expertise do the participants develop within each of the models?

The first model of expert–public interaction is the deficit or dissemination model. The use of the concept of deficit can be traced back to a certain policy panic (DeBoer, 2000). The general solution is to overcome the knowledge deficit in schools and the general population. The deficit model has been much debated within SCR:

> It is a mistake to locate the problem of public understanding in public ignorance; the problem is the presuppositions of the deficit model itself. The deficit model has at least three defects: it embodies a mistaken view of science; it isolates science from

> contexts that give it public significance; and finally, it cannot address the ethical and political issues science raises, or ought to raise. (Gross, 1994, p. 7)

Regardless of what we name this model, it is usually understood as one-way dissemination of information and was the dominant model in PR during the 1980s (Grunig & Hunt, 1984, p. 22). The deficit or dissemination model has since been continually reinvented, and at least seven versions are in circulation (Bauer, Allum, & Miller, 2007; Nielsen & Nielsen, 2006; Rayner, 2004; Wynne, 2006). The first model holds that the public does not have the appropriate scientific or technological knowledge, the second that the public has a negative attitude toward science and technology, the third that the public does not understand the processes of science and technological development, the fourth that there is a deficit in public trust in science, the fifth that there is a public deficit of understanding that "real" science has no ethical/social responsibility for its applications or impacts, and sixth that there is a deficit of knowledge of the benefits of science. One can even add a seventh version: that PCST must attempt to overcome a democratic deficit.

At the same time, though, fundamental changes in the role of science in society have challenged the dissemination model. Slagstad (2006) maintained that *new knowledge regimes* have emerged, and that they use knowledge in new ways to promote modernization. A simple illustration of this trend is found in the relationship between basic science, applied science, and experimental development, as the Frascati Manual defines these categories (Solberg, 2015). When considering the relative strengths of these three categories in Norwegian universities and university colleges, applied science in particular has grown constantly and evenly throughout the past half-century (Solberg, 2015). This growth has encouraged a greater emphasis on user-oriented science communication and thereby strengthened the foundation for the dialogical turn, not the least as the public and users have more obvious roles within applied science.

The second model of expert–public interaction is the dialogue model. When conducting this review, it was difficult to separate the dialogue model from the participation model. Trench (2008b, p. 132) claimed that the two models represent "one-way, two-way and three-way models." In this context, it is also crucial to recall that participation sometimes "does not amount to 'real' participation but superficial pseudo-engagement that comes and goes with the mood of the day" (Lunt, Kaun, Pruulmann-Vengerfeldt, Stark, & Zoonen, 2014, p. 151). Within PR models, Grunig and Hunt (1984, p. 22) distinguished among one-way, two-way asymmetric, and two-way symmetric models. Grunig and Hunt (1984) used the term *coorientation* to define symmetric communication effects as the relationships between ideas and evaluations, and between perceived ideas and evaluations. The resulting degree of symmetry arises from congruence, accuracy, understanding, and agreement between two communicating parties (Grunig & Hunt, 1984, pp. 127-128). Bucchi (2008) and Trench (2008b) were concerned mostly with science's orientation toward the public and the aims of knowledge production. This last element leads precisely to the emphasis on the importance of expertise and the "new problem of extension" (deciding who gets to count as an expert) (H. Collins & Evans, 2007; Dickel & Franzen, 2016; Hetland, 2014). Central to the three key models are various forms of expertise and the position of the public as "a relatively under-theorized doxa shared by both advocates and critics of the public deficit model" (Hess, 2011, p. 628). Understanding the different publics and their roles, consequently, is crucial for improved knowledge of what differentiates the three key models (Braun & Schultz, 2010). Collins and Evans (2007) attempted to map the diversity of expertise. Their project clarified expertise as a social phenomenon and is crucial to a better understanding of the three key models. I return to the question of expertise when discussing the analytical framework.

What Einsiedel (2008, p. 173) calls the "participation explosion" has been described with a wide array of terms, such as *interactive museums*, *stakeholder engagement*, *laypeople conferences*, *constructive technology assessment*, *citizen science*, and *street science*, to mention only a few. This turn to participation is encouraged in both Norwegian and Nordic policy (Hetland, 2014) and European policy initiatives (Socientize, 2015). Research on public engagement, dialogue, and knowledge-building has focused on citizen participation in governing science (Jasanoff, 2012), critical constructivism (Feenberg, 2010), the politics of artifacts (Winner, 1986), awareness and mobilization (Sclove, 1995), public trust (Wynne, 2006), and—not the least—participatory models of "doing science" (Bucchi, 2009; Callon, Lascoumes, & Barthe, 2009; Dickinson & Bonney, 2012; Epstein, 1996).

Consequently, the third model of expert–public interaction is the participation model. User-oriented science communication has a long tradition in the Nordic countries (Tydén, 1993), and over time, the dialogue with users has developed into a full-fledged participation model. This model has roots in the modernization of agriculture, and later strengthened with the opening of new interactive possibilities by new ICT. Even as the importance of science communication grew, dissemination strategies were developed for the applied sciences. From the agricultural extension service came field experiments and corresponding arrangements as models of how innovations can originate and spread. Field experiments serve as science communication originating from practical agricultural and plant culture trials on members' own farms. Agriculture thus has a long history in user-oriented research participation. The agricultural extension services established in the late 1800s and early 1900s promoted science communication according to the dialogue and/or participation model. In Norway, locally funded agricultural extensions were founded in 1927, and a state-funded extension was founded in 1948 (Almås, 2002). According to Almås (2002), politicians saw it as important that the new extension services not be loaded with office work, but that they instead operate in many respects as change agents in their communities. This extension service consisted of two tasks: disseminating knowledge and strengthening rural communities (Rovde, 1995, p. 126). The growing number of communication activities done by extension officers was inspired by the U.S. agricultural extension model for diffusing the results of agricultural research to farmers (Almås, 2002; Rogers, 2003). As this system was established within the public sector, a parallel process took place within the cooperative and private sector. Within the participation model, the first field trial association was established in Hedmark in 1937 (Sandberg, 2001, p. 174). Later, especially since 1962, a number of field trial associations was founded, claiming 19,300 farmers as participants in 1987 (Almås, 2002). When the Ministry of Agriculture reorganized the state-funded extension services in 1992, the extension services within the cooperative and private sectors grew in importance (Sandberg, 2001, pp. 53-54; St.meld.no.40, 1991-92).

The field trial association farmers aimed to improve farming testing research results and more general knowledge in a local context on their own farms. By sharing information and experiences with the other members of the local field trial association, they developed themselves both personally and professionally. Consequently, they belonged to a community of practice (Lave & Wenger, 1991) with a clear interest in the outcomes of the field trials. CS represents a more recent initiative to develop new communities of practice between amateur scientists developing their own expertise. CS is an emerging form of engagement and is of special interest to this thesis, serving as the point of departure for Study VI. Amateur scientists in the natural sciences, social sciences, and humanities are an integral part of these disciplines' histories (Vetter, 2011), as well as popular engagement with science (Fyfe & Lightman, 2007). As two examples, both biology and social anthropology give many illustrations of the importance of amateur scientists (Brenna, 2011; Harris, 1969; Klausen, 1981; Miller-Rushing, Primack, & Bonney, 2012). Here, I concentrate on a more recent understanding of CS. The concept originally had two related but different meanings: as *public participation engagement* and *science communication projects* (Bonney et al., 2009; Dickinson & Bonney, 2012), and as *scientific citizenship* bringing the public and scientists closer together with the aim of including citizens in science and technology policy processes (Irwin, 1995). Both versions of CS may also be seen as a reaction to the deficit model. The first meaning of CS is the main concern of Study VI, while the second meaning of CS is an overarching concern of the whole thesis. The following literature review focuses on the first meaning of CS; however, first I have some words about developing policy as a backdrop for discussing participation.

When developing policy, policymakers position themselves within a specific civic epistemology, or "culturally specific, historically and politically grounded, public knowledge-ways" (Jasanoff, 2005, p. 249). Jasanoff's (2004, 2011) research well illustrates that co-production is an important democratic element in many Western societies. Two components are crucial: empowerment and scope of choice (Perrault, 2013; Pielke, 2007). According to Jasanoff (2005, p. 255), "civic epistemology refers to the institutionalized practices by which members of a given society test and deploy knowledge claims used as a basis for making collective choices." Jasanoff (2005) identified six constitutive, interrelated dimensions of civic epistemology: 1) participatory styles of public knowledge-making, 2) methods of ensuring accountability, 3) the acquisition of public credibility by facts and things, 4) the preferred method for displaying objectivity in public decisions, 5) experts' satisfaction of the desire for order in the management of uncertainty, and 6) citizens' perceptions or knowledge of the reasons for public decisions. Also, these more overall concerns with empowerment and scope of choice may be part of public participation engagement and science communication projects.

Three sub-models of CS (Bonney et al., 2009; Corburn, 2005; Dickinson & Bonney, 2012; Haklay, 2013; Socientize, 2015) are identified in the literature:

a) Contributory model: Projects are designed by scientists, and the public is mainly involved in collecting, validating, and analyzing data. There is much to indicate that an active minority of participants contribute most of the data (Bonney, Philips, Ballard, & Enck, 2016; Hetland, 2011a, p. 330). In some projects, volunteers are asked to contribute themselves as data (Jennett et al., 2014).
b) Collaborative model: Projects are still designed by scientists. However, the participants have a greater influence on the research process. That might entail helping with interpreting the data, drawing conclusions, and helping to adjust protocol for data collection and suggesting new directions for study.
c) Co-created model: Local communities, which might include experts and scientists, most often initiate these citizen-science projects, which often originate outside academic institutions and most of their funding structures. These initiatives focus on local problems, often related to such environmental issues as pollution, health hazards, species conservation, water and air quality, and natural resource depletion (Epstein, 1996; Kullenberg, 2015). The co-created model certainly has much in common with action research and what is called *participatory research* or *participatory action research* (Pain, 2004).

The three models may be understood along a continuum, and according to Tweddle et al. (2012) contributory CS works well for projects that capture the imagination of a broad audience, require large volumes of data, involve recording regularly, and require large-scale analyses, while co-created CS works well for projects that benefit from establishing a community-led or volunteer-led monitoring scheme, involve small numbers of participants, require repeat measurements over time, and are targeted at a specific, locally relevant problem or question (Tweddle, Robinson, Pocock, & Roy, 2012). Dickinson et al. (2012) claimed that the contributory model has been most productive in generating peer-reviewed publications, whereas collaborative and co-created approaches often have more practical goals. Regardless, one may claim that all three models are organizations of participation (Pallett, 2015).

Shirk et al. (2012) expanded on the three models and added two extra models at each end of the continuum. At the end with least involvement is the contractual model, where communities ask professional researchers to conduct a specific scientific investigation and report on the results. At the end with a high degree of involvement is the collegial model, where non-credentialed individuals conduct research independently with varying degrees of expected recognition by institutionalized science and/or professionals. The first model portrays the public as enrolling science and scientists for a specific purpose, while the second model portrays the public as scientist. The second model is in line with the more historical role of amateur science. While these two models add important elements of public participation in scientific research, I will in my review concentrate on the three middle models.

Prior Research on Citizen Science

The following review focuses on CS as public participation engagement and science communication projects and is organized along four topics: 1) participant interaction and community building; 2) training, education, and learning; 3) data collection and validation; and 4) motivation, communication, and how participation is made visible.

Several studies indicate that social aspects of participation are important for certain CS projects (Dickinson et al., 2012; Jennett, Kloetzer, Gold, & Cox, 2013), while other studies do not indicate similar emphasis on the social aspect (Land-Zandstra, Devilee, Snik, Buurmeijer, & van den Broek, 2016). Jennett et al. (2014) made a distinction between one-time participation and experiential studies.

Much of CS is situated within a discourse of public participation, not necessarily on enhancing public competence and learning. One interesting question is whether CS can improve public understanding of science, even if few such projects are designed to achieve such an outcome (Bonney et al., 2016). Bonney et al. (2016) organize their review according to four topics: 1) data-collection projects; 2) data-processing projects; 3) curriculum-based projects, both informal and formal; and 4) community-science projects. The first group of projects was found to produce somewhat mixed learning outcomes, and the second group did not have huge impacts on public understanding. The third group did achieve certain learning outcomes, particularly projects that emphasized inquiry-based learning. Finally, the last group has the greatest potential to achieve a wide range of impacts on public understanding, primarily as these projects typically involve participants not only in collecting data but also in developing research questions, designing research protocols, interpreting data, and disseminating results. This last group falls most clearly within the collaborative and co-created models. Land-Zandstra et al. (2016) found that organizers of CS projects need to find "ways to help participants gain a better understanding of the science behind the measurements, especially when science is rather complex" (2016, p. 57).

Within the three sub-models, public participation might create large amounts of data in a short time, and the concept of *apomediation* represents a new strategy of validation[9] (Eysenbach, 2008). Apomediation is a new socio-technological term coined to describe the third way for users to identify trustworthy, credible information and services. *Apo* is derived from the Latin word for "stand by," and *apomediation* refers to Internet users' ability to bypass gatekeepers and middlemen and go directly to sources, even those not considered expert sources, when accessing information. In this way, the expert "stands by" the user. The Norwegian portal Species Gateway utilizes apomediation in data collection and validation (Hetland, 2011a) along two lines: 1) both professional and amateur scientist are nominated to validate the records within some prioritized areas, and 2) everybody is free to participate in the more general validation processes if they find information that they think should be corrected.

Motivation to participate varies; Batson et al. (2002) identified four categories of motives in general: egoism, altruism, collectivism, and principalism. "Egoism relates to motives that pertain to one's own welfare. Altruistic motives are related to increasing the welfare of others. Collectivism refers to increasing the welfare of a group. Principalism includes motives related to upholding a moral principle (e.g. justice, equality, caring for the environment)" (Land-Zandstra et al., 2016, p. 47). Land-Zandstra et al. (2016) found that most participants "wanted to contribute to scientific research, the environment or health because they were interested in science and the topics of the project" (p. 56); a similar finding was reported from a study of Foldit participants (Curtis, 2015). Reviewing previous research investigating motivation in CS, Jennett et al. (2014) found that *motivations included interest in the research topic, learning new information, contributing to original research, enjoying the research task, sharing the same goals and values as the project, helping others and feeling part of a team, and finally, receiving recognition and feedback*. Another important finding was that motivations changed over time, moving from egoism to altruism, collectivism, and principalism. CS mostly depends on self-recruiting participants, and Haklay claims that most CS activists are "predominantly male, well-educated and from higher income brackets, which gives them both the time to participate in the activity and the financial resources for specialist equipment and/or participation in fieldwork" (2013, p. 113), while Bradford and Israel (2004) found that volunteers in a sea turtle project tended to be older, well-educated white females with an important reason to help and protect sea turtles (Bradford & Israel, 2004). In a larger study of motivations in CS, Raddick et al. (2010) found that the typical respondent listed two motivations (Raddick et al., 2010). In a follow-up study,

[9] When I first used this concept in Study VI, I was not aware of the crucial differences between validation and verification. When you validate something, you make it officially acceptable or approved; conseqently, validation carries the weight of authority. When you verify something, you show that it is true or accurate. I will, therefore, continue to use validation about the process where records are attributed the correct information.

they identified *contribute* as the largest primary motivation for all age brackets and education levels (Raddick et al., 2013).

Crall et al. (2012) used an invasive species CS training program to study the effects on participants' attitudes, behaviors, and science literacy. First, CS participants have stronger positive attitudes toward the environment than the general public; however, Crall et al. (2012) found improvements in science literacy and knowledge. Studying the emotional dynamics of engagement provides another way to explore the different forms of contributions within CS and how public participation and engagement take place (Davies, 2014; Lawrence, 2006), and it is quite likely the emotional dynamics differ within the three sub-models. The emotional is certainly also in play, as we know that "amateur practice was one of the major routes to becoming engaged in more formal scientific activity" (Thurs, 2007, p. 28). Participation may result in bias or skewing (Hetland, 2011a, p. 332), but there is much to indicate that "biases in CS sampling efforts relative to abundance on Earth, these biases are consistent with biases found in professional science" (Theobald et al., 2015, p. 241).

Theobald et al. (2015) found that CS project data were more likely to be "published in peer-reviewed scientific literature if projects sampled at a large spatial extent and had been sampling for decades" (2015, p. 240), and that "projects that trained volunteers in species identification methods, using in-person or online training, were more likely to be published than projects that provided no identification training or trained with a combination of methods" (pp. 240–241). Actually, Theobald et al. (2015) found that the probability of publication was largely unaffected by the data quality assurance measures, and they suggested "that perhaps most projects have adequate data quality measures in place, or that non-professional data can be comparable to data collected by professional scientists" (p. 242). Cox et al. (2015) studied the success in online CS and aimed to measure the relationship between scientific impact and public engagement. They concluded that "it's relatively unlikely for a CS project to meet with success against one of these measures and not the other, so an effective management strategy should target the achievement of both goals instead of one in isolation" (Cox et al., 2015, p. 39). Schäfer and Kieslinger plea for diversity, creativity, and social innovation within CS and provide a matrix presenting

> two important aspects of differentiating instantiations of citizen science: 1) the locus of knowledge creation—moving along a continuum from projects where knowledge creation is mainly in the hands of researchers to those where citizens are the main knowledge producers; 2) the focus of project activities—moving from research driven projects with a core aim answering scientific questions to projects that focus on supporting interventions in socio-ecological systems. (2016, p. 3)

Riesch and Potter (2014) studied scientists' perceptions of CS and raised two issues: first, methodological and epistemological dimensions, and, second, the ethical dimensions of CS. Data quality was a concern of the wider scientific community. Scientists used a range of methods and approaches to ensure quality in CS, including: 1) providing training and close supervision, 2) cross-checking for consistency with the literature, 3) cross-checking for consistency with their own observations, 4) administering a quiz-style questionnaire at the end of research projects to gauge the reliability of public data, and 5) simplifying the tasks asked of the public and adapting the research questions (Riesch & Potter, 2014, p. 112). Negative reactions from the wider scientific community were more commonly expected or anticipated than they actually were. Ethical issues concerned the questions of ownership, attributing authorship and payment, especially as CS can involve outsourcing work that paid professional scientists would otherwise do.

Focusing on the gap between theory and practice on public engagement, five "topics of tensions" are identified (Delgado et al., 2011, p. 828). To summarize, I will shed light on those topics of tension when it comes to policy. First, why should the public participate? Involvement is regarded as important to ensuring democratic participation, defined as broad participation associated with knowledge building, the assessment of risk and ethics, the exchange of knowledge, and the encouragement and diffusion of innovation. The growing importance of dialogue and participation is also an indicator of the weakening importance of Ingelfinger's rule (Toy, 2002). Second, who should be involved? Participants represent user interests and feel the need to stimulate debate, but also possess a genuine desire to develop and contribute with their own expertise. Three, how should participation be initiated? Participation is organized along two dimensions: 1) the intensity of knowledge-building and 2) the sponsored or spontaneous nature of the hybrid forum (Callon et al., 2009). These two dimensions allow interesting variations of participation forms. Four, when is the right time to do participation? Participation is regarded as important along the entire value chain, and hybrid forums[10] or spaces are established for a wide range of objectives. Finally, where should participation be grounded? When ideas on participation migrate, the participation form is often interpreted and adapted to fit a local context; a good example of this trend is laypeople's conferences. Consequently, participation is grounded in an increasing number of hybrid forums or spaces shaped by local contexts.

Communicating Popular Science and Technology

How to differentiate genuine knowledge from popularization? Hilgartner (Hilgartner, 1990) outlined three strategies to answer this question. First, if one defines "genuine scientific knowledge as that which is presented by scientific experts to scientific audiences in scientific forums, all the rest then would be defined as popularization" (Hilgartner, 1990, p.

[10] When it comes to "hybridity," I have used three different concepts in the six studies. First, inspired by Latour (1987, 1993), I used the concept "hybrid community," which I introduced in my PhD thesis (defended in 1994, published in 1996). Later, I read that Gibbons et al. also used the "hybrid community" concept in their 1994 book. Callon et al. (2009) used the concept "hybrid forums," which I also used in Study I and Study V. Finally, I have used "hybrid spaces," inspired by Bowker and Star (1999), in Study VI. The different understandings of hybridity may be understood as a more personal journey toward a deeper understanding of the evolution of a trading zone.

525). In this strategy, it is important to identify the experts. A second strategy is to look at the content, and a third strategy is "to identify the 'original' knowledge and strictly distinguish between its creation and its spread" (Hilgartner, 1990, p. 525). Hilgartner (1990) described the different contexts in which scientific knowledge is communicated and distinguished between upstream and downstream mediating processes. He concluded that "the dominant view of popularization is a serious oversimplification that cannot, on it its own terms, provide an adequate model for the process through which scientific knowledge spreads" (Hilgartner, 1990, p. 533). Not only science but also the different publics' understandings of sciences are simplified. Similar simplifications can be found among science communication critics (Öhman, 1993), within "textbook science," as "*Certainty, simplicity, vividness originate in popular knowledge*. That is where the expert obtains his faith in this triad of knowledge. Therein lies the general epistemological significance of popular science" (Fleck, 1935/1979, p. 115, emphasis in original), and among journalists, who often "confirm the image of science as remote, elitist, consentient, and a collection of 'success' stories" (Einsiedel, 1992, p. 98). The communication of science and technology is done in a context that influences the use of metaphors and other narrative resources. In a study of American science communication, Hornmoen (2003) found first that journalists who understand their assignment within a broader context take a more critical stance, and second, that popularization activities in science journalism and writing have moved from approaching science as an object toward a more scientific approach. However, Norwegian studies of popularization on television have demonstrated that a critical approach may be replaced by restless actuality to prevent viewers from changing the channel (Brinch & Iversen, 2010).

In her review of why scientists communicate or do not communicate science, Searle (2011) listed several reasons that may promote or impede science communication: 1) failure to communicate well, 2) the personal and professional risks of communicating, 3) critical peers, 4) secrecy, 5) a scientifically ignorant or critical public, 6) lack of funding and support, 7) lack of time, and 8) media relations. Some of these reasons are also relevant in a Norwegian and Nordic context. In her study (2011), she found that the survey respondents agreed that scientists have a responsibility to communicate with the general public. Benefits from science communication included:

> positive feelings about themselves, their communication and their work such as satisfaction, enjoyment and self-confidence; and their work and personal success such as direct public participation or co-operation in research, networking and relationship-building. (2011, p. 307)

When Bush (1945) and his advisors chose *Science: The Endless Frontier* as the title of the document that framed science policy and PCST for many years, they reshaped the well-known public image of the frontier as the boundary where old ideas met new possibilities (LaFollette, 1990). One may claim that by using metaphors as *The Endless*

Frontier, Bush and his team associated themselves with science boosters advocating for the deficit model (Perrault, 2013, p. 6).

In her review of the history of science popularization, Perrault identified the three mentioned models of PAST, PEST, and CUSP (2013). I will in the following present her main findings, presented in her 2013 book. She claimed that that there is a two-cultures gap within the “ranks of those who write about scientific issues for nonspecialist readers” (2013, p. 3). In contrast with the science boosters, are the “science critics, who, in a role parallel to that of other professional critics (art critics and historians, literary critics, and so on), combine appreciation of science with the kind of critical analysis that characterizes good scholarship, as well as good critique” (2013, p. 4). Consequently, on the one side are the science boosters, those who partly see PCST as public relations, and partly as a mission to counter negative perceptions of science, while on the other side are those who believe PCST should promote democratic engagement (see also Broks, 2006), or, like Gross, hope that science popularization will aid “the appropriate integration of science into the general culture” (Gross 1995, p. 170). However, the emphasis is still at the booster end of the continuum, claims Perrault. This may even be more so when one talks about technology communication compared to traditional science communication (see also Nelkin, 1995). In between the two sub-models of PAST and CUSP, Perrault outlines the PEST sub-model. The PEST sub-model “addresses some of the shortcomings of the deficit model by conceiving of science popularization in terms of a conversation” (2013, p. 14). Or as Broks states, “we can see attempts at dialogue or PEST in a number of activities; as both top-down (consensus conferences, citizens’ juries, science shops) and bottom-up (e.g. lay experts from medical interest groups or advocacy groups such as Greenpeace or Friends of the Earth)” (2006, p. 126). Another important difference compared with the PAST sub-model is that both PEST and CUSP “recognizes that there is not one public, but many publics that make up civil society, and it therefore recognizes that doxa is formed through participatory discourse” (Perrault, 2013, p. 26). Three roles are explored in the present thesis, first that of boosterism in the utopian narratives, studying the problem of bias (Study II); second that of translators and critics studying the control position in the technology-as-risk narratives (Study III); and third, that of critics studying researchers’ own popularization activities, most of them taking the role as modest witnesses (Study IV).

Boosters, the most common role, lay the foundation for the pro-innovation bias (Rogers, 2003). According to Perrault (2013, pp. 50–51), boosters’ descriptions fall into two general categories: science writing as a celebration of the wonders of science and science writing as a cure for some perceived lack in the non-specialist public. Boosterism has a long history in public communication of science and technology (LaFollette, 1990), as well as in the sciences, either as “buzzwords” (Vincent, 2014) or as exaggerated use of positive words (Vinkers, Tijdink, & Otte, 2015). Vinkers, Tijdink, and Otte (2015) concluded that “The consequences of this exaggeration are worrisome since it makes research a survival of the fittest: the person who is best able to sell their results might be the most successful" (p. 3). From PCST, one knows, for example, that agricultural journalism often "unquestioning[ly] advocates for agriculture and its industrial, political, and technological elites" (Allen, 2010, p. 20). Consequently, boosterism might be a problem. In the classic work *Selling Science*, Nelkin (1995) raises numerous crucial questions linked to boosterism and the pro-innovation bias. She discussed critical aspects, such as different PR techniques, technological enthusiasm, optimism, the celebration of progress, and the media's problematic reliance on corporate sources for information concerning new technology (in short, the hype fascination). In this context, the public has an overwhelmingly favorable attitude toward science and technology, including a general belief in all types of technological fixes, which evolved parallel to the professionalization of science (Berman, 1978). Boosterism and the pro-innovation bias are prominent in public communication of science and technology and can be viewed historically as a fundamental dimension of the deficit model. At the same time, the pro-innovation position travels with less support, especially within a pro-innovation climate (Borup, Brown, Konrad, & Lente, 2006; Flyvbjerg, 2008). A pro-innovation climate varies over time, due in part to changes in the perceived usefulness of specific technologies. Consequently, public opinion might change from one period to the next.

The idea of the popular science writer as a translator avoids some of the drawbacks of the booster role, claims Perrault, and the translator role is often popular among science writers, translating from jargon of science into everyday language. However, it is still perceived as problematic. Perrault does not use much space for either the PEST sub-model or the role of translator. Kirby introduced the concept of *boundary spanner* about a person that has "interactional expertise" and serves as an accepted liaison between scientific knowledge and fictional representations (H. Collins & Evans, 2007; Kirby, 2008). Interactional expertise is "expertise in the *language* of a specialism in the absence of expertise in its *practice*" (H. Collins & Evans, 2007, p. 28, emphasis in original). This may seem contrary; however, interactional expertise is mastery of the language of a domain while never having worked within the domain. Interactional expertise is needed both by a successful participatory ethnographer as well as a specialist journalist. It is also possible to achieve interactional expertise by being an active user, as the pioneer journalists writing about the Internet were (Hetland, 2002b, p. 113). The distinction between users and publics will quite likely be more apparent within technological developments than communication based on scientific research, especially when users have high stakes in specific user values (Hetland, 1996, 2002a). Translators as interactional experts are therefore more likely to appear within technological development of everyday technologies than communication based on scientific research.

Perrault gives the third role, critics, the most attention. Critics "approach their subject with both interest and skepticism" (Perrault, 2013, p. 58). These writers tend to emphasize

> a gatekeeping function (asking questions about the science itself) or a public service function (providing readers with the information they need to make up their own

> minds). Some writers combine the two, describing the popular science writer's job as a combination of sceptical inquiry and reader empowerment. (Perrault, 2013, p. 58)

This implies also a skeptical attitude toward their sources and empowering public action, as these writers "represent a move toward the kind of critical engagement that can make popular science writing a potent force for democratic decision making regarding issues of science in society" (2013, p. 60). However, Öhman claims that popularization only makes us more dependent on expertise and consequently does not improve democracy (1993, pp. 160–164). Perrault states that critics differ from boosters and translators by being more realistic about how science works and how it fit into civil society. Apparently, critics also have a high degree of interactional expertise, so it is more a question of degree than an attribute reserved for only one of the roles.

As part of the translator and critic roles, the control position takes its point of departure in the notion that technology implies risk, and its users may be ungovernable. Both users and technology must be regulated and controlled; i.e., domesticated in order for technology to serve the community. When the problems have been solved, the technology will become domesticated and apparently trivial (until the problems arise again). While invention is the process by which a new idea is discovered or created, adoption is a decision to make full use of an innovation. Rogers (2003, p. 181) defines re-invention as "the degree to which an innovation is changed or modified by the user in the process of its adoption and implementation." Up to the 1970s, re-inventions were looked upon as rare. As a rule, re-inventions were treated as "interference" in diffusion research. Gradually people have come to see re-invention as an important process. In current research dealing with invention and re-invention, the focus has been turned on the co-construction of users and technology (Oudshoorn & Pinch, 2003). The control position may, therefore, be seen as an important element in the co-construction of users and technology.

On the Social Contract between Science and Society

The quest for dialogue and participation stems from two interrelated discourses: the first concerning public understanding of science, and the second based on the discourse on changing science systems. To begin with, expert–public interaction and popularization are presented in the two previous sub-chapters. The discourse on changing science systems is prominent in science and technology studies, as well as in innovation studies, and is central to understanding the new social contract between science and society. In this context, I am especially concerned with how the discourse on changing science systems involves different publics. I will first take a look at different approaches to study changes in the science system (Hessels & Lente, 2008). In their review, Hessels and Lente (2008) did a comparative study of eight alternative diagnoses of changing science systems: 1) new production of knowledge with Mode 1 and Mode 2 (Gibbons et al., 1994; Nowotny et al., 2001), 2) post-normal science (Funtowicz & Ravetz, 1993), 3) Triple Helix (Leydesdorff & Etzkowitz, 1998), 4) post-academic science (Ziman, 2000), 5) academic capitalism (Slaughter & Leslie, 1997), 6) strategic science/research (Irvine & Martin, 1984), 7) innovation systems (Edquist, 1997), and 8) finalization science (Böhme, Van den Daele, Hohlfeld, Krohn, & Schäfer, 1983). Furthermore, the relationship between research driven by the quest for fundamental understanding and research driven by considerations of use give rise to the development of different models of basic science, applied science, and experimental development illustrated by what is called *Pasteur's quadrant* (Stokes, 1997). This quadrant features basic research for use, such as the development of the rabies vaccine; there was no separation between research and application. A second quadrant is Edison's, which is characterized by applied development, e.g., electricity. A third quadrant is Bohr's; the exemplar is quantum physics, in which basic science preceded application. Stokes argued that the most promising quadrant was Pasteur's.

According to Hessels and Lente (2008), socially robust knowledge is emphasized by diagnoses 1 and 2, norms of quality control including extended peers are emphasized by 1, 2, 4, and 6; interaction with other societal "spheres" like industry and government are emphasized by 1, 3, 4, 5, 6, 7, and 8; and finally the incorporation of non-scientific expertise (participation) is emphasized by 2. Only post-normal science explicitly includes public participation; however, the "solution that proponents of this model offer generally boil down to engaging stakeholders in decision-making processes or in the quality assessment of scientific knowledge production" (Hessels & Lente, 2008, p. 745). Regardless, in their discussion, they underlined that both the new production of knowledge with Mode 2 and Triple Helix "includes new 'peers' (users, consultants, and lay persons) and a greater consideration of ethical and political issues" (2008, p. 752). The most interesting contribution of Hessels and Lente is their discussion of the new production of knowledge or Mode 1 and Mode 2, where Mode 1 has an academic context, disciplinarity, homogeneity, autonomy, and traditional quality control (peer review) as the five most important attributes, while Mode 2 has context of application, transdisciplinarity, heterogeneity, reflexitivity/social accountability, and novel quality control as the five most important attributes. Hessels and Lente have two important conclusions of relevance for the present thesis. The first is that it is incorrect to view Mode 1 as the original type of knowledge production; referring to Martin (2003), they find it more appropriate to speak of "*shifts in the balance of* Mode 1 and Mode 2 over time" (2008, p. 756, emphasis in original). The second is that, in comparing Mode 1 and Mode 2, their "review shows that it is time to disconnect the five major constitutive claims and to investigate them separately" (2008, p. 758).

When describing Mode 2 in the original book, little emphasis is placed on the communication of knowledge, and when it is mentioned, it is framed rather traditionally (Gibbons et al., 1994, p. 38). In the later book by Nowotny et al., they emphasize strongly that contextualized knowledge and contextualization depends "on a permanent dialogue between scientists and diverse ‘others’ in society” (2001, p. 134). Contextualization is a consequence of at least three conditions, which may operate at different levels, and not all of which have to be present at the same time:

> the overall shift (or drift) from a model of ‘segregation’ to one of ‘integration’; the selective retention of certain potentials which arise as a result of greater variation; and the place accorded to ‘people’ in our knowledge, be it as actively involved in its production or conceptualized as either objects of research and/or as addressees of ensuing policies. (Nowotny et al, 2001, p. 143)

Two preconditions favor contextualization of the middle range. The first is the “emergence of ‘transaction spaces’ between different groups, disciplines, research fields or other major configurations” (2001, p. 144). The second has to do with “moving beyond the context of application and setting one’s anticipatory vision on what we call the context of implications” (2001, p. 144). Transaction spaces or hybrid spaces are important new forums for the production of new knowledge. Galison (1997) introduced the concept of “trading zones” in his analysis of cooperation in science and technology. The concept is inspired by anthropological studies of how different cultures organize exchanges of goods despite major differences in language and culture (Sahlins, 1972). Galison uses the term to explain how communication is managed within heterogeneous groups of actors with an obstacle of communication. Central to this exchange ratio is a different form of expertise. Galison (1997) described “trading zones” as a place where coordination took place using a sort of “pidgin” language. Later Collins , Evans, and Gorman studied trading zones and interactional expertise (2010) along the twin dimensions of homogeneity-heterogeneity and collaboration-coercion. I will return to those dimensions under the analytical framework.

In the evolution of trading zones, Collins, Evans, and Gorman (2010) proposed a trajectory of evolution starting from the “encouragement” to collaborate to the two fractal models, the *boundary object* and the *interactional expertise*. In the case “of boundary objects the two forms of life remain distinct, each imposing their own meaning on the ‘common’ material object and working with it in their own way” (p. 16). While, in the case “of interactional expertise, one party learns the language of the other while retaining their own material form of life and distinct contributory expertises” (p. 15). Consequently, the dissemination model facilitates that different groups work together without really collaborating in a deeper sense, while the dialogue and participation models facilitate deep collaboration and the development of interactional expertise. All contributory experts are interactional experts, too; however, when taking the step from interactional expertise to contributory expertise, it is important to distinguish between “making a contribution” and “performing a supporting or enabling role and being a contributory expert” (Collins, Evans, & Weinel, 2015, p. 5). Collins and Evans at the same time warn against creating an “interactional expertise lite” (“which would have very wide application but would lose sight of the force that drove the concept’s development”) (2015, p. 113).

Here I will elaborate on boundary objects, while returning to interactional expertise under the analytical framework. Boundary objects refer to elements that link various groups and interests together. Star and Griesemer (1989) defined boundary objects as temporary agreements by different actors and groups on how to relate to a given situation. They describe how a standardized method in natural history for collecting, conserving, marking, and describing finds functioned as a boundary object between amateurs and researchers in what was a research subject among researchers and a subject for hobby activity, exercise of an occupation, or nature conservation among groups of the public. In other words, they establish agreement about what are points of contact in common. Boundary objects are negotiated agreements that contain different interests but, at the same time, open up for slightly different practices. The boundary objects create a dialogue between various interests—and handle stability and ambiguity simultaneously (Wells, 1999). In this way, boundary objects permeate borders at the same time as the established practice is continued. Scientific infrastructures represent "regimes and networks of boundary objects (and not unitary, well-defined objects), boundary infrastructures have sufficient play to allow for local variation together with sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics, and so forth) to be applied" (Bowker & Star, 1999, pp. 313-314) and thereby facilitate scientists, amateurs, and administrators cooperating across disciplines and organizational boundaries. Citizen Science, Cyberscience, E-Science, and Science 2.0 therefore become a manifestation of scientific culture articulated in the face of a new technology (Hine, 2008, p. 34). Bowker argued that this layering of boundary objects creates a form of irreversibility or path dependency in the infrastructure for two reasons: "first because the infrastructure is *performative*; and second because the infrastructure is *diffuse*" (Bowker, 2000, p. 648). Boundary work occurs when people contend for, legitimate, or challenge the cognitive authority of those who control the knowledge production—and the credibility, prestige, power, and material resources that attend such a privileged position (Gieryn, 1995). However, this concept is useful also for analyzing more informal settings like hybrid spaces or forums. Various "hybrid spaces" can be investigated to see what kind of boundary work goes on. A common kind of boundary work involves, e.g., insiders' effort to expel non-real members from their midst (Gieryn, 1995, p. 432). However, boundary work can also be more symbolic, suggesting that both boundary objects and boundary work are terms that blur the distinction between real and socially constructed change.

Consequently, this chapter provides a review that contextualizes the six studies and makes a necessary background for outlining the analytical framework.

Chapter 3 - Analytical Framework

In this chapter, I will outline the general theoretical and conceptual framework for this thesis. The first part of the chapter present models of public communication of science and technology, the format of participation, and the shaping of expertise. The second part of this chapter presents science and technology popularization. Three concepts are discussed: framing, positions, and the shaping of bias. Finally, the third part presents trading zones as an analytical approach to studying science's new social contract with society. The two first parts of the chapter should be regarded as an overview of the framework sections in the six studies, while the third part is specific for this extended abstract.

Models of Public Communication of Science and Technology

Based on the review of prior research on PCST, I identified three elements that are crucially important for developing an analytical framework of *PCST models*.[11] First, what is the primary aim of the models including their broader ideological context? Second, what is the format of public participation? And three, what kind of expertises do the participants develop within each of the models? I will in the following outline an analytical framework along these three dimensions.

The dissemination model builds on a "diffusionist" conception of communication, which implies that expertise and knowledge are to be transported from those that have this knowledge, the expert, to those who do not have it, the general public. This is also the reason why the model often is called the deficit model. One classical contribution is Rogers' book, *Diffusion of Innovations*; the first edition came in 1962 and the last in 2003. He studied for many years the diffusion of innovations among peasants and farmers, and even if he developed his model of diffusion over the years, I will claim that the center of gravity is from the expertise to the receiver. The most important aim of the dissemination model is consequently transfer of knowledge:

> This notion takes for granted, among other things, the possibility of transferring knowledge without significant alteration from one context to another, so that we can simply take an idea from the scientific community and bring it to the general public; and that the same knowledge in different contexts will result in the same attitudes and eventually in the same type of behaviour. (Bucchi, 2009, p. 66)

Rogers' research is of course much more sophisticated than the quote from Bucchi indicates; it is difficult to find social scientists today that adhere to such a simplistic model.

[11] I have highlighted all the bridging concepts when they are first described in the analytical framework.

The dissemination model might therefore be seen as a model that is more often found among practitioners than among social scientists. The ideological context of the dissemination model is influenced by scientism (Welsh & Wynne, 2013), technocracy, and the rhetoric of the knowledge economy, since knowledge economy/society "policies and discourses may be promoting a new social separation of science, rather than fuller integration" (Trench, 2008b, p. 128).

The question of *expertise* and the different publics have generated a debate with two apparently opposing standpoints. On the one side we find those that are primarily interested in understanding how different forms of expertise develop (H. Collins & Evans, 2007, 2015; H. Collins et al., 2015; Durrant, 2008; Gorman, 2010), while on the other side "what questions knowledge should be addressing, and thus, what (combinations of) knowledge should be in play" (Wynne, 2008, p. 24). One important issue for Wynne in this respect is that we cannot understand publics in relation to science unless we also "critically examine the elephant in the room–what is the 'science' which we are supposing that people experience and sense in each of these situations?" (2008, p. 21). I concur with Wynne that this is two different points of departure and an important task; however, I find it difficult to understand that these two points of departure are contrary and not possible to unify.

Collins and Evans (2007, pp. 2–3) start "from the view that expertise is the real and substantive possession of groups of experts and that individuals acquire real and substantive expertise through their membership of those groups." All individuals possess ubiquitous tacit knowledge as 1) "beer-mat knowledge" (without a deeper insight into why it works), 2) popular understanding, and 3) primary source knowledge. Concerning specialists' tacit knowledge, Collins and Evans (2007) distinguish between contributory expertise and interactional expertise (i.e., expertise that is needed to manage a field of knowledge through interactions but does not contribute to it). Based on this distinction, they attempted to develop a periodic table of expertise (see Table 3.1). Among the expertise dimensions around which the table is constructed are specialist expertises and meta-expertises. The knowledge dimension proceeds from basic knowledge possessed by all people to highly specialized knowledge that only a few acquire.

Table 3.1
The Periodic Table of Expertises (from Collins & Evans, 2007, p. 14)

UBIQUITOUS EXPERTISES					
DISPOSITIONS				Interactive Ability	Reflective Ability
SPECIALIST	*UBIQUITOUS TACIT KNOWLEDGE*			*SPECIALIST TACIT KNOWLEDGE*	
EXPERTISES	Beer-mat Knowledge	Popular Understanding	Primary Source Knowledge	Interactional Expertise	Contributory Expertise
				Polimorphic	*Mimeomorphic*
META-	*EXTERNAL (Transmuted expertises)*		*INTERNAL (Non-transmuted expertises)*		
EXPERTISES	Ubiquitous Discrimination	Local Discrimination	Technical Connoisseurship	Downward Discrimination	Referred Expertise
META-CRITERIA	Credentials		Experience		Track-Record

Hybrid forums or *spaces* are, within the context of this thesis, important arenas for developing collaboration and expertise. Collaborative technologies may be used to shape hybrid forums or spaces with heterogeneous actors and agendas, and the collaboration activities may be facilitated by the development of *boundary objects*, *boundary infrastructures*, and *boundary work* (Bowker, 2000; Bowker & Star, 1999; Gieryn, 1995; Guston, 1999; Star, 2010; Star & Griesemer, 1989). These terms help us to establish a theoretical process-oriented perspective on how negotiations and competition for different interpretations and practices within a given "hybrid space" take place. Inspired by the double delegation (Callon, 1999; Callon et al., 2009) and Bucchi's (2009) aim to map public participation in science and technology, I map how participation is understood in different experimental traditions. The first delegation, according to Callon et al. (2009), implies secluded research, and the second delegation delegative democracy. To understand *formats of participation*, I have used two contributions (Braun & Schultz, 2010; Rasmussen, 2005). Studying participatory governance arrangements, Braun and Schultz (2010) found four major constructions of publics: the general public, the pure public, the affected public, and the partisan public. The general public speaks as anonymous individuals; the pure public speaks as concrete individuals, often "naïve citizens" as the subject of education; the affected public speaks as concrete individuals, the authentic expert with firsthand knowledge from a specific area of life; and finally the partisan public speaks as interest groups with knowledge about the landscape of possible arguments. To understand how participation and expertise develop over time, Rasmussen (2005) explores three concepts: *authoring*, *positionality*, and *improvisation*.

According to Rasmussen (2005), authoring demonstrates how social practice is constructed and maintained, positionality reveals the dynamics of social interactions and how they relate to participants' joint construction of knowledge and understanding, and finally, improvisations increase analytical sensitivity to change. The freer the participants are to play out authoring, positionality, and improvisation, the stronger their participation in the knowledge construction process is. The format of public participation within the dissemination model is as the general public with the possibility of authoring and, to a certain degree, positionality and improvisation.

The dialogue and participation models have extra momentum thanks to the evolution of ICT and the Internet. However, is the Internet turning science communication inside-out (Trench, 2008a)? One knows that the Internet will quite likely make the boundary between back-stage preparations and front-stage performances more open and increase access to previously restricted information (Goffman, 1959; Meyrowitz, 1985). On the other hand, important development in expert–public interaction also opens up for more use of the dialogue model. One important aim of the dialogue model is to improve discussion of the implications of research. The ideological contexts are linked to social responsibility and the integration of science into the general culture. The format of public participation within the dialogue model is as pure public with the possibility of authoring, positionality, and improvisation within predefined frames (Goffman, 1986). The expertise that the pure public might achieve is interactional expertise, with elements of contributory expertise. Finally, the participation model aims for a setting of the aims, the establishment of the research agenda, and participation in research. The ideological contexts are civic science and democracy. The format of public participation within the participation model is as affected and/or partisan public with broad possibilities to play out authoring, positionality, and improvisation. The expertise that the affected and/or partisan public might achieve is contributory expertise. Table 3.2 summarizes the previous presentation.

Table 3.2

Analytical Framework of Science Communication Models (expanded on and elaborated from (Bucchi, 2009, p. 69; H. Collins & Evans, 2007; Rasmussen, 2005; Trench, 2008b, p. 131))

Communication model	Aims	Ideological contexts	Format of public participation	Expertise
Dissemination (deficit) model	Transfer of knowledge	Scientism Technocracy Rhetoric of the knowledge economy	General public: possibility of authoring and, to a certain degree, positionality and improvisation	Popular understanding and primary source knowledge
Dialogue model	Discussion of the implications of research	Social responsibility Culture	Pure public: authoring, positionality, and improvisation within predefined frames	Interactional expertise, with elements of contributory expertise
Participation model	Setting of the aims, establishment of the research agenda, and participation in research	Civic science Democracy	Affected public and partisan public: broad possibilities to play out authoring, positionality, and improvisation	Contributory expertise

Science and Technology Popularization

Within the dissemination model, the three sub-models of PAST, PEST, and CUSP guide the study of science and technology popularization (Perrault, 2013). However, unlike Perrault's (2013) use of rhetorical genre theory, I have adopted the model developed by Gamson and colleagues for studying policy dramas (Gamson & Lasch, 1983; Gamson & Modigliani, 1987). Science is ready-made for "presentation as drama; it has suspense, action, and resolution" (LaFollette, 1990, p. 111), as well as scientific advising and decision-making (Hilgartner, 2000; Wynne, 2011). In connection with a selected theme in this model, a particular use of concepts is established. From a large inventory of possible reference frames, expressions, metaphors, and paradoxes, a smaller repertoire is selected. The purpose of the model is to analyze the use of this repertoire to describe particular aspects of a phenomenon. The model has two principal components: *frames* and *positions* (Gamson & Modigliani, 1987). Metaphors, exemplars, catchphrases, depictions, and visual images are framing devices, whereas roots, consequences, and appeals are reasoning devices for a more general position (Gamson & Lasch, 1983). Also important to the framing process is the selection of facts, context, and examples (Reese, 2001) and how chaperones (spokespersons, users, celebrities, witnesses, experts, and authorities) are engaged in the text to support claims (Hetland, 2015). Morgan (2011, p. 30) defines chaperones as “the people who act as knowing or unknowing companions” for traveling facts. Facts that stand alone might be perceived as weak; therefore, it is important to have allies who support claims or attack those who could explicitly oppose these claims (Latour, 1987).

Latour (1987) argues that scientific and technological development can be appropriately understood by considering it to be a negotiating process in which cooperation is built by recruiting external interests from the cultural fields and new collaborators from the fields of nature and technology. Chaperones often are witnesses instrumental to journalists’ claims and are necessary for facts to travel effectively, even if the claims might be false. Chaperones might also be sources; however, sources encompass a larger inventory of persons (including anonymous sources), publications, and other records. Examining how chaperones are used in texts to promote a specific frame or position is critical. According to Entman, Matthes, and Pellicano (2009), Gamson and colleagues (Gamson & Lasch, 1983; Gamson & Modigliani, 1987) define framing as the central organizing idea or storyline, whereas the definition developed by Entman et al. (2009) specifies what frames generally do, including defining problems, diagnosing causes, making moral judgments, and suggesting remedies. These two definitions belong to different phases of the framing process, which occurs at “four levels: in the culture; in the minds of elites and professional political communicators; in the text of communications; and in the minds of individual citizens” (Entman et al., 2009, p. 176).

Framing relates to how individuals and groups perceive and communicate about the world (Goffman, 1986).

> To frame is to *select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation* for the item described. (Entman, 1993, p. 52, emphasis in original)

Furthermore, “scientists can use framing to motivate greater interest and concern; to shape preferences for policies informed by or supportive of science; to influence political or personal behaviour; to go beyond polarisation and unite various publics around a common ground; to define policy choices or options; and/or to rally fellow scientists around shared goals or strategy” (Nisbet, 2010, p. 43). Ihlen and Nitz (2008, p. 1) suggest that practitioners are more likely to succeed if they can strategically construct master frames—that is, “frames with a wider cultural resonance than issue-specific frames.” However, framing is not necessarily singular; it might also be “double—be it either conflicting, competing, incompatible or compatible framing” (Hetland, 1996, p. 15).

When studying the reasoning devices for a more general position, the present study has been especially concerned with the construction of bias. The PAST sub-model offers one important element of specific importance for the present thesis: boosterism, or the *pro-innovation bias*. This bias reflects the dominant optimistic bias in modern society favoring scientific and technological innovations (Flyvbjerg, 2008; Gripenberg, Sveiby, & Segercrantz, 2012; Kahneman, 2011; Lovallo & Kahneman, 2003). Rogers and Shoemaker described *pro-innovation bias* as early as 1971, and 30 years later, Rogers (2003, p. 106) stated that "not enough has been done to remedy the problem." Pro-innovation bias implies that "an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected" (Rogers, 2003, p. 106). Gripenberg et al. (2012) suggested two principal reasons for this bias. First is that the axiom "innovation is good" is taken for granted. Second is the separation of discourses on desirable and undesirable consequences. Flyvbjerg (2008) adds a third reason: actors often have no incentive to de-bias a specific forecast. Consequently, pro-innovation bias might also imply strategic misrepresentations, whose purpose is to gain advantages in competitive environments.

When does a position turn into a bias? Entman (2007) understood bias along three dimensions. The first dimension is distortion bias, which refers to news that distorts or falsifies reality. The second dimension is content bias, in which a text favors one side instead of presenting an impartial viewpoint. The third dimension is decision-making bias, in which the writer has a distorted understanding of an issue. Entman (2010) distinguished between two primary sets of decision-making biases. Of these, the "media's catering to audiences as consumers in the marketplace" (Entman, 2010, p. 394) is of special interest in the case of the Internet. He also distinguished between slant and bias, contending that the term *media bias* only applies when a slant holds over time (Entman, 2010).

Biases exist in two related aspects of frames: 1) psychological biases that might influence all communicating parties, or in Entman's (2007) terminology, decision-making bias; and 2) frames that the communicator sponsors, which, in Entman's (2007) terminology, includes distortion and content biases. Entman (2007) argued that bias is under-theorized despite its crucial implications for political power and democracy. Regarding the first aspect of bias, "one of the most scrutinized psychological biases is the tendency to evaluate negative information more strictly than positive information" (Dan & Ihlen, 2011, p. 372), which often leads to an optimistic bias (Kahneman, 2011). The reader's decision-making bias then could "create consonance and dissonance even where none actually exists" (Baum & Gussin, 2007, p. 26). In the second aspect of bias, news stories provide a critical arena for framing contests in which different sponsors fight for their preferred frames (Dan & Ihlen, 2011).

In the present thesis, praise and blame constitute pivotal framing devices for specific biases. In addition, an important aspect of pro-innovation bias is siding with the information provider. Having studied public communication of science and technology since the 1940s, Bauer and Gregory (2007) explained that public communication of science and technology has developed from communicating scientists with an educational aim to the practice of PR for science and technology. However, PR activities are often "invisible," and journalists using PR materials often did not cite their sources because they do not "want to disclose their dependency on public relations" (Göpfert, 2007, p. 222). PR for science and technology implies the promotion of scientific and corporate institutions to different publics. Information subsidies play a critical role in capturing the attention of the news media and journalists. Earlier studies on information campaigns found that campaigns used information subsidies to selected media channels and other strategies, such as lobbying, to mobilize public opinion, politicians, and the policy agenda in favor of intended outcomes (Bauer & Bucchi, 2007). Strong evidence indicates that "information subsidies influence not just which topics are covered by the media (first-level) but also how these topics are described (second-level)" (Ragas, Kim, & Kiousis, 2011, p. 258).

Overall, most PR activities are source-biased. The status of the source, the number of sources, and the context of the claims are also relevant. Thus, to capture readers' attention, framing processes and the enrollment of chaperones are crucial. As chaperones, spokespersons usually advocate ideas and interests, and often have agendas with a pro-innovation bias, frequently leading the communicator to side with the innovation provider and to assign blame to non-adopters (Lievrouw & Pope, 1994; Rogers, 2003). Consequently, pro-innovation bias favors the source over the recipients. In addition, it is often synonymous with a pro-technology bias and a preference for technology-push strategies (McCurrey, 2000). Several authors therefore identify a link between a pro-innovation bias at the micro level and a pro-innovation climate and culture that favor adoption for its own sake and facilitate factors that help promote and sustain innovation (Bardini, 1994).

Rogers (2003) stated that, if not promoters but users (or non-users) had sponsored pioneering research, the nature of diffusion research might have been structured quite differently. Wyatt (2003) identified four groups of non-users: resisters, rejecters, the excluded, and the expelled. She emphasized the need to understand non-users, as well as users, and to avoid blackboxing them into one category. Blackboxing of non-users occurs commonly in the mass media, which mostly perceive non-users as old-fashioned and outdated or unfortunate and excluded. Kline (2003) and Wyatt (2003) argued that viewing resistance to technology from a functionalist perspective reinforces the promoters' framing of success. Pro-innovation bias then has a strong counterpart: the individual-blame bias, which faults individuals, not a system, for not adopting a certain innovation (Rogers, 2003). Often, late or non-adopters are blamed individually for not adopting an innovation or being traditional or irrational.

The *control* position involves a variety of control measures. How this control might be exercised varies. The factors that contribute to giving form to the control position are linked to: (a) the delegation of responsibility and (b) the point of time in the process when control should be exercised. Control can either be performed by individual and/or social regulations or delegated to humans and/or non-humans (e.g., technology) (Latour, 1992). Individual and/or social regulations imply that a single individual, or an individual organization, is responsible for keeping this wilderness under control. Delegation to technology or institutions means that technology and/or control bodies are established to keep an eye on the activity on the Internet. The timeframe is also important. Is this control to be proactive or reactive? Is it to prevent undesirable activities on the Internet before they take place (ex-ante), or is this control to be primarily exercised after the undesirable activities have taken place (ex-post)? In the master narrative of technology-as-risk, control activities are categorized into four ideal situations where the focus is directed: (1) individual control, (2) social control, (3) technological control, and (4) institutional control (see Table 1 in Study III).

Different frames and positions represent important *domestication* strategies that integrate ICT into households (Silverstone & Haddon, 1996) and society (Hetland, 2012). On the societal level, the concept of domestication finds its counterpart in the mediatization concept (Hartmann, 2009). Mediatization is a meta-process of discursive appropriation or domestication (Hartmann, 2009; Hetland, 2012). The positions of control and pro-innovation are important elements in these meta-processes. The concept of mediatization has been used to understand the constant growth of the media's influence in contemporary society (Hjarvard, 2013; Lundby, 2009). Rödder (2009, p. 453) highlighted two aspects of the mediatization of science: "(1) an increasing media attention for scientific issues and (2) an increasing orientation of science towards the media." Seen in this light, "the media play an important role in the production and circulation of knowledge and interpretations of science" (Hjarvard, 2013, p.10). This role also implies that, as an important part of science's social contract, public communication of science and technology promotes alterative understandings that mobilize actors for different agendas. Increasingly, visibility in the media is perceived as an important indicator of social relevance. This view is also reflected in the change from the slogan "publish or perish" to "be seen in public or perish" (Väliverronen, 1993). Consequently, the media orientation of science has led to the use of PR activities (Bauer & Bucchi, 2007; Nelkin, 1995; Shinn & Whitley, 1985).

Science's New Social Contract with Society

Studying science's new social contract with society is in the present thesis done by studying *how public participation is encouraged and organized*. Using the metaphor *trading zone*, Galison aims to explain how communication is managed where there is a high degree of incommensurability. Galison makes a crucial point in this respect, stating:

> Two groups can agree on rules of exchange even if they ascribe utterly different significance to the objects being exchanged; they may even disagree on the meaning of the exchange process itself. Nonetheless, the trading partners can hammer out a local coordination, despite vast global differences. (Galison, 1997, p. 783)

Galison applies the metaphor to science, and Collins, Evans, and Gorman have developed the metaphor along two axes (2010). "One dimension is the extent to which power is used to enforce trade—this is the collaboration-coercion axis. The other dimension is the extent to which trade leads to a homogeneous new culture—this is the homogeneity-heterogeneity axis" (2010, p. 9). This is described as in Figure 3.1.

Collins, Evans, and Gorman (2010) underlined that trading zones only apply when there are difficulties of communication and one work to overcome these difficulties.

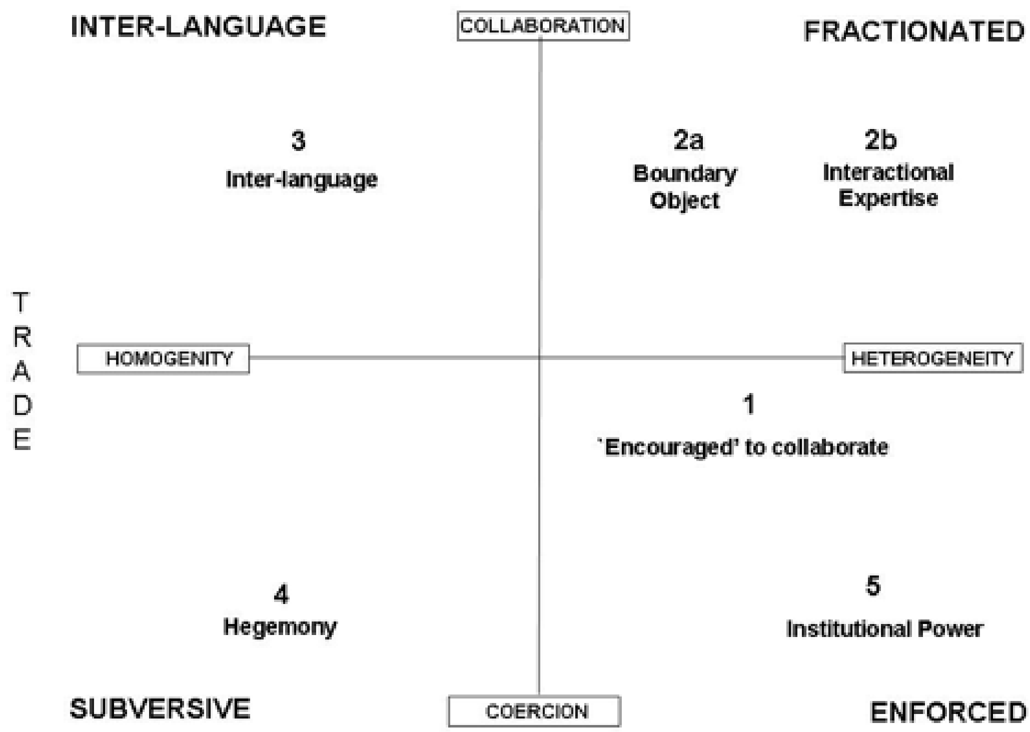

Figure 3.1. Evolution of a trading zone (from Collins, Evans, & Gorman, 2010, p. 17).

In the context of this thesis, I will use the trading zone concept to analyze the work that takes place when developing the different models of communication to engage publics, bridge different social worlds, and facilitate the development of expertise. As the review illustrates the three models—dissemination, dialogue, and participation—as well as the three sub-models—PAST, PEST, and CUSP—multiple interpretations are given over time. One example is the deficit or dissemination model; over time, at least seven versions have come into circulation (see page 14). Consequently, it is important to open up these three key models—dissemination, dialogue, and participation—for elaboration and discussion. The evolution of trading zones is the approach selected in this thesis, and the NMSC constitutes an important context for studying science's new social contract with society.

The Nordic Model of Science Communication and Science's New Social Contract

In light of the review on prior research on science communication and the analytical framework, several crucial research topics seem understudied. Despite the long-existing discussion on the deficit model, few studies actually discuss the problem of the pro-innovation bias within science communication activities. Actually, in the mentioned six essays discussing the deficit model, none really discuss the problem of bias within the context of the deficit model (Cortassa, 2016; Ko, 2016; Meyer, 2016; Raps, 2016; Simis et al., 2016; Suldovsky, 2016), this in spite of the missionary zeal so characteristic of the deficit model. I consequently find it especially important to critically examine the problem of bias in science communication (Hetland, 2015). Neither do the mentioned six essays to any extent discuss how science communication might invite one to a more critical understanding of science and technology in public (Perrault, 2013). I consequently find it especially important to examine how the deficit or dissemination model opens up for public engagement (Hetland, 2012) and critical understanding of science and technology in the public (Hetland, 2016b).

Callon et al. (2009) highlighted the two delegations. The first delegation implies secluded research, and the second delegation implies delegative democracy. These two delegations are important to understanding the dialogue and participation models. Consequently, I will critically examine the room for dialogue and how participants may partake in both knowledge and policy construction processes (Hetland, 2011a, 2011b). To summarize, I am studying the actual communication work that is taking place within the three models.

By critically examining how the three science communication models are used, I will also argue strongly that models are not "empty vessels"—quite the opposite; they are specific ways of framing communication and involvement. This fact makes it also meaningful to study the models as trading zones. Galison (1997) makes the point that trading partners can hammer out local coordination, despite vast global differences. I will use the trading zone concept to explore public communication of science and technology, the communicating partners not necessarily sharing the same framing of the situation, so the framing might consequently be double—be it either conflicting, competing, incompatible, or compatible (Hetland, 1996, p. 15). In spite of these differences, the trading partners hammer out a local coordination. However, I will claim that these differences are exactly what we are studying, and I will, in contrast to Collins, Evans, and Gorman (2010), claim that if there is simply a trade or a trading zone, we do not know before the study is actually done. I will consequently handle the situation as a trading zone at the outset. One problem with my studies, especially the studies within the dissemination model, is that I have limited knowledge of how the publics actually read the texts under study. Only Study IV makes it possible to study the framing differences. However, from earlier studies, we know that there is a framing struggle going on (Hetland, 1999, 2002b), and a more overall research aim is therefore to study what exactly is left behind and what is put forward when a science communicator meets his or her public(s).

The three science communication models are "shared mental models" framing activities providing scripts for action, even if they are understood somewhat differently by the communicating parties. Models are as such intersections of "discursive and material practice, partially—but not completely shared" (Galison 2010, p. 32). I will claim that the deficit or dissemination model is a fairly stable mental model that has been with us for a long time, and the model survives despite having been under continuous attack for many years (Cortassa, 2016; Ko, 2016; Meyer, 2016; Raps, 2016; Simis et al., 2016; Suldovsky, 2016). This persistence and stability, unifying a wide range of actors, makes it into a boundary object of great interest to multiple stakeholders. On the other hand, the dialogue and participation models are more in flux. The actors are to collaborate with a minimum of common language—they are collaborating within an evolving trading zone, developing interactional expertise. Since modernity increasingly involves experimentation, we all have to develop interactional expertise to handle new experimental situations interpreting the new realities. Shared mental model zones are consequently evolving within the context of the NMSC. On the other side, not everyone is partaking in the communication activities, though enough actors are partaking so as to facilitate the claim that this is an important arena for studying the importance of involvement facilitating social change. As already stated, the three science communication models exchange and add features over time, and thereby the models are also getting more complex. Changes introduced by ICT are certainly a crucial element in this respect.

Finally, an important part of the social contract between science and society is science communication in the spirit of the Enlightenment, or

> Ever since the Enlightenment, it has been felt that science and thus today's science communication, must contribute to the public good, and that, in a democracy, it is the duty of government to defend it against all private interests, but now some wish to reduce science simply to a productive role: they want to relinquish its autonomy and gear knowledge to practicality alone. Similarly, in their view, science communication should refrain from taking a critical stance and be content with fascinating people and promoting scientific vocations. Heaven forbid that it should try to inform citizens! (Schiele, Marec, & Baranger, 2015, p. 179)

In the following chapter, I will present the research methods.

Chapter 4 - Research Methods

In this chapter, I will first give an overview of the six studies. Next, I will present the general methodological approach for this thesis, which is primarily qualitative but also combines quantitative methods. The chapter should be regarded as an overview of the methods sections in the six studies. Finally, the chapter concludes with some ethical aspects of the work.

Overview of the Six Studies

From the schematic presentation in Table 4.1, one will understand that the research process was not linear and straightforward. First, after writing and publishing Studies III, V, and VI, I saw that they could form part of an interesting thesis about public communication of science and technology. Studies I, II, and IV, therefore, are situated so that they should shed light on important questions missing in the three other studies. However, this also implies that part of the overarching analytical framework for Studies II, III, and IV first came into place when I read Perrault's book (2013). In retrospect, Studies V and VI could have profited from a clearer discussion of the dialogue and participation models before publishing. This is part of the learning process and is hopefully compensated for in this extended abstract. Second, the organization of the six studies aims to develop a stepwise ecological argument. The bridging concepts across the six studies are *models*, *participation*, *delegation*, *hybridity*, *expertise*, *frames/framing*, and *positions*; these concepts are described in Chapter 3. Some more specific concepts like *pro-innovation bias*, *control*, *domestication/mediatization*, *boundary objects, boundary infrastructure* and *trading zones, authoring*, *positionality*, and *improvisation* are also described in Chapter 3, while *expectations* and *modest witness* are described under the specific study. Table 4.1 gives an overview of the six studies.[12]

[12] I got the idea for the table from Søreide (2007).

	Study I	Study II	Study III
Paper title	Models in Science Communication Policy: Formatting Public Engagement and Expertise, *Nordic Journal of Science and Technology Studies,* 2014, 2(2), 5–17.	Popularizing Internet: Traveling Companions Supporting the Good News, *Nordicom Review,* 2015, 36(2), 157–171.	Internet Between Utopia and Dystopia: The Narratives of Control, *Nordicom Review,* 2012, 33(2), 3–15.
Material	A study of nine white papers on 1975–2013 science policy, one white paper on innovation policy, and other related documents.	2,772 newspaper articles about the Internet from the print editions of *Aftenposten* (morning edition; 1,334), *Dagbladet* (813), and *Dagsavisen* (625) from 1995 to 2006.	2,772 newspaper articles about the Internet from the print editions of *Aftenposten* (morning edition; 1,334), *Dagbladet* (813), and *Dagsavisen* (625) from 1995 to 2006.
Research questions	(1) How does the dialogical turn cut across the three communication models (dissemination, dialogue, and participation) in Norwegian science-communication policy over time? (2) How does each model constitute a developmental zone in which changing understandings of public engagement and expertise are played out?	(1) How are different actors or chaperones enrolled in popular texts to substantiate a specific framing in the portrayal of the Internet by the Norwegian press? (2) How is a position transformed into a bias, and how is such a bias constituted?	(1) How do the expectancy cycles related to the Internet fluctuate in the mass media? (2) How do the narratives of control contribute to the domestication processes of the Internet?
Analytical concepts	Bridging concepts: Models, participation, delegation, hybridity, expertise	Bridging concepts: Frames, positions Specific concepts: Pro-innovation bias, chaperones	Bridging concepts: Frames, positions Specific concepts: Expectations, control
Findings	The dialogical turn cuts across the three communication models to (1) ensure democratic participation, knowledge-building, and the encouragement of innovation; (2) participants represent user interests, the need to stimulate debate but also possess a genuine desire to contribute; participation is organized along two dimensions: a) intensity of knowledge-building; and b) the sponsored or spontaneous nature of hybrid forums; hybrid forums are established for a wide variety of objectives; when ideas on participation migrate, the participation form is adapted to local contexts.	(1) A position is turned into a bias using praise and blame as important framing strategies, and praise and blame are substantiated by accompanying chaperones. (2) The pro-innovation bias in technology communication manifest the individual-praise, pro-technology, individual-blame, technology-blame, and (not the least) source biases.	(1) The expectancy cycles for the Internet in the mass media fluctuate in a manner comparable to the stages of the innovation-decision process. (2) The control position promotes individual, social, technological, and institutional control and is more prominent when the Internet is lower on the media agenda.

Table 4.1 Overview of the six studies

	Study IV	Study V	Study VI
Paper title	Public Communication of Technological Change: Modest and Less Modest Witnesses. Submitted (later published in *Nordic Journal of Science and Technology Studies* 4(2), 5-16)	The User Paradox in Technology Testing, *Nordic Journal of Digital Literacy*, 2011, 6(1.2), 7–21.	Science 2.0: Bridging Science and the Public, *Nordic Journal of Digital Literacy*, 2011, 6(Special Issue), 326–339.
Material	86 feature articles (*kronikker*) written by scholars of Internet research from the print editions of *Aftenposten* (morning edition; 50) and *Dagbladet* (36) from 1995 to 2012.	Meta-review of earlier design and policy experiments with ICT within the education field.	30 interviews with relevant actors and document studies.
Research question(s)	Compared to journalists, how do Norwegian researchers portray technological change when they popularize Internet research?	(1) How are users understood in different quasi-experimental traditions regarding user participation in the knowledge construction process? (2) How are users understood in different quasi-experimental traditions regarding user participation in the policy construction process? (3) How do these understandings influence how experimental lessons are transformed into policy and practice?	(1) What characterizes participation in knowledge production and collaboration within the systematic biology and biodiversity in Internet-based hybrid spaces? (2) How does apomediation identify trustworthy, credible information and services given the multiple voices operating in Internet-based hybrid spaces? (3) How do the interfaces used to stimulate collaboration function as bridging devices among different user groups and stakeholders?
Analytical concepts	Bridging concepts: Frames, positions, models Specific concepts: Modest witness, technology change, expectations	Bridging concepts: Framing, delegation, hybridity Specific concepts: Authoring, positionality, improvisation	Bridging concepts: Hybridity, expertise Specific concepts: Boundary objects, boundary infrastructures, apomediation
Findings	Researchers attempt to situate their popularization in research-based argumentation framed by two opposing understandings of technological change, while journalists situate their popularization in an expectation-based argumentation framed by two opposing understandings of technological expectations. Whereas researchers emphasize facts, journalists emphasize expectations.	(1,2) The more opportunities users have to play out authoring, positionality, and improvisation, the more included they are in the transformation process from the experimental phase to policy and practice. (3) The durability and extension of networks and framing are essential for transformation into policy and practice.	Boundary infrastructures presuppose two levels of boundary objects. (1) The first level facilitates communication and trust. (2,3) The second level facilitates activities that reach out and make apomediation important. Bridging different boundary objects then facilitates the building of boundary infrastructures.

Table 4.1 Overview of the six studies

Multiple-Case Design

In an interesting discussion where Gross compared two cases studying the effects of the Chernobyl disaster on Western Europe, "Robert Paine's of Lapp reindeer herders, and Brian Wynne's of Cumbrian sheep farmers" (1994, p. 10), Gross argued for the contextual model, and stated that case studies produce genuine knowledge. The SCR has shifted from cognition to context, accompanied by an ethnographic turn in the study of PCST (Irwin & Michael, 2003). Following this, my research design could be described as a multiple-case design (Flyvbjerg, 1991, 2006; Yin, 2014), each case still being holistic (Yin, 2014), allowing for multi-sited ethnography combined with textual analysis, interviews, and document studies. The ethnographic approach uses ethnography as the study of blended worlds in the micro spaces that are shaped by emerging activities (Hetland & Mørch, 2016; Hine, 2015).

Having a multiple-case design, the background is also multiplex. I have long wanted to write about PCST in a manner that "uncovered" the magnitude and complexity of PCST and contributed to the more theoretical discussion on science communication models. Since 1984, I have been interested in new ICT, and studied technologies as Videotex/Teledata and Minitel within the framework of "constructive technology assessments" (Rip, Misa, & Schot, 1995)—technologies that are now in the oblivion of unsuccessful innovations. When the Internet appeared as a public service in Norway in 1994, my intuition told me that "this is it." And intuition is certainly important in selecting case studies (Flyvbjerg, 2006). I applied to the Research Council of Norway under the *Societal and Cultural Presuppositions for Information and Communication Technology* program for a grant for the *Media-technological dramas: The Internet Meets the Public* project, and the application was approved. The project started in the spring of 1997 and was planned to conclude in the fall of 2000. My intention was to study the narratives of the Internet in Norway for the three first years (Godø & Hetland, 2003; Hetland, 1999, 2002b). So the case has been with me for more than 20 years. Around 2007, I submitted a more synthesizing paper to a journal and was rejected; the reason I was told was that the material had too short a time span to be still interesting. Consequently, I decided to extend the timespan and included 2006 and the years between. That was actually a lucky decision, as, while studying only the three first years I missed out on important parts of the innovation-decision process and how PCST changed over time.

Originally, my intention was to study the two master narratives that I found in the literature (Bloomfield & Vurdubakis, 1995; Mulkay, 1993), the utopian narratives and the dystopian narratives, or the narratives of hope and fear. However, by using the model of Gamson and colleagues, distinguishing between the different positions, I identified that there were actually three master narratives, not two, and the narrative in between was the technology-as-risk narrative with the control position, while the dystopian narrative was more or less absent when it came to the Internet. Consequently, this case made it possible to study only two of the three master narratives that I identified (Hetland, 2012, 2015). This case is rich both when it comes to data and timespan, and this richness has made it possible to study the development over 12 years, studying how the media balance evolves over time (Hetland, 2012), as well as the parallel enrollment of chaperones (Hetland, 2015). As such, the Internet case facilitated a mixed-methods research design (Creswell, 2014).

Intuitively, I assumed that PCST would appear differently when it was not mediated by journalists, but came directly from the researchers themselves. In an earlier article, I had distinguished between the direct route, the middleman route, and the bazaar route (Hetland, 2002b), inspired by several contributions (Bucchi, 1998; Callon, 1998; Fleck, 1935/1979; Lewenstein, 1995). The whole time, I intended to do a comparative study comparing PCST along the direct route with the middleman route. This was before I had read the study of Perrault (2013), which later made me make a clearer distinction between the PAST, PEST, and CUSP sub-models. Studying the direct route gave me a small surprise, since I did not at the outset assume that the narratives would be that different (Hetland, 2016b). The direct route inspired an exploration of the role of the modest witness. Studying the direct route, I also extended the time span to achieve richer data material.

The dialogue model has been with me for a long time. As already mentioned, I started doing what may be called “constructive technology assessments” in 1984, and after 10 years, I defended my PhD in 1994 (Hetland, 1996). I am still surprised by the gap between what was actually done in the attempts to test technology and what the actors said they do, and I decided to do a restudy of some experimental approaches, studying learning phenomena when ICT is introduced. This was done by recapturing my earlier studies and studying one large policy experiment introducing ICT in Norwegian schools, called PILOT. This long interaction with the dialogue model over a time span of more than 20 years has fostered “context-dependent knowledge and experience” (Flyvbjerg, 2006, p. 222), and I concur with Flyvbjerg that,

> Like other good craftspeople, all that researchers can do is use their experience and intuition to assess whether they believe a given case is interesting in a paradigmatic context and whether they can provide collectively acceptable reasons for the choice of case. (Flyvbjerg, 2006, p. 233)

The more collective reasons are linked to the fact that experimentation is embedded in modern society (Hetland, 1996), and that the gap between what experts aim for and what they achieve is a general concern within both practical life and social science (Flyvbjerg, 2008; Kahneman, 2011).

However, tests do not simply report on pre-existing facts, but, more importantly, are also mechanisms for defining and producing the traits and capacities that the tests supposedly measure. Technology testing has revealed some of the potential of ICT, but has also illustrated that users tend to prefer the medium that experimenters suggest would be most effective for the purpose in question. We therefore experience that testing technology is an important part of the shaping of technology, making our images into reality. This may partly be understood as what Rosenthal has called the “experimenter expectancy effect” (Rosenthal, 1963). This means that the results of experiments tend to come out in a way that favors the experimenter's expectation of how they ought to come out, however much he or she tries to avoid bias.

The experimenter's expectation bias also influences the explanation of failures. One way, which is usually taken by scientists who have come up with negative results, is to say that negative results illustrate that it is necessary to change how we framed the test, not necessarily what we tested. Failures, therefore, do not necessarily tell us anything about the technology, but primarily something about the test. When one discusses the long range of quasi-experiments, it is important to bear this in mind. With technology testing, the experimenters strive to make the technology comply with their expectations embedded in the tests as to how the technology should or should not perform. When the technology does not perform according to the experimenters' expectations, the experimenters often look for external reasons for the failures, not explaining the problematic construction of their own images.

The participation model came to me when I did something quite differently: evaluating university museums' digitalization activities. On behalf of the University Museums Commission, appointed by the Norwegian Ministry of Education and Research, a colleague and I evaluated university museums' work in digitalizing their collections (Hetland & Borgen, 2005). Fifty people were interviewed, some of them several times. About half of them worked within natural history, while the other half worked within cultural history. More detailed references to the empirical material are given in Hetland and Borgen (2005). Later, in 2010, I did follow-up interviews with crucial actors within natural history, at the Global Biodiversity Information Facility (GBIF) both in Norway and at the international GBIF Secretariat at the Natural History Museum in Copenhagen, the Norwegian Biodiversity Network (SABIMA), and the Norwegian Biodiversity Information Centre (NBIC). The follow-up interviews were selected to study critical issues in the process of building boundary objects and boundary infrastructures and the role of apomediation in this respect. When the boundary infrastructure came into place in 2008, I understood that this could develop into an interesting and rich case that provided opportunities for studying the participation model. However, at that time, the very concept of *citizen science* was just emerging as a more unifying concept portraying amateurs/volunteers participation in doing science, the most prominent contribution at that time being Irwin's quite different use of the concept (1995). When it comes to doing the CS case, I studied biology many years ago, and this old knowledge made me more comfortable doing the case study; however, it is also possible that this made me blind to some important developments. After reading Hine's (2008) reflections on this, however, I do not think so.

Technoscience may be described as building networks, and we have followed scientists, amateurs, and policy actors at work; how do they enroll or exclude actors and resources building boundary objects and boundary infrastructures through problematization, interessement, and the definition of obligatory passage points (Latour, 1987)? Latour called this the translation model. The translation model offers methods and concepts to open up the innovation process. The research questions were analyzed by following important and often controversial issues in the interviews, combined with document studies of the same issues; what kind of transformations do these issues undergo later in the hands of others, and how are these controversies resolved? In the process, we have followed how various groups and interests are linked together, building boundary objects and boundary infrastructures, while establishing routines for quality assessment.

Finally, designing the four different case studies (II+III, IV, V, and VI), I looked for literature that described the policy context of science communication in Norway. I was not able to find such a study, and decided to write the policy article (Hetland, 2014) as *the last bit of the puzzle* using Norwegian policy documents since 1975, especially the 10 white papers presenting science policy and innovation policy between 1975 and 2013, as the most important source for a content analysis. This "case study" was not part of the original plan, but it became necessary to contextualize the four previous case studies.

In selecting the case studies, the aim has been to capture the rich ambiguity of PCST. Flyvbjerg warns against summarizing dense case studies, but I have aimed for some general lessons about PCST so that every article contributes to understanding the ecosystem of science communication by focusing on some critical issues within the different models outlined in Figure 1.1. The study of how the Internet has been popularized in the Norwegian press in particular might be an exemplar that can establish a reference point or serve as a paradigmatic case (Flyvbjerg, 2006). As Flyvbjerg (1991, 2006) quite rightly underlined, it is not possible to identify a specific case as paradigmatic in advance. However, this case is rich and involves many actors (journalists, researchers, readers, and other relevant stakeholders) in different ways. As well, the Internet represents both an innovation and a cluster of accompanying innovations. Not the least, it involves all citizens in a changing understanding of how "networks constitute the new social morphology of our societies" (Castells, 1996, p. 469). Even if one argues against both soft and hard versions of technological determinism (Smith & Marx, 1994), expectations certainly have real consequences (N. Brown & Michael, 2003), and from the last two decades, it is difficult to find a similar, all-embracing case of public communication of science and technology. The cases are thus selected to be exemplars that highlight more general characteristics of the models in question (Flyvbjerg, 2006).

Science and Technology Narratives

The main database used in the present study consists of 2,772 newspaper articles about the Internet from the print versions of the morning edition of *Aftenposten* (1,334), *Dagbladet* (813), and *Dagsavisen* (625) for the period 1995–2006. *Aftenposten* is Norway's largest newspaper and has been described as independently conservative. *Dagbladet* is Norway's second-largest tabloid newspaper and has been described as liberal. *Dagsavisen* is the former party organ of the Norwegian Labour Party, but in recent years has been described as independent. The aim was not to compare these newspapers, but to select three papers covering the breadth of the Norwegian press, both politically and journalistically. From 1995 to 1996, 40.2% of the Norwegian population over the age of 13 read one or more of the three newspapers studied (42.2% in 1996–1997). The press was and still is important because:

> For most people, the reality of science is what they read in the press. They understand science less through direct experience or past education than through the filter of journalistic language and imagery. The media are their only contact with what is going on in rapidly changing scientific and technological fields, as well as a major source of information about the implications of these changes for their lives. (Nelkin, 1995, p. 2)

Through most people's lifetimes, the mass media will provide the public with more information about the nature of science than even the best educational experience (LaFollette, 1990, p. 19). One clear advantage of selecting newspaper articles was that the print media offers "an inventory of cultural elements, such as events, dates, metaphors, frames, and symbols associated with a specific issue" (Peters, Heinrichs, Jung, Kallfass, & Petersen, 2008, p. 87). However, the traditional electronic mass media (Brinch & Iversen, 2010), as well as social media, are of course also important arenas for science communication (Welbourne & Grant, 2015).

The criteria for selecting an Internet article followed those used by Bader (1990) in a case study of articles on research. One of Bader's (1990) criteria was that roughly half of the article should discuss the object of the study. Correspondingly, one criterion was that the Internet should be a central theme of the article; in other words, at least half of the selected article should deal with one or more sets of potentials or problems concerning the Internet. The selection of articles was also based on the following criteria: 1) the article has a word count of at least 200, 2) the Internet is mentioned in the headline or the introductory text, and 3) the text was written by a journalist—all types of journalists, not only science and technology journalists. Excluded from the text corpus were short news reports, editorials, debates, and feature articles (*kronikker*) by researchers and longer feature articles by journalists with a mix of positions.

Whenever possible, the articles were collected from electronic sources: 1) *Aftenposten*, for the entire period, 2) *Dagbladet* after 1 January 1998, and 3) *Dagsavisen* after 1 February 2002. For the missing periods, I manually conducted data collection. Though I did not have a full overview of the total article population, it was possible to use *Aftenposten* as an indicator. For this newspaper, all articles were coded in the electronic source according to their topic. The selected articles represented 32% of the total population. From 1995 to 1999, 47% of all articles in *Aftenposten* met the selection criteria, but only 27% from 2000 to 2006. The primary reason for this decline might have been the increase in the proportion of articles with fewer than 200 words, which rose from 37% of all articles in the first period to 48% in the second. The second reason was use of the term *Internet* as a selection criterion. During the period studied, the term *Internet* was increasingly replaced by its shortened version of *net* or more specific terms. A smaller control study of these articles did not capture new information. Therefore, it is reasonable to assume that the diversity and the changes in the period studied were identified. Including all the articles that satisfied these specific criteria permitted combining a qualitative textual analysis with a quantitative approach. Approximately a third of the data were double-coded for the variables studied. The intercoder agreement coefficient, calculated using Holsti's (1969) method, yielded a range of 96.1% to 97.7% for the three items (position, chaperones, praise and blame) (see Table 7.1 in Appendix 1). When coding a position, no distinction was made between slant and bias, as the pro-innovation bias was consistent over time (Entman, 2010).

In Study IV, we retrieved and coded 86 digitized feature articles (*kronikker*) that were collected from the Atekst/Retriever database. The study covers feature articles from 1995 to 2012 from the newspapers *Aftenposten* and *Dagbladet*. The feature articles were coded with the help of HyperRESEARCH, a program aimed to do computer-assisted qualitative data analysis (CAQDAS). HyperRESARCH is useful to organize, manage, and analyze a textual corpus of the mentioned size. Each feature article was coded several times to test hypotheses and facilitate a repeating comparison of the text gathered (Hesse-Biber & Dupuis, 2000).

Consequently, the research method selected is a multiple-case design, and the science and technology narratives are studied by selecting a text corpus of 2,772 newspapers articles and 86 feature articles about the Internet. In the next chapter, I will present a summary of the studies and a discussion of findings and contributions.

Ethical Aspects of the Work

Conducting the work with this thesis, I have adhered to the *Guidelines for Research Ethics in the Social Sciences, Law and the Humanities* (NESH, 2006). The thesis builds on free and independent research done by the author. The studies as they were undertaken utilized neither directly or indirectly personal data; consequently, the studies were not subject to notification to the Data Protection Official for Research. Only Study VI did in its 2005 version contain some identifiable data; how that was handled is described in Hetland and Borgen (2005, p. 32). I have strived to adhere to good reference practice; however, writing the extended abstract, I have only in the beginning of each chapter (2, 3, and 4) underlined that the chapters should be regarded as overviews of the respective literature reviews and analytical and methodological parts of the six articles that are Part II of this thesis. I have not found it feasible to refer to actual text elements within each of the articles. The same is relevant for Chapter 5, which discusses the contributions of the six studies. Furthermore, to facilitate a free and open dialogue, all the articles are published in open-access journals and made available on academia.edu, researchgate.net, and UiO: DUO Research Archive.

Chapter 5 - Summary of the Studies and Discussion

In this chapter, I summarize the findings from the six studies that form Part II of this thesis and discuss their empirical, methodological, and theoretical contributions to the field of SCR. I began this thesis with the ambition to study the ecology of public communication of science and technology. Three key research questions guide the thesis. First, how is public communication of science and technology organized in different models of expert–public interaction? Second, how do different models of science and technology popularization frame science and technology narratives? Third, building on the first two questions, what are the implication of these models for the social contract between science and society? The two first key questions are addressed from various angles in the six studies, while the third question is addressed in the extended abstract.

Each of the six studies included in this thesis represents an attempt to understand an important element in the ecology of public communication of science and technology. Study I explores the policy context of public communication of science and technology in Norway (Hetland, 2014). Studies II, III, and IV examine the dissemination model. The first two studies address two master narratives: utopian narratives with a pro-innovation position, which are related to the PAST model (Hetland, 2015), and technology-as-risk narratives with a control position, which are related to the PEST and CUSP models (Hetland, 2012). Study IV probes how Norwegian researchers, compared to journalists, portray technological change when they popularize Internet research, which is related to the CUSP model (Hetland, 2016b). Study V addresses the dialogue model (Hetland, 2011b) and Study VI the participation model (Hetland, 2011a).

Models in Science Communication Policy—Study I

Hetland, P. (2014). Models in science communication policy: Formatting public engagement and expertise. *Nordic Journal of Science and Technology Studies*, 2(2), 5–17.

Although this study was not the first chronologically, it is presented first, as it explains fundamental policy issues and conceptual and analytical grounds on which all six studies rest. In Study I, I draw from Bucchi (2009), Bucchi and Trench (2008), and Callon, Lascoumes and Barthes (2009) to elaborate how the three communication models (dissemination, dialogue, and participation) are best understood along two dimensions: 1) the intensity of cooperation among different actors in knowledge production processes and 2) the extent to which a sponsor elicits public participation. Within the dissemination model, Perrault (2013) identifies the three sub-models (PAST, PEST, and CUSP). The aim of the study is twofold: 1) to substantiate that the dialogical turn cuts across all three main communication models and 2) to study how each model facilitates the transformation from engagement of participants to the acquisition of different kinds of expertise by participants (H. Collins & Evans, 2007).

Based on a content analysis of nine white papers presenting science policy and one white paper presenting innovation policy, I describe how Norwegian policy on science communication has been presented since 1975. Policies concerning science communication have changed gradually over time. The most important change concerns the increased importance of dialogue and participation in all three main models. Under an active policy aimed at encouraging dialogue, sponsored hybrid forums that encourage participation have been developed gradually. In addition, social media have facilitated increased spontaneous public involvement in a correspondingly growing number of hybrid forums. Dialogue and participation have thus become crucial parts of science and technology development, and the traditional division between science and science communication has been challenged by the various forms of dialogue within the dissemination model. In other words, a broader inventory of types of communication and involvement has emerged.

The dissemination model experienced notable development during the 1990s and the first decade of the 21st century. Consequently, the dissemination model remains an important communication model, a finding well documented by Brossard and Lewenstein (2010). The dialogue model, which aims to bridge the single delegation and extend the peer community, was developed as a policy model in the 1990s. Experimentation had already become a central work form in modern society, and increasing numbers of persons have become familiar with science and technology through reform activities and more formative experiments to manage social change. The dialogue model, therefore, contains a number of activities resulting from clear political initiatives involving the public and users. The participation model in general, which aims to bridge the double delegation, has its roots in the agricultural extension model, a highly successful model based "on client participation in identifying local needs, planning programs, and in performing evaluation and feedback" (Rogers, 2003, p. 394). The participation model has developed along two tracks. First, central to innovation policy has been the inclusion of a steadily increasing number of innovation measures. Participation has thus become important to shape innovations and promote diffusion. Second, social media have enabled completely new ways of participation, including virtual collaboration.

Popularizing the Internet—Study II

Hetland, P. (2015b). Popularizing the Internet: Traveling companions supporting the good news. *Nordicom Review,* 36(2), 157–171.

In popular science and technology writing, boosterism is prominent. Writers overwhelmingly describe science and technology in enthusiastic terms, promoting the deficit or PAST model. A crucial characteristic of the PAST model is its pro-innovation bias: in the texts, writers enroll chaperones, such as spokespersons, users, celebrities, witnesses, experts, and authorities, to support their claims. Both boosterism and pro-innovation bias limit the publics' critical understanding of science and technology. Therefore, I closely analyze how different framing devices are used to shape pro-innovation bias. I explore two research questions: 1) How are different actors or chaperones enrolled in popular texts to substantiate a specific framing in the portrayal of the Internet by the Norwegian press? 2) How is a position transformed into a bias, and how is such bias constituted?

Exploring public communication of science and technology through a case study of how the mass media have communicated about the Internet is revealing, not least because this new media technology provides rich opportunities to study numerous aspects related to the PAST model and pro-innovation bias. The first research question focuses on how chaperones are used to substantiate pro-innovation bias in Internet communication. Bias is understood along three dimensions. Content and decision-making biases dominate communication about the Internet. Distortion bias is more difficult to detect, as this study focuses on the texts rather than how they are produced. Regarding content bias, source bias plays the most crucial role in the media favoring one side rather than providing an impartial presentation. Regarding the decision-making bias, individual praise and blame and praising and blaming technology frame the view of new technology as the key driver of economic growth and progress. The second research question is aimed at exploring the path from positions to biases. Entman (2010) described a process of shifting from framing a position as one of several possibilities to a slanted presentation, and finally, to a biased presentation. The underlying assumption is that the unbiased position is the ideal position from which one can distinguish biases. However, Gripenberg et al. (2012) present strong empirical evidence that a pro-innovation bias is the typical position in technology communication. This claim is substantiated by the present study. Generally, praise and blame are used as critical framing strategies to turn a position into a bias.

The Internet between Utopia and Dystopia—Study III

Hetland, P. (2012). Internet between utopia and dystopia: The narratives of control. *Nordicom Review*, 33(2), 3–15.

Narratives about expectations are significant in the diffusion process of innovations. These narratives utilize resources about opportunities and potential risks. They exert a performative force, spurring different actors to make technology their own, and thereby contribute to the domestication processes of innovations.

The Internet has often been envisioned as a technological utopia, framed by the rhetoric of hope. However, a study of the popular discourse reveals three master narratives: utopian narratives containing the pro-innovation position, dystopian narratives containing the anti-diffusion position, and technology-as-a-risk narratives containing the control position. While anti-diffusion narratives are more or less invisible in the popular texts, narratives of control are surprisingly absent in the scientific discourse about the Internet. This study explores narratives of control as presented in the Norwegian press from 1995 to 2006. This study investigates two research questions: First, how do the expectancy cycles relating to the Internet fluctuate in the mass media? Second, how do the narratives of control contribute to the domestication processes of the Internet?

This exploratory study supports two general conclusions. First, expectations are important for the diffusion of innovations. The higher the Internet is on the media's agenda (the stages of knowledge and implementation), the more prominent the pro-innovation position is. In stages when the Internet is lower on the media's agenda, the control position increases in importance. Hypes, such as the dot.com hype, are important for two reasons: they frame expectations and spur diffusion. Consequently, hype is most visible during the implementation stage.

Second, technological innovations in both popular and policy-driven discourses can be understood through three master narratives. The utopian narratives are prominent in modern society; they signify progress and hope. In this respect, the narratives about risk and control are an important counterpart to the utopian narratives. Winner (1977, p. 98) claims that technological development is most productive when the breadth of possibilities is neither foreseen nor controlled. Technology always does more than planned. This fact is so deeply ingrained in general knowledge that it becomes part of intentions. The narratives of control are an interesting example of how risks are politicized and demonstrate that the media formulate not only threats but also solutions. Nohrstedt (2010, p. 18) claims that late-modern society "has become obsessed with the fact that our lives are not entirely safe and under our control." The Internet narratives substantiate that, even as the media create problems or danger, the media also seek control of these very problems and dangers. The rhetoric of fear, consequently, is balanced by the rhetoric of control. In this manner, not only are the problems and dangers created in and by the media, but so are the solutions. The media, therefore, are important actors in domesticating new technology.

Public Communication of Technological Change—Study IV

Hetland, P. (2015a). Public communication of technological change: Modest and less modest witnesses. Submitted (later published in *Nordic Journal of Science and Technology Studies* 4(2), 5-16)

Whereas science and technology journalists look for news value to attract audiences' attention, most researchers communicating their results act as "modest witnesses" to calm exaggerated expectations. Thus, this study describes how Norwegian researchers portray technological change when they popularize Internet research in comparison with journalists' narratives. The technology popularization field is structured along two dimensions: 1) from PAST via PEST to CUSP, and 2) from expectation-based argumentation to research-based argumentation. Most journalists position their contributions closer to expectation-based argumentation, whereas most researchers position their contributions closer to research-based argumentation. Within the trichotomy of pro-innovation, control, and anti-diffusion, most journalists locate their contributions close to the PAST model (the pro-innovation position), while smaller numbers locate their contributions closer to the PEST and CUSP models (the control position). In the dichotomy of continuity and discontinuity, most researchers position their contributions close to the CUSP model (continuity), while small numbers position their contributions closer to the PEST model (discontinuity). Therefore, one can claim that the media, not researchers themselves, primarily drive mediatization processes. Most researchers attempt to curb the mediatization processes and do not aim for visibility for its own sake (Goodell, 1977), as they are concerned primarily with communicating reliable, socially robust knowledge (Nowotny et al., 2001).

Consequently, while journalists often situate their popularization of technology within narratives of expectations, technology popularization by researchers is often situated within a more general discourse on technological change, making *the role of the modest witness* a guarantor of scientific validity (Haraway, 1997). Consequently, the role of modest witness seems to be a crucial part of the professionalization of the research profession, and the "authority of the modest witness paradoxically stems from the appearance that authorship itself disappears" (Leach, 2011, p. 189). Ultimately, their modesty is not gained by what they know, but by all they know they do not know.

The User Paradox in Technology Testing—Study V

Hetland, P. (2011b). The user paradox in technology testing. *Nordic Journal of Digital Literacy*, 6(1.2), 7–21.

The sociology of testing has identified a paradox: Even when users are important to performing tests, their contributions are often blackboxed (Hetland, 1996; Pinch, 1993; Woolgar, 1991). In the early 1990s, Brown and Collins (A. L. Brown, 1992; A. Collins, 1992) introduced design experiments as a new approach for studying learning phenomena in quasi-experimental settings facilitating dialogues. I claim that, despite this highly important turn in the sociology of testing, the user paradox remains unresolved. Therefore, in this study, I examine experimental approaches for studying learning phenomena when ICT is introduced, with the aim to contribute to opening this black box.

Much experimental activity has a quasi-experimental design, as the aim has been to evaluate the effectiveness or impact of learning interventions, to design innovative learning environments, or to evaluate technology policy changes. Different experimental approaches are closely linked to the idea of the social laboratory. Callon et al. (2009) claim that laboratories can be understood as a three-stage process of translation. In the first stage, the complex world is translated into the laboratory, reducing the complexity to a manageable scale. In the second translation, the laboratory is transformed into a machine for producing inscriptions, making possible their discussion, interpretation, and mobilization in learned debates. In the third translation, the laboratory results are translated back into the complex world (Callon et al., 2009). In a quasi-experimental design, the distinction between the three stages can be more blurred.

Three interrelated questions are asked in this study: How are users understood in different quasi-experimental traditions when it comes to user participation in the knowledge construction process? How are users understood in different quasi-experimental traditions when it comes to user participation in the policy construction process? And, finally, how do these understandings influence how the experimental lessons are transformed into policy and practice?

Although not explicitly stated, this study explores the dialogue model and uses three concepts (authoring, positionality, and improvisation) to probe the room for dialogue (Rasmussen, 2005). The freer participants are to play out authoring, positionality, and improvisation, the stronger their participation in the knowledge and policy construction processes is. The study structures the room for dialogue along two axes: the intensity of participation in knowledge and policy construction processes. In the first quadrant (Hetland, 2011b, p. 10), entitled "the circumscribed user" (Akrich & Latour, 1992), lies true experimental design, with strict limitations on participants playing out authoring, positionality, and improvisation. The researcher or experimenter controls the knowledge construction process, and the distance between research results and policy and practice likely is never overcome. In the upper-right quadrant, entitled "the bridging single delegation," participants are increasingly involved in the knowledge construction process but only to a very limited degree in the policy construction process (at least not in the context of the experiment). In this context, participants are given opportunities to handle the first delegation. In the lower-right quadrant, entitled "the bridging double delegation," participants are increasingly involved in both the knowledge and the policy construction process. These participants are given opportunities to handle the first and second delegation. In the lower-left quadrant, entitled "the ascribed user" (Akrich & Latour, 1992), there is no planned experimental activity, but users participate in the activity of setting through an attribution process whose origin is in the setting itself (the ascribed user may later actively participate in the policy construction processes).

Consequently, the chosen experimental approach is an important element in transforming lessons into policy and practice. I claim that, the more opportunities users have to play out authoring, positionality, and improvisation, the more they are included in the transformation process from the experimental phase to policy and practice. In other words, the choice between different experimental traditions influences the room for dialogue and, accordingly, the diffusion of innovations. Experimental activity, therefore, is best understood as a translation process building networks. The durability and extension of these networks are essential for the success of experiments and the dialogues that facilitate the dissemination process. Durable networks also imply that the actors involved have a compatible framing of events, as divergent frames easily lead to disintegration. Finally, it is important to bear in mind that experimental activity conducted within a technology push or a pro-innovation strategy requires a strong network of social actors to facilitate the transformation from the experimental phase to policy and practice.

Science 2.0—Study VI

Hetland, P. (2011a). Science 2.0: Bridging science and the public. *Nordic Journal of Digital Literacy*, 6(Special Issue), 326–339.

Collaborative technologies create new possibilities for doing science and including amateurs/volunteers in knowledge production. The online portal Species Gateway, launched in 2008, has opened up for national participation in biodiversity mapping. This portal has been a great success and serves as a point of departure for studying the participation model. CS is depicted as a novel mode of organization and culture in scientific communities (Waldrop, 2008). Eysenbach (Eysenbach, 2008) proposes a framework with five major components or themes to describe Medicine 2.0: 1) social networking, 2) participation, 3) apomediation, 4) collaboration, and 5) openness. Apomediation is a new socio-technological term coined to describe the third way for users to identify trustworthy, credible information and services.

Based on these concepts, the research questions are formulated as follows: What characterizes the participation in knowledge production and collaboration about systematic biology and biodiversity in Internet-based hybrid spaces? How does apomediation play out to identify trustworthy and credible information and services, given multiple voices operating in Internet-based hybrid spaces? Finally, how do the interfaces used to stimulate collaboration function as bridging devices between different user groups and stakeholders?

In this study, I identify important processes in building boundary infrastructures. Most important is developing boundary objects that facilitate collaboration. Successful boundary infrastructures presume two levels of boundary objects. The first level facilitates communication and trust. At this level, one finds the EU Inspire Directive, the standardization of names and species thesauri, and the growing standardization of validation routines. These boundary objects are structured by more formal standardization processes and informal self-organized processes. This layer of boundary objects also facilitates the management of standardized forms, such as the Red List and Alien Species List. The convergence of these processes increases the level of trust in the information provided by boundary infrastructures. The second level of boundary objects facilitates activities that reach out to different communities and society at large. Important boundary objects, so far, are the Species Maps.

Boundary infrastructures, therefore, presume two bridging activities. First, standards are important bridging devices between different boundary objects. The standardization of names and species thesauri, data standards, and agreed-upon validation routines enables the exchange of information among different sources. Second, new services, such as the Red List and Species Maps, have sufficiently consistent structure to permit the application of the full array of bureaucratic tools (e.g., forms, statistics). This second bridging activity opens up the boundary infrastructure to a wide array of possible applications that producers and users might develop later.

Discussion of Findings and Contributions

In this section, I detail the empirical and analytical findings of the six studies and how they contribute to the field of SCR. I discuss the empirical findings for each of the two first overall research questions. First, how is public communication of science and technology organized in different models for expert–public interaction? Second, how do different models of science and technology popularization frame science and technology narratives? Next, I turn to the methodological and theoretical contributions of this thesis, while the discussion of the implications for the social contract between science and society are presented in the concluding chapter.

Empirical Contributions

Exploring Different Models of Expert–Public Interaction

Both Trench (2008b, p. 131) and Bucchi (2008, p. 69) discuss different models of expert–public interaction, identifying three communication models I prefer to call the dissemination, dialogue, and participation models. To distinguish between these three key models, Trench (2008b, p. 131) and Bucchi (2008, p. 69) use topics, such as emphasis, aims, ideological and philosophical associations, and the orientation of science to the public. Although useful, this approach misses a stronger focus on understanding public involvement. How does each model facilitate the transformation from engagement of participants to the acquisition of different kinds of expertise by participants? To expand on these models, I find it useful to combine the traditional discussion of them with a new perspective on the role of expertise in the practice of science and the public evaluation of technology (H. Collins & Evans, 2007). Collins and Evans (2007) proposed a radical new perspective on the role of expertise that makes it easier to distinguish between the three key models. Combining these two discussions in Study I, I show how these three key models are best described along two dimensions: 1) the intensity of co-operation among different actors in knowledge production processes and 2) the extent to which a sponsor elicits participation. Four participation forms for users and the public are described: 1) dissemination, 2) dialogue, 3) participation, and 4) ambivalence. The fourth form is certainly interesting and an important reminder that disengagement with science and technology in the traditional sense is not necessarily the opposite of engagement (Brint & Cantwell, 2012). However, in this thesis, I do not have the time or space to discuss this fourth form to any extent. I will also underline, with reference to the discussion between Collins and Evans et al. and Wynne (page 30), that this is not just another reinvention of the deficit model, but a necessary topic to be elaborated on to move forward and avoid what Irwin calls *moving in circles* (2009).

The first empirical contribution of this study is an overview of Norwegian public communication of science and technology policy since 1975 (Study I). Three key models of expert–public interaction are central to public communication of science and technology: the dissemination model (often called the deficit model), the dialogue model, and the participation model (Bucchi, 2008; Trench, 2008b). Since 1975, concerns with public engagement over time have led to a more dialogical mode across the three key models of public communication of science and technology policy in Norway (Hetland, 2014). Under an active policy, sponsored hybrid forums that encourage participation have been developed gradually. In addition, ICT and social media allow spontaneous public involvement in an increasing number of hybrid forums. Dialogue and participation have thus become crucial parts of public communication of science and technology, and shape public engagement and expertise (H. Collins & Evans, 2007).

The second empirical contribution is a detailed study of the dissemination model and its three sub-models of science and technology popularization: PAST, PEST, and CUSP (Perrault, 2013). This is described in more detail under the narratives (see pages 60-61).

The third empirical contribution is a study of the dialogue model (Study V). Rasmussen (2005) described and analyzed participation with three concepts: authoring, positionality, and improvisation. According to Rasmussen (2005), authoring refers to how social practice is constructed and maintained, positionality reveals the dynamics of social interactions and their relation to participants' joint construction of knowledge and understanding, and improvisation increases analytical sensitivity to change (p. 224). To open up both science and democracy, Callon et al. (2009) call for experimental activity in hybrid forums. The empirical contribution of this study is a better understanding of the differences between design experiments (A. L. Brown, 1992; A. Collins, 1992) and policy experiments (Hetland, 1996; Rondinelli, 1993). Design experiments are aimed at bridging the single delegation, but policy experiments the double delegation. Consequently, the dialogue model also has important variations.

The fourth empirical contribution is a study of the participation model (Study VI). Collaborative technologies can be used to shape hybrid spaces with heterogeneous actors and agendas, and collaboration activities can be facilitated by the development of boundary objects and boundary infrastructures (Bowker, 2000; Bowker & Star, 1999; Star, 2010; Star & Griesemer, 1989). As Dickinson et al. (2010) quite rightly emphasized, most large-scale citizen-science projects perform long-term monitoring at a geographical scale beyond the reach of ordinary research methods. Study VI did not discuss the variations between different participation models (Socientize, 2015); however, I have returned to those later (see pages 18-21).

Exploring How Different Models of Science and Technology Popularization Frame Science and Technology Narratives

As mentioned, the dissemination model contains three sub-models of science and technology popularization. The first empirical contribution is a detailed study of boosterism, or pro-innovation bias (Rogers, 2003) (Study II). Writers overwhelmingly describe science and technology in enthusiastic terms, promoting the deficit or PAST sub-model (Perrault, 2013). A crucial component of the PAST sub-model is its pro-innovation bias: in texts, writers enroll chaperones, such as spokespersons, users, celebrities, witnesses, experts, and authorities, to support their claims. Both boosterism and pro-innovation bias limit the public's critical understanding of science and technology. This study makes a detailed exploration of pro-innovation bias in the popularization of the Internet in the Norwegian press and journalists' use of chaperones to support their claims. I demonstrate that, in popularizing the Internet, pro-innovation bias manifests other biases, such as individual-praise, pro-technology, individual-blame, technology-blame, and source biases (Hetland, 2015). Pro-innovation bias is prominent in public communication of science and technology, reflecting its status as a crucial part of public discourse. Pro-innovation bias is also an important domestication strategy used to predict and shape the future. Pro-innovation bias is a fundamental part of the deficit model, as "science boosters tend to see popular science writing as a form of public relations" (Perrault, 2013, p. 5), demonstrating a missionary zeal for PCST. Generally, praise and blame are used as critical framing strategies to turn a position into a bias. In turn, praise and blame are substantiated by accompanying chaperones who serve as essential vehicles for a specific bias, as they often favor information providers.

The second empirical contribution is the identification of three meta-narratives or master narratives: utopian narratives containing the pro-innovation position (Study II), dystopian narratives containing the anti-diffusion position, and technology-as-a-risk containing the control position (Study III). Study III explores the narratives of control presented in the Norwegian press from 1995 to 2006 and studies how the expectancy cycles of the Internet fluctuated over time within this period. This study supports two general conclusions: 1) the expectancy cycles for the Internet in the mass media fluctuate in a manner comparable to the stages in the innovation-decision process and 2) the control position promotes individual, social, technological, and institutional control and is more prominent when the Internet is lower on the media agenda (Hetland, 2012). The technology-as-a-risk narrative invites readers to engage with science and technology in a more critical manner, providing a good example of the PEST model and partly the CUSP model.

The third empirical contribution is a study of the CUSP model (Study IV). When journalists popularize a highly topical new technology, such as the Internet, they do so within technological expectations. When researchers popularize Internet research, they situate their popularization within both retrospective and prospective understandings of technological change. As well, journalists tend to appeal to emotionally involved users or pioneers, and most researchers to responsible citizens acting as “modest witnesses.” Journalists dramatize the future by boosting new technology or turning risks into threats, while most researchers pour oil onto troubled waters, indicating skepticism toward the journalistic approach. Consequently, the technology popularization field is structured along two dimensions: from PAST via PEST to CUSP and from expectation-based argumentation to research-based argumentation (Hetland, 2016b).

Methodological and Theoretical Contributions

The present thesis makes several methodological and theoretical contributions to the field of public communication of science and technology. First, as elaborated, this thesis contributes to a more systematic understanding of the three key models of PCST. In Study I, each model is analyzed as a development zone (with reference to Study I, later I would have preferred that I had called it a trading zone) where policymakers and stakeholders experiment with possibilities for members of the public to act out their own expertise to enhance engagement. A review of Norwegian science communication policy clearly reveals how, at a policy level, concerns with public engagement have led over time to a more dialogical mode across the three key models of public communication of science and technology policy. Involvement is regarded as important to ensuring democratic participation, defined as broad participation associated with knowledge building, the assessment of risk and ethics, the exchange of knowledge, and the encouragement and diffusion of innovation. Thus, the most important theoretical contribution to science communication is how each model can be analyzed as development zones or trading zones.

Much previous research in this field has blackboxed the dissemination model by labeling it the deficit model. Several have attempted to open this black box, and Perrault (2013) introduced the three sub-models of PAST, PEST, and CUSP. While the PAST sub-model most closely resembles the deficit model, the two other open up a broader understanding of the dissemination model. Thus, in Study II, I explore two important aspects of the PAST sub-model: first, how different chaperones are enrolled in popular texts to substantiate a specific framing and, second, how a position is transformed into a bias and how such a bias is constituted. Consequently, the most important theoretical contribution to the PAST sub-model is a better understanding of bias in PCST and how biases are constituted. In Study III, I explore an understudied aspect of an important master narrative in PCST: how risk is controlled in the narrative of risk. Technology-as-risk narratives taking the control position provide examples of both the PEST and the CUSP sub-models. The control position promotes individual, social, technological, and institutional control and is more prominent when the Internet is lower on the media agenda.

The last conclusion emerges from a methodological contribution, as Studies II and III combine quantitative and qualitative methods to study how the expectancy cycles of the

Internet fluctuated over time within the period studied. Study II adds an important element in the framing process: how chaperones (spokespersons, users, celebrities, witnesses, experts, and authorities) are enrolled in texts to support authors' claims. Studies II and III make theoretical contributions showing that the mass media are an important arena for domestication processes, that these domestication processes are examples of mediatization, and that many of the potential positive and negative contributions of new technologies are created in and by the media (Nohrstedt, 2010). The media thus play an important role in the production and circulation of knowledge and the interpretation of science and technology (Hjarvard, 2013; Väliverronen, 2001). These two studies also add to knowledge of how chaperones influence the framing processes over time.

Study IV contrasts Studies II and III by focusing on the texts written by researchers, instead of those mediated by journalists. As such, this study also examines the CUSP model. The position outlines the role of expertise, which might be a multifaceted and not a unitary construct. In this respect, the root analysis represents the underlying approach to technological change. Reader engagement is encouraged by appeals to a specific position. The position also represents the expert advice offered by researchers. In this regard, contextualization and the production of socially robust knowledge are important elements of the position (Gibbons, 1999; Nowotny et al., 2001). Study IV explores how researchers popularize Internet issues in comparison to the popularization activities of Norwegian journalists. The most important conclusion is that researchers attempt to situate their popularization activities in a research-based argumentation framed by two opposing understandings of technological change, whereas journalists do so in an expectation-based argumentation framed by two opposing understandings of technological expectations. Researchers emphasize facts, journalists expectations. These two different worldviews lead researchers to emphasize continuity and journalists what will happen. Consequently, researchers communicating Internet research are often "modest witnesses" strongly influenced by continuity. Most researchers seem worried about the narratives promoted by journalists (and a few of their colleagues), and many see it as their mission to present a more sober picture of technological change. Therefore, one can claim that the media, not researchers, primarily drive mediatization processes.

It is clear that journalists have a stronger personal, relational focus that appeals to emotionally involved readers and use tropes, catchphrases, and illustrations that make it possible for readers to relate to pioneering scientists and facilitate reader engagement by involving the reader in using and exploring technology. Most researchers have a less personal, relational focus that highlights the ambiguity of new technology. They use tropes, catchphrases, and illustrations that involve readers as democratic participants and facilitate reader engagement by involving readers in public debate. Overall, journalists are inclined to appeal to the emotionally involved user or pioneer, and researchers to the responsible citizen. Thus, the most important theoretical contribution of Study IV is a better understanding of the rhetorical differences between the PAST, PEST, and CUSP sub-models and the role of witnessing.

Leaving the dissemination models and its three sub-models of PAST, PEST, and CUSP, the next model is the dialogue model. In this context, the author uses dialogue about how one organizes participation. Accordingly, Studies V and VI discuss the different dimensions and implications of dialogue and participation. Inspired by the single and double delegation (Callon, 1999; Callon et al., 2009) and Bucchi's (2009) aim to map public participation in science and technology, Study V offers a map of how to understand participation in different experimental traditions. The first delegation, according to Callon et al. (2009), involves secluded research, and the second delegation delegative democracy. To open up both science and democracy, Callon et al. (2009) call for experimental activity in hybrid forums. The first axis of the diagram (see Figure 1 in Hetland 2011b, p. 10) thus plots the extent to which participants in the experiments contribute to the knowledge construction process, and the second axis the extent to which they contribute to the policy construction process. The mapping does not indicate intrinsic qualities of the different methodological traditions, but rather my interpretation of how some key authors perceive these approaches. Consequently, the theoretical contribution of Study V is a framework for analyzing dialogue and participation in both knowledge and policy construction processes.

Study VI addresses an important aspect of collaborative-knowledge-construction processes: the question of validation. How does one validate information when the flow of new information almost exceeds the usual validation routines? Apomediation is an important tool in commons-based peer production (Benkler, 2006; Hetland, 2016a), and this study contributes to how it might be understood within CS.

Both Studies V and IV are multi-cited ethnographic studies (Hine, 2015; Marcus, 1995), and their methodological contribution is also linked to how one tracks phenomena across multiple sites, tracing networks (physical and online) and identifying social worlds (Hetland & Mørch, 2016).

Chapter 6 - Conclusions, Limitations, and Further Work

Conclusions

I started with Gregory Bateson's *Steps to an Ecology of Mind* (1972), and I will use some insight from that study in this concluding discussion. Bateson claims that, to achieve healthy systems, great flexibility is needed. He defined flexibility *as uncommitted potentiality for change* (1972, p. 497). This study of PCST models illustrates that the models are flexible in many respects. They are flexible over time, incorporating different aims, ideological contexts, formats of public participation, and expertise. Exactly this flexibility is a crucial element to accomplish the social contract between science and society. It is not so that the dissemination model is more old-fashioned than the two other models. All three models develop along their own trajectory, as well as exchanging important features over time.

As already stated, the contract between science and society is not a legal contract in the usual sense, but a long-term social contract executed under the conditions of uncertainty (Williamson, 1979, p. 237) involving a number of aims, financial contributors, public and private institutions, mediators, publics, and other relevant stakeholders. The governance of these complex relations has led to the emergence of three key models of expert–public interaction. I will argue that models of science communication are both scientific abstractions understood by SCR in retrospect and prospective ways of organizing PCST activities. As such, science communication models are essentially contested artifacts whose meaning is evoked and debated in a variety of contexts with a range of effects. They are constantly in the making, both as analytical entities and as way of organizing science communication activities. Increasingly, participation is a result of professionalization and institutionalization of public participation, as illustrated by Studies I, V, and VI. At the same time, national civic epistemologies are at play, and I will claim that, similar to Denmark and Sweden (Horst, 2012; Kasperowski & Bragesjö, 2011), the participatory governance of science and technology in Norway is founded on cultural traditions of dialogue involving both general, affected, pure, and partisan publics (Braun & Schultz, 2010), as well as expertise in its various forms (H. Collins & Evans, 2007). One might therefore claim that the cultural traditions of dialogue are constitutional elements of the NMSC. Consequently, models are continuously reinvented, not only the deficit/dissemination model (Bauer et al., 2007; Rayner, 2004; Wynne, 2006), but also models of dialogue and participation. At the same time, models or shared mental models are "standardized" ways of understanding and doing things at an organizational level (Star, 2010). Gross (1994) gave a small illustration of this in his comparative Chernobyl discussion.

Technological innovations have made it possible to build spaces for interaction and participation. Jasanoff defined constitutional moments as brief periods in which, "through the unending contestation over democracy, basic rules of political practice are rewritten, whether explicitly or implicitly, thus fundamentally altering the relations between citizens and the state" (Jasanoff, 2011, p. 623). I concur with Jasanoff about the importance of constitutional moments; however, it is not possible to understand the evolvement of the modern constitution without taking into account the populations of hybrids (Latour, 1993). To identify the constitutional moments and the evolving number of hybrids, I will use the trading zone concept (H. Collins et al., 2010; Galison, 1997) to analyze how models evolve.

The dissemination model is supported by a number of actors promoting the model (Study I). It is perceived as a low-cost model with high visibility, claiming little participant engagement. However, on the policy level, the dissemination model include more and more participatory arrangements, and focuses on publics like children and youth, teachers, and journalists. The imperative to undertake science communication is also increasingly a precondition for applying for research funding. A number of communication channels has been developed, and all state-financed research institutions are encouraged to develop an active science communication policy, not the least using new ICT possibilities. All studies indicate that science communication has strong support among the different publics, and there is a certain move over time from PAST measures to CUSP measures. However, the dissemination model primarily aims for popular understanding and primary source knowledge. Studying the dissemination model in action is done in Studies II, III, and IV. The PAST sub-model is the model most frequently encountered through the utopian master narrative and the pro-innovation position. Spokepersons are important accompanying chaperones for this position. A specific problem with the PAST sub-model is the pro-innovation bias that manifests several other biases, such as individual-praise, pro-technology, individual-blame, technology-blame, and source biases. The PEST sub-model (and partly the CUSP sub-model) is studied through the other important master narrative; the technology-as-risk narratives containing the control position, be it individual, social, technological, or institutional control. Authorities are important accompanying chaperones for this position. The driving force for both master narratives are expectations appealing to emotionally involved users, pioneers, or interested readers. This is in contrast to the CUSP sub-model explored by a case study where the researchers handle their own science communication activities. The researchers indicate skepticism as to the journalistic approach; they situate their popularization within both a retrospective and prospective understanding of technological change, often appearing as "modest witnesses" appealing to responsible citizens.

The dissemination model is actually a much richer model than many critical accounts of the deficit model indicate, involving a range of different actors and publics, and is not the least still an important part of the social contract between science and society promoted by crucial policy actors. Consequently, the dissemination model is resilient. The seven reinventions mentioned earlier (page 14) illustrate this well. This plasticity, as well as perseverance and standardized ways of doing things, is the main reason why I will analyze the model as a boundary object. Boundary objects refer to elements that link various groups and interests together, be it institutions, mediators, or publics. Often, boundary objects are perceived as mediating material culture, yet I find it useful to use the concept about a science communication model that, in spite of its plasticity, still unite the actors around a fairly stable set of aims, format of public participation, and expertise. At the same time as boundary objects contain different interests, they also open up for different practices, be it one of the three sub-models. The very concept of *boundary object* is most useful at the organizational level and when the level of scope for the concept is fairly specific (Star, 2010). The dissemination model handles both stability and ambiguity simultaneously (Wells, 1999). In this way, boundary objects permeate borders at the same time as the established practice is continued and reinvented. Models as boundary objects are boundary objects of the ideal type (Star & Griesmer, 1989, p. 410), abstracted from all domains and fairly vague. They serve as means of communicating and cooperating on a more symbolic level.

The dialogue and participation models aim to reach out to users as important partisan publics, but also the pure publics (Studies I, V, and VI). The two models are perceived as high-cost models claiming involvement and engagement of communicators and participants. The models presuppose high internal involvement, but do not necessarily have high external visibility. The two models assume first interactional expertise and, in its most advanced form, contributory expertise like field experiments on participants' own farms or CS activities. The dialogue model aims to bridge the single delegation and extend the peer community, but within rather predefined frames addressing pure publics shaped by practices and settings. The more opportunities users have to play out authoring, positionality, and improvisation, the more included they are in the transformation process from the experimental phase to policy and practice. The participation model aims to bridge the double delegation and involves both the affected public and the partisan public contributing in research and development processes, as well as policy processes. Collaborative technologies create new possibilities for doing science and include amateurs/volunteers in knowledge production. Quality assessment or validation highlights some important ambiguities. As boundary organizations, the different NGOs like SABIMA, together with NBIC, have organized the validation with the help of national coordinators and a network of experts, and the costs are shared between the different actors. The validation activity has three levels. First, openness encourages self-control; people do not want to be exposed to excessive ignorance. Second, they can ask for help from fellow observers to validate their observation, comment on pictures, etc. The third is the more formal validation. One of the most important aspects of collaborative technologies is that the technology facilitates bridging activities and thereby co-exploration. Museum collections have for many years been important boundary objects between amateurs, professionals, and conservation authorities. The collections have, however, been difficult to access for a growing number of new purposes. The digitalization of the collections has built bridges between a number of more or less well-structured boundary objects in local use. The ability to link boundary objects together into boundary infrastructures thus depends on bridging activities between a heterogeneous set of actors and repositories. We have identified four steps toward a new boundary infrastructure. First, the digitalization of museum collections was an important premise to facilitate bridging activities. With that start, the privatization of collecting activities was challenged; professionals and amateurs met on new arenas, and the natural history collections from all Norwegian museums were bridged together. Second, the establishment of the Global Biodiversity Information Facility made a bridge between the Norwegian collections and an increasing number of collections around the globe. This has also made standardization an even more important precondition for scientific collaboration. Third, the establishment of Species Gateway gave a new opportunity for the amateur community to participate in a national mapping activity, and has facilitated bridging activities between science and the public in new manners. With Species Gateway, a successful boundary object has been established between the scientific community, the amateur communities, and conservation authorities. The mapping of biodiversity is made into a huge collaborative enterprise. Fourth, the bridging activity between the more science-driven museum collections and the more interests-driven Species Gateway has facilitated new services as obligatory passage points for planning authorities. Bridging different boundary objects together into boundary infrastructures facilitates the development of interactional expertise, which in many respects is an important precondition for developing contributory expertise.

I will describe the figure 3.1 by an example from Study VI. Step 1 arises when public authorities and NGOs encourage amateurs/volunteers and scientists to collaborate using a new Internet application, such as Species Gateway. The new Internet application is through the Norwegian GBIF node linked together with other information providers, including all the important scientific institutions, NGOs, and some private companies, through the service Species Map. Species Map is then a boundary object (Step 2a) and a catalyst for building a new boundary infrastructure for biodiversity mapping. If the culture between amateurs/volunteers and scientists become more homogeneous, one might move to step 3, where the fractionated trading zone becomes an inter-language trading zone. However, this is not likely to happen since science languages are more and more specialized, and dedicated groups of amateurs will most likely only adopt parts of the scientific language to function as interactional (and contributory) expertise (Step 2b).

The new thought “that gives rise to interactional expertise is that the contributions to a form-of-life on language on the one hand, and practice on the other, can be analytically and empirically separated” (Collins & Evans, 2015, p. 115). The long fieldwork activity invested in the dialogue model by the author that began in the mid-1980s and ended in the late 1990s gave this author what Collins and Evans call “fieldwork interactional expertise” (2015, p.

116). Interactional expertise may both be seen "through its transitive relationship to contributory expertise" (Collins, Evans, & Weinel, 2015, p. 2) and as contributory expertise contributing to policy processes while negotiating between upstream and downstream political framing (Collins, Evans, & Weinel, 2015, p. 6). Both the dialogue and the participation model are important models within the social contract between science and society. The dialogue model contributes to policy processes bridging the single delegation and extending the peer community, and the participation model bridging the double delegation and involving participants in both the knowledge and the policy construction process.

Consequently, trading zones emerge when "individuals, organizations, or governments perceive an opportunity or a threat, and cooperate toward realizing the opportunity or avoiding the threat" (Mills, Rorty, Isabella, & Chen, 2010, pp. 266–267). However, within the fractionated trading zone, two outcomes are possible: either a kind of boundary object that will mean different things to different people, yet these differences are not "sufficiently important to undermine the joint project" (Collins, Evans, & Gorman, 2010, p. 18), or a kind of interactional expertise where "some members of the trading zone become sufficiently interested in the others' work to want to understand more about it" (Collins, Evans, & Gorman, 2010, p. 18). In the case of the boundary object, the joint project is a low-cost communication model with high visibility, claiming little engagement of the participants. If this model is also efficient, counting the effects is not always made into an important issue, since visibility in itself quite likely is considered an effect, and I will claim that this is the main reason why the model lives on so well in public life. In the case of interactional expertise, the joint projects are being organized either within the dialogue or the participation model. These models are high-cost models claiming high involvement and engagement of communicators and participants. Whether these models will evolve into a deeper collaboration with a further evolution of the trading zone remains to be seen.

This thesis has eight crucial contributions to an improved understanding of public communication of science and technology. By critically examining the three science communication models, dissemination, dialogue and participation, the thesis makes five contributions: 1) a study of how public appreciation of science and technology are promoted by the use of bias, 2) a study of how public engagement with science and technology are promoted by mediatization processes, 3) a study of how researchers in their popularization activities promote critical understanding of science and technology being modest witnesses, 4) a study of the dialogue models' room for participation in knowledge and policy construction processes, and 5) in studying the participation model, a better understanding of citizen science and boundary infrastructures. Finally, the thesis has three more general contributions: 6) it represents the first comprehensive examination of science communication policy in Norway; 7) focusing on technology, it links science communication research and innovation studies; and 8) it contributes to a more analytical approach studying the three science communication models as trading zones within the context of the NMSC.

To conclude with a more policy-relevant statement, my overall claim is that all three models and the variations within them are an important part of the new social contract between science and society. The important issue is not to erase the deficit/dissemination model from our repertoire, but to perceive all three models as trading zones where different interests are represented to carry on exploring their potentiality for change. However, so far, the NMSC has provided an important backdrop emphasizing the inclusion of all sciences, contractual obligations, dialogue across the three communication models, and public involvement in science communication innovations.

Limitations

Case studies have certain limitations, as they depend on strong involvement, sensitivity, and integrity by the researcher describing and understanding the cases. As already mentioned, I wanted to "uncover" the magnitude and complexity of PCST and contribute to the more theoretical discussion on science communication models. I will therefore start with the limitations that evolve from those aims. Two questions are important. First, have I chosen case studies that makes it possible to meet those aims? Second, are they undertaken in a manner that uncovers the magnitude and complexity of PCST? First, Study I was undertaken when I had a good overview of my own case material as well as the literature. Later, I did not uncover any new material that shed a different light on the analysis outlined in Study I. Consequently, my conclusion is that I have managed to provide breadth and depth to the understanding of Norwegian science communication policy. Second, Studies II, III, and IV all concern the communication of a new technology—the Internet. Some limitations are obvious: the Internet is a success story in which the mass media are both mediators and increasingly users. Mediatization implies, therefore, that the media often create problems and dangers they have self-interests in solving. The control position might have been more prominent if the technology studied had been a technology not used by the mass media. Obviously, the case was not suitable to study the dystopian narratives containing the anti-diffusion position. This limitation was not foreseen, but in retrospect, not surprising. To study the dystopian narratives, I should simply have chosen another case. On the other hand, my present experience tells me that it might be difficult to find a similar rich case that contains all three narratives. Alternatively, the Internet case should have been supplemented with a contrasting case study of a more controversial technology, like gene technology and biotechnology or nuclear power. However, in the SCR literature, these two topics are well-covered, so I am not convinced that I would have added important new knowledge to the SCR by selecting one more case. As mentioned previously, Study V has been an important "companion" through long periods of my career. Consequently, I might have been circumscribed in my preunderstanding of the dialogue model and not open enough to new insight. I do not think so, but others have to judge. Study VI is the case study that is least developed and in some respects has more the character of an explorative case study. This is certainly an important limitation, but give also important directions for further work.

Further Work

Even if I claim that dystopian narratives containing the anti-diffusion position is well-covered in studies of other technologies, I think it would have been useful to study this narrative with the same analytical framework that I have used on the two other master narratives. The Internet case has made me highly aware of the pro-innovation bias. Pro-innovation bias constrains critical debates about how new technology affects society and about the possible undesirable consequences of the same technology. Perrault (2013) argued that science and technology communication has a twin duty: to inform and educate about science and technology on the one hand, but also to probe and criticize it on the other. Pro-innovation bias prevents the performance of both duties. Therefore, in Study II, I propose three research pursuits of relevance to future studies on pro-innovation bias in science and technology communication: the framing of public discourse, the integration or separation of consequences, and how chaperones are used to handle complex issues (2015, p. 169), while in Study III, I ask if a case study of a technology that is more foreign (and threatening) to the mass media would modify my claims (2012, p. 14). I think the dialogue model (Study V) is still interesting, and one important pursuit is to study the variations within the dialogue model and how these variations might guide further use of the model. Finally, the participation model (Study VI) is as already said the least developed, and in my present and further work, I will concentrate on understanding this model better. I will explore how the model evolves as a trading zone facilitating crowd-sourcing activities, novel validation strategies, social networking, and the establishment of more stable communities involving different user groups and age groups, and finally, study what happens to old relationships between science communities and amateur communities when new technologies are introduced.

Appendix 1

Table 7.1. Data file

Variable	Values	Frequency	Percent	Intercoder agreement	Intercoder reliability
Newspaper	*Aftenposten*	1,334	48.1		
	Dagbladet	813	29.3		
	Dagsavisen	625	22.5		
	Total	2,772	100		
Year	1995	114	4.1		
	1996	345	12.4		
	1997	275	9.9		
	1998	270	9.7		
	1999	311	11.2		
	2000	542	19.6		
	2001	205	7.4		
	2002	141	5.1		
	2003	139	5.0		
	2004	155	5.6		
	2005	128	4.6		
	2006	147	5.3		
	Total	2,772	100		
Position	Pro-innovation	1,903	68.7	97.7	0.95
	Control	869	31.3		
	Anti-diffusion	0			
	Total	2,772	100		
Chaperones 1–9	Spokespersons	2131	51.6	96.1	0.94
	Users	623	15.1		
	Experts	525	12.7		
	Authorities	852	20.6		
	Total	4,131	100		
	With chaperones	2,139			
Praise and blame	Praise or neutral	2,010	48.7	96.9	0.95
	Praise and blame	800	19.4		
	Blame	1,321	32.0		
	Total	4,131	100		

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PART II:
THE STUDIES

Study I

Hetland, P. (2014). Models in Science Communication Policy: Formatting Public Engagement and Expertise. *Nordic Journal of Science and Technology Studies, 2*(2), 5–17.

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MODELS IN SCIENCE COMMUNICATION POLICY

Formatting Public Engagement and Expertise

by Per Hetland

Three models of expert-public interaction in science and technology communication are central: the dissemination model (often called the deficit model), the dialogue model, and the participation model. These three models constitute a multi-model framework for studying science and technology communication and are often described along an evolutionary continuum, from dissemination to dialogue, and finally to participation. Underlying this description is an evaluation claiming that the two latter are "better" than the first. However, these three models can coexist as policy instruments, and do not exclude each other. Since 1975, concerns with public engagement over time have led to a mode that is more dialogical across the three models within science and technology communication policy in Norway. Through an active policy, sponsored hybrid forums that encourage participation have gradually been developed. In addition, social media increasingly allows for spontaneous public involvement in an increasing number of hybrid forums. Dialogue and participation thus have become crucial parts of science and technology communication and format public engagement and expertise.

Keywords: Science communication, policy, public engagement, expertise

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Introduction

Although several authors have aimed to analyze science and technology communication in Norway from a broader perspective (Andersen and Hornmoen 2011, Bentley and Kyvik 2011, Kyvik 2005, Løvhaug 2011), there is no thorough analysis of Norwegian science and technology communication policy framing those activities. Consequently, the present paper aims to study Norwegian science and technology communication policy and how it has evolved since 1975. In a Norwegian context, the emphasis on the communications of science and technology was expanded and strengthened in 2003, in the revised "Act Relating to Universities and University Colleges," where it was declared that higher education institutions have three assignments: education, scientific research, and public communication of science and technology. Consequently, public communication of science and technology is sometimes called the third assignment. The third assignment should: 1) contribute to science and technology communication; 2) contribute to innovation; and 3) ensure the participation of staff in public debate.[1] We know from studies of the third assignment in Sweden that the assignment was understood both within a dissemination model as well as in more dialogical models (Kasperowski and Bragesjö 2011).

The sectoral principle has been fundamental to Norwegian science and technology policy since 1972 (Skoie 2005:61). In keeping with this principle, each of the 15 ministries in Norway has an overall responsibility for research in and for its specific sector, whereas the Ministry of Education and Research has a role in coordinating national policy. When it comes to science and technology communication policy, several other ministries have crucial roles, especially when it comes to user-oriented science and technology communication. Further, the Ministry of Local Government and Modernisation is responsible for the central government communication policy. The underlying principle for central government information and later communication policy in Norway has progressed from the publicity principle (Informasjonsutvalget 1962) to the principle of public information (FAD 1978), and from there to the communication principle (AAD 1992), culminating in the principle of participation (FAD 2009). The principle of communication implies that public authorities engage in two-way symmetric communication with the citizens with the purpose of achieving mutual understanding, whereas the participation principle implies that public authorities shall take advice from affected citizens and involve them in the shaping of policies and services. Dialogue and participation are consequently growing more important within central government communication activities, and this development is a crucial backdrop for how science and technology communication policy has evolved since 1975.

Three models of expert-public interaction in science and technology communication are suggested by Bucchi and Trench: the dissemination model (often called the deficit model), the dialogue model, and the participation model (Bucchi 2009, Trench 2008). As both Bucchi and Trench emphasize, these three models can coexist as policy instruments, and they do not exclude each other. Concerns with public engagement over time have led to a more dialogical mode across the three models. This paper uses Norwegian science and technology communication policy as an example. The aim of the paper is twofold: 1) to substantiate that the dialogical turn cuts across all of the three communication models, and 2) to study how each model facilitates the transformation from engagement to the acquirement of different kinds of expertise among the participants (Collins and Evans 2007). In Norway, the concept "science communication" includes also the communications of social sciences and humanities. For simplicity, when referring to the communications of science and technology the abbreviated terms communication of science or science communication are used throughout the paper. All translations from Norwegian to English have been done by the author. In the following section, I present a typology of how public engagement and expertise are formatted.

Theoretical and conceptual issues

The quest for dialogue and participation stems from two interrelated discourses: the first concerning public understanding of science, and the second based on the discourse on the new production of knowledge. To begin with, the vocabulary of public understanding of science has changed over the last two decades (Suerdem et al. 2013). Concern with public engagement has led to a shift from the dissemination model to more dialogical models. Suerdem et al. present a lexicographic and bibliometric study of the journal *Public Understanding of Science* over the last 20 years, in which they conclude that "the theoretical topics shift from modelling public understanding to formatting public engagement" (p.13).

The discourse on the new production of knowledge is concerned with new features such as transdisciplinarity, heterogeneity, the extended peer community, and the new dynamic relationship between society and science (Gibbons et al. 1994, Leydesdorff and Etzkowitz 1998, Nowotny, Scott, and Gibbons 2001, Funtowicz and Ravetz 1992). This discourse is prominent in science and technology studies, as well as in innovation studies. Concepts such as Triple Helix, Mode 2, and Science 2.0 are all concepts central to understanding the new production of knowledge.

The dissemination model is often perceived as a simple transfer

[1] http://www.lovdata.no/all/nl-20050401-015.html

model where knowledge is communicated by experts to various publics in an attempt to enlighten the same publics. The much-used concept for the same model in science communication, the deficit model, can be traced back to the work of C. P. Snow (1963), which claims that there is one split between the natural sciences and the humanities, and one split between the natural sciences and their applications. In his understanding of science and socioeconomic development, Snow applies a linear diffusion of innovations model that also underpins the deficit model. The deficit may be overcome or the diffusion of innovations may take place only if the public is educated or enlightened. The deficit model, as well as the linear diffusion of innovations model has therefore been the object of much criticism (Fagerberg, Mowery, and Nelson 2005, Hetland 1996, Irwin and Michael 2003). The criticism of the deficit model is strongly linked to the dominant view of science popularization as downstream representations (Hilgartner 1990). The press seems to constitute the most important "intermediary communication device" in this respect (Le Marec and Babou 2008:49). Bech-Karlsen offers a suggestion as to how the enlightenment tradition may be understood in different contexts. In defense of the enlightenment tradition, Bech-Karlsen points to the basic distinction between the Nordic and continental European traditions. "The Nordic variant is based upon a dialogue and respect for the recipient's values, while the European model regards the recipient as 'an empty container' which shall be filled with knowledge" (Bech-Karlsen 1996:22). Bech-Karlsen supplements this by describing the classic European tradition as a transfer of knowledge from the expert to the layperson. In the Nordic tradition, the expert enters into a dialogue with the layperson. Bech-Karlsen maintains that there is nothing principally authoritative within the enlightenment tradition, but rather the authoritative aspects are temporary and circumstantial. A similar argument is made by Broks and Perrault when they present the CUSP model or Critical Understanding of Science in the Public (Broks 2006, Perrault 2013). Within dissemination activities, Perrault identifies three models, Public Appreciation of Science and Technology (PAST), Public Engagement with Science and Technology (PEST), and CUSP. She uses the three models to study how researchers and journalists frame their popularization activities. Her main point is that "popular science writing can and should contribute to civic engagement" (p. 8) and thereby empower readers. The CUSP model aims to resolve the "lingering deficit model characteristics by suggesting a kind of science communication that considers all the elements of science-in-society, including their interactions, to be worth scrutinizing" (p. 15).

Increasingly, dissemination is also perceived as an important activity when applying for research funding: media exposure is made into an indicator of social relevance. This is also reflected in the change from the slogan "publish or perish," to "be seen in public or perish" (Väliverronen 1993). In Norway, about half of the faculty published at least one popular science article during a three-year period, whereas six percent of the faculty published half of all popular science articles (Kyvik 2005). The changes affect not only faculty members. Public relations personnel of academic institutions are also incorporated into the dissemination process (Bauer and Bucchi 2007, Nelkin 1995). Consequently, personnel experience a convergence between the policy for dissemination of science and institutional public relation activities.

In spite of the growing literature on dialogue and participation, there are few distinct definitions that strictly separate the two concepts (Bucchi 2009, Bucchi and Trench 2008, Callon, Lascoumes, and Barthe 2009). Therefore, I treat the three communication models as part of a continuum, which is best described along two dimensions:1) the intensity of cooperation among different actors in knowledge production processes and 2) the extent to which public participation is elicited by a sponsor (Bucchi 2009) (see Figure 1).

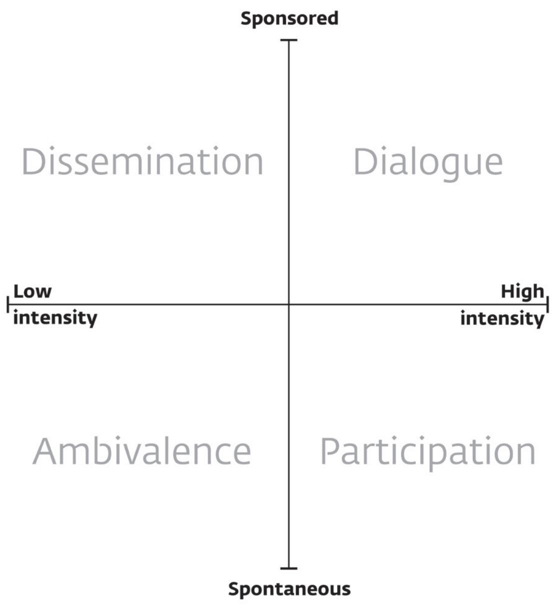

Figure 1. Participation forms for users and the public.
Source: Modeled after Bucchi 2009:66

The upper-left quadrant illustrates policy measures within the dissemination model. As already indicated by Bech-Karlsen, the space for a more active role may be larger within the Nordic tradition than it is within the classic European tradition. The upper-right quadrant represents policy measures within the dialogue model. Within the dialogue quadrant, one is able to bridge the single delegation, that is the delegative democracy or traditional representative democracy (Callon 1999, Callon, Lascoumes, and Barthe 2009). The lower-right quadrant represents policy measures within the participation model. Within the participation quadrant, one is able to bridge the double delegation, that is the delegative democracy and the secluded science by which society entrusts specialists. To encourage science and technological development and democratic participation, Callon et al. emphasize the significance of hybrid forums that permit new forms of political participation and broader insight and influence compared to the central ethical dilemmas existing within science and technological development. Hybrid forums provide opportunity for a broad number of actors who wish to contribute to the development of science and technology, and those who are involved constitute a heterogeneous group of actors, including experts, politicians, technologists, and lay people, simultaneous to the themes that are taken up cut across traditional boundaries. However, it is not always clear what participation implies (Delgado, Kjølberg, and Wickson 2011). Delgado et al. identify five "topics of tension" when applying the concept of participation. These can be formulated as the following questions:1) Why should the public participate? 2) Who should be involved? 3) How should it be initiated? 4) When is the right time to do it? 5) Where should it be grounded? (p. 828). I return to these tensions later in the text.

Finally, there is the "science and technology ambivalence" quadrant. Science and technology ambivalence is a rather heterogeneous category, including motivated rejection, conspiracist responses, pseudoscience, ideology, and faith (Gieryn 1999, Lewandowsky, Oberauer, and Gignac 2013). The category is an important reminder that disengagement with science in the traditional sense is not necessarily the obverse of engagement (Brint and Cantwell 2012).

Central to the three models are the various forms of expertise, and the fact that the public "remains a relatively under-theorized doxa shared by both advocates and critics of the public deficit model" (Hess 2011:628). Understanding the different publics and their roles is consequently paramount for a better understanding of what differentiate the three communication models (Braun and Schultz 2010). Collins and Evans approach science communication through an attempt to map the diversity of expertise. They start from the view that "expertise is the real and substantive possession of groups of experts and that individuals acquire real and substantive expertise through their membership of those groups" (p. 2-3). All of us possess that which we call ubiquitous tacit knowledge, either in the form of 1) "beer-mat knowledge" (without a deeper insight into why it works); 2) popular understanding; and/or 3) primary source knowledge. Concerning specialist tacit knowledge, Collins and Evans distinguish between contributory expertise and interactional expertise (i.e., expertise required to manage a field of knowledge through interaction but does not contribute to the field). With this as the point of commencement, they attempt to develop a periodic table for expertise. Along the expertise dimension the table is constructed around, Collins and Evans refer to specialist expertises and meta-expertises. Along the knowledge dimension, one proceeds from basic knowledge (which we all have) to highly specialized knowledge (which only a few acquire). Their project contributes to a clarification of expertise as a social phenomenon and is crucial to a better understanding of the three communication models.

Finally, one problem needs to be mentioned: the relationship between models people claim to use and what they actually do. As Brossard and Lewenstein (2010) document in an assessment of how real-world outreach activities accord to the theoretical models, most outreach activities tend to use the dissemination model as a backbone, even if they claim to do something different. Consequently, the present study of models in science communication policy is primarily a study of the policy that frames science communication, not a study of how science communication is actually performed.

Method

In the next section, I provide a review of how Norwegian science communication policy has developed since 1975. The empirical basis is a content analysis of nine white papers presenting science policy, and one white paper presenting innovation policy (see Table 1).

White Paper Science Policy	Title	Responsible Minister
St.melding nr. 35 (1975-1976)	Om forskningens organisering og finansiering [The organization and financing of research]	Bjartmar Gjerde, Labour Party
St.melding nr. 119 (1980-1981)	Om utviklingen i forskningens organisering og finansiering [Developments in the organization and financing of research]	Einar Førde, Labour Party
St.melding nr. 60 (1984-1985)	Om forskningen i Norge [Research in Norway]	Lars Roar Langslet, Conservative Party
St.melding nr. 28 (1988-1989)	Om forskning [On research]	Hallvard Bakke, Labour Party
St.melding nr. 36 (1992-1993)	Forskning for fellesskapet [Research for the common good]	Gudmund Hernes, Labour Party
St.melding nr. 39 (1998-1999)	Forskning ved et tidsskille [Research at the beginning of a new era]	Jon Lilletun, Christian Democratic Party
St.melding nr. 20 (2004-2005)	Vilje til forskning [Commitment to research]	Kristin Clemet, Conservative Party
St.melding nr. 30 (2008-2009)	Klima for forskning [Climate for research]	Tora Aasland, Socialist Left Party
Meld.St. 18 (2012-2013)	Lange linjer – kunnskap gir muligheter [Long-term perspectives – knowledge provides opportunity]	Kristin Halvorsen, Socialist Left Party
St.melding no.7 (2008-2009)	Et nyskapende og bærekraftig Norge [A creative and sustainable Norway]	Sylvia Brustad, Labour Party

Table 1 White papers presenting science policy and innovation policy

For simplicity, I will refer to the years and the relevant page later in the text, except for the Innovation White Paper that will be referred to in full.

In the textual analysis, I have primarily done an ex-ante appraisal of the different policy measures that are proposed within science and technology communication (Rip 2003). However, most of the mentioned policy measures are implemented, and a short ex-post evaluation is included for some measures. Six of the science policy white papers together with the single innovation policy white paper have been presented by Labour Party–dominated governments. Three of the white papers have been presented by Conservative and Liberal governments. However, there is a large degree of consensus within Norwegian science and technology policy and consequently few examples of major disagreements. I have therefore not attached any importance to the party-political dimension in this respect. Studies concerning the science policy debate in the Nordic countries nevertheless show that science policy most often attracts only the interest of "immediate stakeholders and people with expert knowledge about the specific area" (Kallerud et al. 2011:76).

This paper, which is based on relevant policy papers, presents a study of policy. In contrast, another interesting approach has been to study the merits public communication of science gives within scientific institutions. From an earlier mapping we know that the qualification requirements for achieving competence within the higher education and research hierarchies have moved from a broader set of requirements, defined in 1970, to a more narrow definition of academic requirements from 1995 and onward (Finne and Hetland 2005). The change is also an important part of policy and practice; however, this point is beyond the scope of this paper.

The white papers and other relevant material are rich materials for analysis. Within each communication model, description is partly organized in a chronological manner; however, because the paper aims to explore crucial aspects of all three models for science communication used in Norwegian science communication policy a theoretical/conceptual organization has been chosen. The dissemination model as it is implied in the policy papers will be presented first. The Lasswell model – "Who (says) What (to) Whom (in) What Channel (with) What Effect" is a well-known dissemination model of communication, and, as such, it may be used to organize the description of the different policy measures within this model (Lasswell 1948). For the dialogue and participation models, the descriptions will be organized according to the central issues as described by Bucchi (2009) and Trench (2008). It is not possible to present the material in full, and the paper will only present some trends and illustrative examples.

The dissemination model

Regarding who, the center of gravity shifts from researchers and journalists in the first white papers (1975-1976:79 & 1980-1981:47) to public relations and dissemination institutions in the later white papers (e.g., 2012-2013:36). The proposals to focus on the training of researchers and journalists must be seen in the light of the virtual absence of science journalism at that time (Eide and Ottosen 1994). In addition, there were established awards based on excellent dissemination by researchers (1988-1989:69). One important problem was mentioned in two white papers, the question of whether the assessment criteria for academic positions took the question of dissemination seriously enough (1975-1976:79 & 1988-1989:69); however, a more narrow definition of academic requirements was implemented in 1995, emphasizing academic production in international peer reviewed journals. There is also a growing interest in what the journalists and researchers are going to tell the public. In the mid-1990s, Erling Dokk Holm was the research coordinator of the Norwegian Research Council (NRC), and he suggested that the concept of science dissemination should be changed from "popularization" to "something more." The latter, somewhat indeterminate concept, implies a reorientation from "the end product" to "process" (Holm 2000). This reorientation highlights a problem concerning the dissemination of provisional research findings, something that had been already mentioned in the 1975-1976 white paper: "Over the years, there have been many examples of uncritical dissemination of provisional research findings which possibly can have had good press value" (1975-1976:78). Attempts to solve the problem have been made employing Ingelfinger's rule, first presented by Franz J. Ingelfinger in 1969 in The New England Journal of Medicine. In practice, Ingelfinger launched "an embargo designed to keep scientific findings out of the media until peer-reviewed and published" (Toy 2002:195). The most important policy measure was to establish the National Committees for Research Ethics in Norway in 1990 (1992-1993:113-117). The guidelines for the social sciences, humanities, law and theology as well as the guidelines for health and medicine entail rules in line with Ingelfinger's rule, whereas the corresponding research ethics rules for the natural sciences and technology do not refer to Ingelfinger's rule in the current regulations.[2] Early in the new century, a proposal was launched whereby an "expert portal" (2004-2005:194) would be established to stimulate investigative multisource journalism

[2] http://www.etikkom.no

concerning science (2004-2005:125), as an attempt to encourage the CUSP model. At the same time, the significance of public relations increased, and in the 2012-2013 white paper, it is emphasized that research results are also a "sales product" and that science dissemination is increasingly linked to the marketing of science and its results (2012-2013:36). The educational system is consequently understood as an important means for ensuring a knowledgeable public and a critical press.

Whom shall be considered as "the public" beyond the general public is unclear in the first white papers. The point of commencement was that if we were to succeed in engaging the public, then science journalism would have to be improved. The 1992-1993 white paper was the first to address the issue of which members of the public should be prioritized. The white paper specified that the NRC was to have the task of preparing a national strategy for science dissemination aimed at the public in general (1992-1993:154). In the national strategy (NFR 1997), the following overall objective is formulated: "Through a general dissemination of research, the aim is to encompass that part of the general public who are not traditional users of research simultaneous to including research in the public debate" (p. 7). Three main groups are defined as especially important: 1) Children and youth who will form the basis for recruitment of future researchers, 2) teachers, who are disseminators of research results to their pupils, and 3) journalists, who disseminate research and who, because of their position, can influence the science policy debate.

In addition, the same white paper states that the dissemination element should be incorporated as a systematic part of research programs and projects under the NRC (1992-1993:154). Dissemination was to be imperative. Information Director Paal Alme of the NRC writes: "In practice, if the researcher has made no attempt to disseminate state-funded research to the general public, this could result in exclusion or demands on refunding a grant" (Alme 1995). Even though such a regulation was never imposed, the statement is an expression of the increased importance attached to the dissemination activities.

The question of what channel is not made clear in the first white papers, whereas, at the same time, political measures and technological development resulted in an increased number of channels. The NRC, research institutions, and researchers comprise a three-dimensional structure that has a special responsibility for establishing innovative dissemination processes. A number of specific measures have been established or expanded, mentioned in several of the white papers, and in NFR 1997. The Norwegian Contest for Young Scientists commenced because of a private initiative as early as 1968 and grew in ambition and extent. The Nysgjerrigper Science Knowledge Project for children in primary schools was established in 1990. The Norwegian Science Week was inaugurated in 1995, during which year the Science Channel was established as a joint project incorporating the largest universities and university colleges with weekly transmissions by the Norwegian Broadcasting Corporation. This activity came simultaneous to the launch of a number of other projects directed toward children and youth including TV series such as Newton. Forskning.no [Science.no] was established in 2002 as an online newspaper devoted to Norwegian and international science, including several possibilities for feedback and debate. By May 2014, the collaboration involved 80 research and educational institutions. The Science Centres Programme was established in 2003 as an important project, not least for stimulating the interest of youth in the STEM-fields (science, technology, engineering, and mathematics). In May 2014, Norway had nine regional science centers and five additional specialized science centers. Further, it was important to strengthen museums' activities focused on schools. Both the museums and the science centers adopted social media to increase the possibility for inquiry-based learning. Finally, the Researcher Grand Prix was established in 2010.

In the 2004-2005 white paper, all state-financed research institutions are encouraged to develop their own dissemination strategies, and the Ministry was to develop a "dissemination indicator in the financial model for universities and university colleges" (2004-2005:128). Following two reports (UHR 2005, 2006), it was clear that there were larger problems than initially thought. In the first report, indicators were proposed for publication in popular (nonscientific) journals, feature articles in newspapers, popular science journals, student texts, lectures concerned with user-oriented specialist conferences, and other forms of dissemination to the general public. At the same time, there was an interest in stimulating R&D knowledge via the Internet. In the second report, "innovation and interaction with the industry" were emphasized, in addition to many of the same activities mentioned in the first report. However, the proposed dissemination indicator was not implemented, although the institutions were encouraged to develop an active dissemination policy (2008-2009:129). In many respects, it can be claimed that the dissemination indicator in the financial model was "dead in the water" when the number of channels increased and that which it was desired to measure had become difficult to measure.

What should be the results of science communication? Central to the 1975-1976 white paper was the need to disseminate information on the scope and limitation of science, such that as many people as possible would be able to evaluate the significance of science (1975-1976:77). The support of the public is thus considered an important assumption for a well-functioning science policy. Whether public support is a result of dissemination is not known, but according to the Special Eurobarometer "Science and Technology" from 2010, as much as 87 percent of the Norwegian population support scientific research even though research in itself does not result in any obvious immediate benefits. This percentage is higher than any other country in the survey (European Commission 2010). In recent years, the focus has been on children and youth, not least because they are an important recruiting ground for the STEM-fields. In 1974, 7.4 percent of the population had a university or college education. By 2012, this had increased to 29.8 percent of those aged 16 and above. Throughout the whole period, with few exceptions it has been difficult to ensure satisfactory recruitment to the STEM-fields. Among employees aged between 25 and 34, only 1 percent have STEM-training, whereas the OECD mean is 1.6 percent (KD 2010). Consequently, several new activities are planned in order to improve recruitment in those fields, among them strengthening the Science Centres Programme and the Energy-Programme at selected schools (2012-2013:37, 63 & 99).

Over time, the dissemination model has been enriched by a movement from PAST-measures toward CUSP-measures. At the same time, the dissemination model was challenged by fundamental changes in the role of science in society. Slagstad (2006) maintains that new knowledge regimes emerge and that knowledge is taken into use in new ways in order to promote an extensive modernization. A simple illustration of this change is to be found in the relationship between basic science, applied science, and experimental development as the Frascati Manual defines these categories. If we look at the relative strength of these three categories in Norwegian universities and colleges, it is particularly applied science that has grown constantly and evenly throughout the last half-century (NFR Ongoing). The growth has also substantiated a greater emphasis on user-oriented science communication and thereby strengthened the basis for the dialogical turn, not least because the public and users have more apparent roles within applied research.

The dialogue model

Already in the 1975-1976 white paper, the user of the research is introduced as an involved actor who can obtain more out of research if channels for two-way communication are established (1975-1976:79). Five reasons for two-way communication are given: 1) the researchers get corrective feedback and ideas; 2) the users get an opportunity to participate; 3) the research results are more easily accepted by the users and adopted if relevant; 4) both researchers and users enrich their knowledge; and finally 5) the users get a better understanding of certainty and uncertainty when interpreting the results. The coming white papers mention dialogue activities and introduces, for example, trainee-programs (1980-1981:47). However, the 1992-1993 white paper introduces the user as a much more active participant. This implies a clearer profile of science communication policy and increased emphasis on the application perspective (1992-1993:148-153) whereas, it is simultaneously emphasized that the acquirement of expertise is primarily the responsibility of the user (1992-1993:148). In the white paper, mention is also made of the Norwegian Biotechnology Advisory Board, established in 1991 (1992-1993:117). Biotechnology was presented as being of special significance concerning security and risk assessment. Important tasks include informing the public administration, and, not least, stimulation to debate in matters of science ethics. The Board has a broad basis in professionals, users, and lay people. The 1998-1999 white paper also attached importance to dialogue in various ways. It is emphasized that dissemination and application can be more difficult when those who are to apply the results have not participated in the research process (1998-1999:83). The authorities therefore recognized the need for new forums, and, in 1999, they established the Norwegian Board of Technology (1998-1999:123). The Norwegian Board of Technology was to determine the possibilities and consequences of new technology, for both society and the individual citizen. The results were to be made known to Parliament as well as to other authorities and the public. At the same time, the Board was to encourage actively public debate on technology. The Board would determine the specific areas for discussion and its working methods. However, importance was to be attached to methods by which lay people would be engaged in the activities. The Norwegian Board of Technology today employs a number of working methods, such as lay peoples' conferences, workshops, citizen's panels, and hearings. In other words, the authorities wish to engage the public in a more comprehensive technological debate.

The dialogue model assumes what Collins and Evans call "interactional expertise" (2007). Interactional expertise was defined by Evans and Collins by means of an illustration. They write, "if 'talking the talk' corresponds to primary source knowledge (knowing what has to be said), and 'walking the walk' corresponds to contributory expertise (actually being able to perform the task), the interactional expertise corresponds to 'walking the talk' – that is, being able to use the language in novel settings in much the same way as a contributory expert might" (Evans and Collins 2010:59). In other words, an interactional expert would be able to express him- or herself concerning a given field of knowledge without necessarily being able to contribute to knowledge within that field. A good example of this is lay peoples' conferences (1998-1999:123). Holding a conference where a lay panel is confronted with a given area of knowledge assumes interactional expertise. Lay peoples' conferences are an attempt to democratize participation. What this implies in practice will vary, however (Nielsen, Lassen, and Sandøe 2007). Nielsen et al. have made a comparative study of three lay peoples' conferences on genes technology in its broadest form in Norway, Denmark, and France. What was especially interesting was that the relationship between that which took place at the conference and the major question of democracy was experienced quite differently in the three countries. In Norway and Denmark, lay people's conferences were seen as a part of the overall democracy. In France, however, lay people's conferences were considered as being directly "incompatible with democracy" (p. 27). Correspondingly, the participation of the lay people was seen quite differently. In France, the lay people are regarded as "les naïfs." In Norway, they were accredited with "everyday knowledge" or "folk knowledge." In Denmark, their contribution was primarily considered as a contribution to "deliberative democracy." The different understandings naturally have different implications for how participants are prepared for participation. In France, much importance is attached to providing knowledge to the participants in what is to be the main subject of the conference; they are to be "semi-experts." In Norway and Denmark, much greater importance is attached to the social skills in preparing the lay panelists to "perform" at the conference vis-à-vis the experts (p. 32). In other words, they are required to acquire considerable interactional expertise in order to be good participants at lay peoples' conferences. The Norwegian informants had the broadest standpoint in this respect. They considered that "lay people could participate in a meaningful way without any prior training or education in the topic in question" (p. 33). In order to be a part of Evans and Collins's picture, they should be able to "walk the talk," and thereby achieve a new role for the public. In the innovation white paper, the role is also extended to include assessments of the different technologies' potential for innovation and economic growth (St. melding no. 7 [2008-2009]:117).

One group of activities mentioned sporadically in the white papers is the various "field trials," such as design experiments, usability trials, and policy experiments (e.g., 1975-1976:19 & 1992-1993:138 & 1992-1993:149). Today's society is characterized by experiments with the aim of developing new solutions encompassing many areas of society. Field trials have been discussed in the 1975-1976 white paper, and new learning methods and health issues are mentioned specifically (1975-1976:19). In some areas, trial projects are so widely used that laws and regulations exist governing their activity. Whereas design experiments and usability trials are primarily examples of the dialogue model, policy experiments are, at best, examples of the participation model (Hetland 2011).

The participation model

In the 1975-1976 white paper, a distinction was made between three target groups for scientific results: researchers, users, and the public (1975-1976:77). What is important here is that user-oriented science communication, and science communication toward the public, is considered within the same policy area. The NRC launched a policy for user-oriented science communication in 1996. The policy underlines that user-oriented science communication requires two-way communication between the researcher and the user, and that the recipient must have the necessary skills and knowledge to make use of the research results. The aim is to empower the users to act. Further, they emphasize that user-oriented science communication should substantiate monitoring and evaluation (NFR 1996).

Simultaneous to operating with a division of science communication, within the nine white papers, there are grounds to believe that the interplay between the two traditions has important implications for how the participation model develops over time. User-oriented science communication is built on a long tradition in the Nordic countries (Tydén 1993), and over time, the dialogue with users develops into a full-fledged participation model. This model has its roots in the modernization of agriculture, simultaneous to new communication technology opening up for new interactive possibilities. In a number of white papers, agriculture and "the agricultural extension model" (Rogers 2003:165-166) has been given as an example of the participation model (e.g., 1992-1993:151-152). From the agricultural extension service, field experiments and corresponding arrangements are models of how innovation can originate and spread. Field experiments represent science communication originating in practical agricultural and plant culture trials on members' "own farms." The first trial association in Norway was established in 1937. Agriculture, therefore, has a long history in user-oriented research participation. Within the NRC and Innovation Norway, a number of measures have been developed that stimulate the commercial aspects, the research activity, and the association between them. The mentioned comprehensive policy area was finally the subject of a separate white paper for innovation policy. The policy measures gradually became so many in number that the white papers discuss modern innovation theory as Triple Helix and Mode 2 (Gibbons et al. 1994, Leydesdorff and Etzkowitz 1998, Nowotny, Scott, and Gibbons 2001). Although it should be emphasized that these theories are controversial, it is difficult not to interpret the active policy in the field of science and innovation as being precisely a stimulation of Triple Helix and Mode 2. These theories and concepts become models for much of the political rhetoric. Triple Helix and Mode 2 are stimulated at an early stage through proposals for mobility incentives between the different research communities, producers, and users. It is emphasized on several occasions that dissemination of knowledge is most effective when occurring through mobility and networks. The concept of interaction (e.g., 2004-2005, 2008-2009, 2012-2013 and St. melding no. 7 [2008-2009]) has gradually been attaining a central place in the white papers. In the first decade of the 21st century, an "industrial PhD" was proposed precisely to encourage this interaction (2004-2005:103).

As mentioned the sectoral principle gives the different ministries crucial roles, especially when it comes to user-oriented science communication. Interesting examples of interaction are given by two ministries, the Ministry of Climate and Environment and the Ministry of Health and Care Services. The Ministry of Climate and Environment launched a new service called Artsobservasjoner [Species Observations] through The Norwegian Biodiversity Information Centre in 2008 (MD 2009). It is a digital reporting system open to everybody. From May 2008 to May 2014, 10.5 million observations have been recorded, mostly by lay people. These observations are crucial in many respects, and one application is the Species Map Service used by planners and the like. Citizen science is consequently one emerging method of participation (Dickinson and Bonney 2012). While Species Observation is open to everybody, the health field is frequently more structured, and its meeting places are typically closed. Samspill 2.0 [Interaction 2.0] aims to improve patients', users', and other stakeholder's information about health and health services. Further, patients and users shall have easy access to information about their own health situation and the possibility to participate in their own treatment (HOD 2010). Within citizen science, one important issue is how to identify trustworthy and credible information (Eysenbach 2008, Hetland 2011). Consequently, apomediation is launched as the "third way" by which users can recognize trustworthy information, and thereby it is an important element in promoting the participation model. Both within the private and public sector, the white papers emphasize participation by employees and users (e.g. St. melding no. 7 [2008-2009]:19-29 & St. melding no. 7 [2008-2009]:126). The participation model aims to involve the different publics in doing science and therefore gives broad possibilities to play out engagement and expertise.

Conclusion

Policies concerning science communication have gradually changed over time. The most important change concerns the increased importance of dialogue and participation within all three main models. Through an active policy aiming at dialogue, sponsored hybrid forums that encourage participation have gradually been developed. In addition, social media has facilitated an increase in spontaneous public involvement in a correspondingly increasing number of hybrid forums. Dialogue and participation thus become crucial parts of science and technology development. The traditional division between science and science communication was thus challenged by the various forms of dialogue, also within the dissemination model. In other words, we have a broader inventory of types of communication and involvement. Each model therefore constitutes a development zone where policy-makers experiment with the possibility for the public to act out their own expertise in order to enhance engagement. On the basis of the two dimensions, the degree of cooperation and the degree of sponsorship, Bucchi draws a map of public participation in techno-science (Bucchi 2009:66). I will exemplify this map while drawing on some of the policy measures mentioned in the white papers since 1975 (Figure 2).

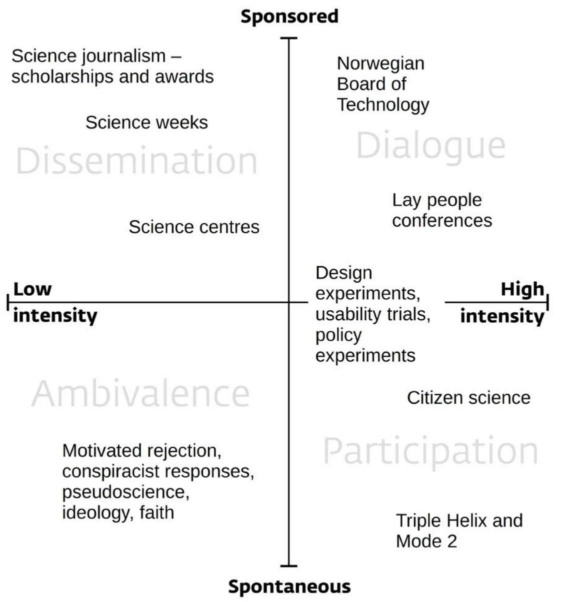

Figure 2. Participation forms for users and the public.
Source: Modeled after Bucchi 2009:66

The upper-left quadrant illustrates policy measures within the dissemination model. The dissemination model experienced notable development during the 1990s and the first decade of the new century. The competition element was employed both in respect of the lay people and of researchers, thereby increasing the possibilities for engagement. The popularized news-flow is increasing rapidly, not least because of the establishment of the online newspaper forskning.no, including both many bloggers and the possibility for discussing the news presented. Further, Norway is steadily acquiring more competent science journalists. Both the more traditional and newer media are attaining feedback channels. There is much to suggest that multisource journalism is increasing both generally and as issues become more domesticated (Hetland 2012). Both processes give the public greater opportunity for engagement. Science centers and museums are adopting social media, increasing the possibilities for inquiry-based learning. The political attention on science communication has resulted in the motto "to be seen in public or perish" being taken seriously by researchers and institutions. The dissemination model consequently remains an important communication model, a finding that is also well documented by Brossard and Lewenstein (2010). Activities within the dissemination model invite the public to participate in a process where knowledge building is of a more general character. The expertise acquired by users is primarily that which Collins and Evans call "popular understanding" and "primary source knowledge" (Collins and Evans 2007:19-23). Over time, there has been an interesting movement from PAST-measures to CUSP-measures within dissemination activities. The movement is apparent in some of the policy measures suggested and implemented.

The upper-right quadrant represents policy measures within the dialogue model. The dialogue model, which aims to bridge the single delegation and extend the peer community, was developed as a policy model in the 1990s. Experimentation had already become a central work form in modern society, and increasing numbers of persons are becoming acquainted with science and technology through reform activities and the more formative experiments to manage social change. Within the dialogue model, we therefore find a number of activities because of clear political initiative involving the public and users. What characterizes these activities is that they represent an extension of democracy in forms such as the Norwegian Board of Technology and lay peoples' conferences. It is maintained that participation is important in order to ensure the development of knowledge, good risk assessment, and diffusion of innovations. However, it can also be claimed that the construction of different publics is an inherent weakness within the dialogue model (Braun and Schultz 2010), and that the model therefore gives opportunities for playing out participation and expertise within rather predefined frames. The fact that, according to Braun and Schultz, such groups are not authentic publics, but pure publics shaped by practices and settings, limits the speaking positions available. The expertise with which users contribute is primarily what Collins and Evans call "interactional expertise" (Collins and Evans 2007:28-40) but with elements of "contributory expertise" (2007:24-27).

The lower-right quadrant represents policy measures within the participation model. The participation model in general, which aims to bridge the double delegation, has its roots in the agricultural extension model as a highly successful model based on "client participation in identifying local needs, planning programs, and in performing evaluation and feedback" (Rogers 2003:394), and it has developed along two tracks. First, central to innovation policy was the inclusion of a steadily increasing number of innovation measures. Participation thus became important to shape innovations and promote diffusion. Second, social media has enabled participation in completely new ways, enabling virtual collaboration. Examples such as biodiversity mapping with the aid of species observation and patients' participation illustrate the new possibilities for exercising citizen science. The fact that public authorities undertake special responsibility for establishing boundary infrastructures, as the Species Observations, also facilitates the participation of lay people in knowledge building in new ways (Bowker and Star 1999). Participation is linked either to collaborative knowledge building, which assumes communal effort within the general sphere of knowledge, or because the user has a genuine user skill and is a central player in constructing his or her own activity, health, and welfare. The participation model involves both the "affected public" and the "partisan public" (Braun and Schultz 2010) – that is a public that is either affected by the issue at hand or different kinds of interest groups. Consequently, the participation model opens the broadest possibilities to play out participation and expertise. The expertise with which users contribute is primarily that which Collins and Evans call "contributory expertise" (2007:24-27).

Finally, there is the "science and technology ambivalence" quadrant. Science and technology ambivalence is almost never mentioned explicitly in Norwegian science communication policy, but it is frequently implicit as an important reason for promoting science communication at all.

A review of Norwegian science communication policy clearly reveals how at a policy level concerns with public engagement over time have led to a mode that is more dialogical across the three models within science and technology communication policy. Involvement is regarded as important to ensure democratic participation, a broad participation associated with assessment of risk and ethics, exchange of knowledge, and knowledge building, as well as the encouragement of innovation and its diffusion. The growing importance of dialogue and participation is also an indicator of a weakening importance of Ingelfinger's rule. Those participating represent user interests, the need to stimulate debate, but also a genuine desire to develop and contribute with one's own expertise. Participation is organized along two dimensions: a) intensity of knowledge building, and b) whether the hybrid forums are sponsored or spontaneous. The two dimensions open up for an interesting variation of participation forms. When ideas on participation "migrate," an interpretation often occurs that adapts the participation form to fit a local context – a good example being lay people's conferences. Participation is consequently grounded in an increasingly number of hybrid forums shaped by local context.

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Study II

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Popularizing the Internet

Traveling Companions Supporting the Good News

Per Hetland

Abstract

In popular science and technology writing, "boosterism" is prominent. Writers overwhelmingly describe science and technology in enthusiastic terms, thereby promoting the deficit or Public Appreciation of Science and Technology model (PAST). A crucial aspect of the PAST model is its pro-innovation bias: writers enroll chaperones in the texts, such as spokespersons, users, celebrities, witnesses, experts, and authorities, to support their claims. Both "boosterism" and pro-innovation bias constrain the public's critical understanding of science and technology. This study includes a detailed exploration of pro-innovation bias in the popularization of the Internet in the Norwegian press and how journalists use chaperones to support their claims. The author demonstrates that, in popularizing the Internet, pro-innovation bias manifests several other biases, such as individual-praise, pro-technology, individual-blame, technology-blame, and source biases.

Keywords: pro-innovation bias, science and technology communication, Internet, framing, praise, blame

Introduction

A pro-innovation bias reflects a dominant optimistic bias in modern society in favor of scientific and technological innovations (Flyvbjerg 2008; Gripenberg, Sveiby, & Segercrantz 2012; Kahneman 2011; Lovallo & Kahneman 2003). Rogers and Shoemaker described pro-innovation bias as far back as 1971, and thirty years later, Rogers (2003, p. 106) stated that "not enough has been done to remedy the problem." Pro-innovation bias implies that "an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected" (2003, p. 106). Gripenberg et al. (2012) suggested two principal reasons for this bias. The first is that the axiom "innovation is good" is taken for granted. The second is the separation of discourses on desirable and undesirable consequences. Flyvbjerg (2008) added a third reason: an actor often has no incentive to de-bias a specific forecast. Consequently, pro-innovation bias might also imply strategic misrepresentations, the purpose of which is to gain an advantage in competitive environments.

Pro-innovation bias is also prominent in science and technology communication and might historically be perceived as a fundamental dimension of the deficit or Public Appreciation of Science and Technology model (PAST) (Perrault 2013). Perrault described three types of roles among science and technology writers: boosters, translators, and critics. The most common role, which is that of the boosters, corresponds to pro-innovation bias. According to Perrault (2013), boosters' "descriptions fall into two general categories: science writing as a celebration of the wonders of science and science writing as a cure for some perceived lack in the nonspecialist public" (p. 50-51). Boosterism has a long history in science and technology communication (LaFollette 1990). I prefer, however, to use the concept of "pro-innovation" instead of "boosterism," because this is a study of popular texts and not a study of the three mentioned roles of science and technology writers, including the fact that pro-innovation has a long history as an analytical concept. In her classical work *Selling Science*, Nelkin (1995) raised numerous crucial questions that were linked to pro-innovation bias. She discussed critical aspects, such as different public relations (PR) techniques, the media's problem of reliance on corporate sources of information concerning new technology, the celebration of progress, technological enthusiasm, and optimism (in short, the hype fascination). All of these aspects are accompanied by the fact that the public has an overwhelmingly favorable attitude toward science and technology, including a general belief in all types of technological fixes, which has evolved in parallel with the professionalization of science (Berman 1978). Nelkin's (1995) questions remain valid and critical. Therefore, I closely analyze how different framing devices are used to shape pro-innovation bias. I examine two research questions: (a) how are different actors or chaperones enrolled in popular texts to substantiate a specific framing in the portrayal of the Internet by the Norwegian press; and (b) how is a position transformed into a bias and how is such bias constituted?

The Internet has often been envisioned as a technological utopia framed by the rhetoric of hope (Flichy 2007). However, in popular discourse, three master narratives are identified: utopian narratives containing the *pro-innovation position*, dystopian narratives containing the *anti-diffusion position*, and technology-as-risk narratives containing the *control position* (Hetland 2012). These three master narratives represent attempts either to domesticate new media technology or to alienate oneself from it (Aune 1996; Hartmann 2009; Silverstone & Haddon 1996). Perrault (2013) described two other roles apart from the booster role, namely, the roles of translators and critics. Perrault claimed that "the idea of the popular science writer as translator avoids some of the drawbacks of the booster role, but is still problematic" (p. 57). This role creates an image of neutrality, whereas information is neither disembodied nor neutral. Translators position their writing within the Public Engagement with Science and Technology model (PEST). The third role is that of the critics: "these writers tend to emphasize a gatekeeping function (asking questions about the science itself) or a public service function (providing readers with the information they need to make up their own minds)" (Perrault 2013, p. 58). Perrault called this model the Critical Understanding of Science (and Technology) in Public or CUSP. The technology-as-risk narratives containing the control position provide examples of both the PEST and the CUSP models (Hetland 2012). Selecting the Internet as a case study in science and technology communication has one crucial advantage: it provides a unique wealth of information simply because the mass media has extensively covered it, whereas the public increasingly uses it in most aspects of life. Thus, one might claim that, in science and technology communication, the Internet is an "exemplar" that might establish a reference point or constitute a paradigmatic case (Flyvbjerg 2006). The Internet represents both an innovation in itself and a cluster of accompanying innovations (Abbate 1999). In 1973, Norway was the first country outside the US to adopt ARPAnet, the predecessor to the Internet (Daling & Thomassen 2006). In the present study, the issue is not whether the Internet, as an innovation, actually has high relative advantage (Rogers 2003), but how the Norwegian press has presented the narratives about the Internet from 1995 to 2006. During this twelve-year period, the pro-innovation position was dominant in 68.7% of the stories and the control position in 31.3%, whereas the anti-diffusion position was more or less absent from press reports. Two factors make Norway an interesting case study on the traditional media's portrayal of the Internet. First, in 2009, 90.9% of its population used the Internet – one of the highest penetration rates in the world. Second, in 2008, Norway's average circulation of paid-for daily newspapers was 570.6 per 1,000, which is one of the highest average circulation rates in the world (Leckner & Facht 2011). These are valid reasons to assume that the majority of Norwegians encountered the Internet through daily use and as newspaper readers during the period under study.

In the next section, I discuss the theoretical framework and a conceptualization of pro-innovation bias. Among the critical issues is how praise and blame frame a particular position. This is followed by the methodology section and the presentation of findings. The final section summarizes the findings and points to further research possibilities.

Theoretical and Conceptual Issues

To study pro-innovation bias in popular narratives about the Internet, I adopted the model that William A. Gamson and his colleagues constructed (Gamson & Lasch 1983; Gamson & Modigliani 1987). In connection with a selected theme, a particular use of concepts is established. From a large inventory of possible reference frames, expressions, metaphors, paradoxes, and so forth, a smaller repertoire is selected. The purpose of the model is to analyze how this repertoire is used to describe particular aspects of a phenomenon. The model has two principal constituents: *frames* and *positions* (Gamson & Modigliani 1987). Metaphors, exemplars, catchphrases, depictions, and visual images are framing devices, whereas roots, consequences, and appeals are reasoning devices for a more general position (Gamson & Lasch 1983). However, the selection of facts, context, and examples are also important for the framing process (Reese 2010) as well as how chaperones – spokespersons, users, celebrities, witnesses, experts, and authorities – are enrolled in the text to support claims. Morgan (2011, p. 30) defined chaperones as "the people who act as knowing or unknowing companions" for traveling facts. Facts that stand alone might be perceived as weak; therefore, it is important to have allies that support claims or attack those who could explicitly oppose these claims (Latour 1987). In his book, Latour argued that scientific and technological development could be appropriately understood by considering it as a negotiating process in which cooperation is built by recruiting external interests from the cultural field and new collaborators in the field of nature or technology. Chaperones are often witnesses or instrumental to claims that journalists make; they are necessary for facts to travel effectively, even if claims might be false. Chaperones might also be sources; however, sources include a larger inventory of persons (including anonymous sources), publications, and other records.

At the same time, the pro-innovation position travels with less support, especially within a pro-innovation climate (Borup, Brown, Konrad, & Lente 2006; Flyvbjerg 2008). The pro-innovation climate varies over time. Such variation might be linked to changes in the perceived usefulness of, for example, a specific technology. Therefore, public opinion might change from one period to the next. Today, an overall pro-innovation climate exists in Norway. The 2010 Eurobarometer, which included Norway for the first time, provided one example of this climate. The survey found that, among 32 European countries, Norway displayed the greatest optimism toward eight selected technologies: information and communication technology, biotechnology, space exploration, solar energy, nuclear energy, nanotechnology, wind energy, and brain and cognitive enhancement (Gaskell et al. 2010). This optimism is also reflected in the civic epistemology of which Norwegian science and technology policymaking is part (Jasanoff 2005).

Examining how chaperones are used in texts to promote a specific frame and/or position is critical. Entman, Matthes, and Pellicano (2009) claimed that Gamson and colleagues (Gamson & Lasch 1983; Gamson & Modigliani 1987) defined framing as the central organizing idea or storyline, whereas their definition specified what frames generally do, which includes defining problems, diagnosing causes, making moral judgments, and suggesting remedies. These two genres of definitions belong to different phases of the framing processes, because framing processes occur at "four levels: in the culture; in the minds of elites and professional political communicators; in the text of communications; and in the minds of individual citizens" (Entman et al. 2009, p. 176).

When does a position turn into a bias? Entman (2007) understood bias along three dimensions. The first dimension is "distortion bias," which applies to news that distorts or falsifies reality. The second dimension is "content bias," which implies that the text favors one side instead of presenting an impartial viewpoint. The third dimension is "decision-making bias," which implies that the writer's understanding of an issue is distorted. Entman (2010) distinguished between two primary sets of decision-making biases, of which the "media's catering to audiences as consumers in the marketplace" (p. 394) is of special interest in the case of the Internet. He also distinguished between slant and bias, stating that the term "media bias" only applies when slant holds over time.

Therefore, biases exist in two interrelated aspects of frames: (a) the psychological biases by which all communicating parties might be influenced – in Entman's (2007) terminology, decision-making bias; and (b) the frames that the communicator sponsors, which in Entman's (2007) terminology includes distortion and content biases. Entman (2007) stated that bias is under-theorized in spite of its crucial implications for political power and democracy. In terms of the first aspect of bias, "one of the most scrutinized psychological biases is the tendency to evaluate negative information more strictly than positive information" (Dan & Ihlen 2011, p. 372), which often leads to an optimistic bias (Kahneman 2011). The reader's decision-making bias might, therefore, "create consonance and dissonance even where none actually exists" (Baum & Gussin 2007, p. 26). When it comes to the second aspect of bias, news stories constitute a critical arena for framing contests in which different sponsors compete for their preferred frames (Dan & Ihlen 2011).

In the present study, praise and blame constitute pivotal framing devices for specific biases; in addition, an important part of pro-innovation bias is to side with the information provider. Having studied science and technology communication since the 1940s, Bauer and Gregory (2007) described science and technology communication as developing from communicating scientists with an educational mission to PR for science and technology. The first part of this period was captured in the "Ingelfinger rule" of 1969, which was an embargo to keep scientific results out of the media until they were published in peer-reviewed journals (Toy 2002). The second part of this period was marked by an increasing influence of PR in science and technology journalism. However, PR activities were often "invisible"; journalists using PR material often did not bother to cite their sources because "journalists don't want to disclose their dependency on public relations" (Göpfert 2007, p. 222). PR for science and technology implies the promotion of both scientific and corporate institutions to different publics. In this process, information subsidies play a critical role in capturing the attention of news media and journalists. Earlier studies of information campaigns illustrated that campaigns included both information subsidies to selected media channels and other strategies, such as lobbying to mobilize public opinion, politicians, and the policy agenda in favor of intended outcomes (Bauer & Bucchi 2007). A strong indication exists that "information subsidies influence not just which topics are covered by the media (first-level) but also how these topics are described (second-level)" (Ragas, Kim, & Kiousis 2011, p. 258).

Overall, most PR activities are source biased. The status of the source, the number of sources, and the context of the claims are also relevant. Thus, to capture the reader's attention, framing processes and the enrollment of chaperones are crucial. Chaperones, in the form of spokespersons, usually advocate ideas and interests and very often have an agenda with a pro-innovation bias, which frequently leads the communicator to "side" with the innovation provider and blame non-adopters (Lievrouw & Pope 1994; Rogers 2003). Consequently, pro-innovation bias favors the source over the receivers. In addition, it is often synonymous with a pro-technology bias and a preference for technology-push strategies (McCurrey 2000). Several authors, therefore, identify a link between a pro-innovation bias at a micro-level and a pro-innovation climate and culture that favor adoption for its own sake or facilitative factors that help promote and sustain innovations (Bardini 1994).

Rogers (2003) stated that if the pioneer research had been sponsored not by promoters but by users (or non-users), the nature of diffusion research might have been structured quite differently. Wyatt (2003) identified four groups of non-users: resisters, rejecters, the excluded, and the expelled. She emphasized the need to understand non-users as well as users and to avoid blackboxing them into one category. The blackboxing of non-users commonly occurs in the mass media, which mostly perceive non-users as either old-fashioned and outdated or unfortunate and excluded. Kline (2003) and Wyatt (2003) argued that viewing resistance to technology from a functionalist perspective reinforces the promoters' framing of success. Therefore, pro-innovation bias has a renowned counterpart, the individual-blame bias, which consists of blaming the individual for not adopting a certain innovation rather than searching for a system to blame (Rogers 2003). Often, non-adopters or late adopters are blamed individually for not adopting an innovation, or for being traditional or irrational.

In the following sections, I examine how different actors or chaperones are enrolled within popular texts to substantiate a specific frame and position. I also analyze how pro-innovation bias manifests several other biases.

Method

The database that I used in the present study consisted of 2,772 newspaper clippings about the Internet from the paper editions of the following newspapers: the morning edition of *Aftenposten* (1,334), *Dagbladet* (813), and *Dagsavisen* (625). *Aftenposten* is Norway's largest newspaper and has been described as independently conservative. *Dagbladet* is Norway's second largest tabloid newspaper and has been described as liberal. *Dagsavisen* is the former party organ of the Norwegian Labor Party, although, in the past few years, it has been described as independent. My aim was not to compare the three newspapers, but to select three newspapers covering the breadth of the Norwegian press, both politically and journalistically. From 1995 to 1996, 40.2% of the population over the age of 13 read one or more of the three newspapers included in the investigation (42.2% in 1996-1997).

The criteria for selecting an "Internet article" corresponded with those used by Bader (1990) in her case study of articles on research. One of her criteria was that roughly half of the article should discuss the object of her study. One of my criteria was that the Internet should be a central theme of the article. This meant that at least half of every article should have dealt with one or more sets of prospects or problems concerning the Internet. In addition, the selection of articles was based on the following criteria: (a) the article should have a word count of at least 200, (b) the Internet should be mentioned in the headline or in the introductory text, and (c) the text is written by a journalist – all types of journalists, not solely "science and technology" journalists. Excluded from the text corpus are short news reports, as well as editorials, debates, and longer feature articles with a mix of positions.

Whenever possible, the articles were collected from electronic sources: (a) *Aftenposten,* for the entire period, (b) *Dagbladet,* after January 1, 1998, and (c) *Dagsavisen,* after February 1, 2002. For the missing periods, I conducted the collection manually. Whereas I did not have a full overview of the total article population, it was possible to use *Aftenposten* as an indicator. For this newspaper, all articles were coded in the electronic source according to their topic. The selected articles represented 32% of the total population. For the period covering 1995 to 1999, 47% of all the articles in *Aftenposten* met the selection criteria for the study. This proportion declined to 27% from 2000 to 2006. Perhaps, the principal reason for this was the increase in the proportion of articles with fewer than 200 words. These comprised 37% of all articles in the first period and 48% in the second. The second reason for this was use of the term "Internet" as one of the selection criteria. During the period that I studied, the term "Internet" was increasingly replaced either by its shortened version, "net," or by terms that were more specific. A smaller control study of these articles did not offer new information. Therefore, it is reasonable to assume that I have identified both the diversity and the changes in the period under study. By including all of the articles that satisfied specific criteria, I could combine a qualitative textual analysis with a quantitative approach. Approximately a third of the data was double-coded for the variables in focus. The intercoder agreement coefficient, calculated using Holsti's (Holsti 1969) method, yielded a range of 96.1% to 97.7% for the three items (position, chaperones, praise and blame). When coding a position, I did not distinguish between slant and bias because pro-innovation bias is consistent over time (Entman 2010).

Enrollment of Chaperones and the Shaping of Pro-Innovation Bias

The enrollment of chaperones within texts plays a critical role in the framing process. Ubiquitous authoritative resources for journalists include not only science advisors but also spokespersons, users as lay experts, and public authorities. Four categories of chaperones are defined in the present context: (a) spokespersons, including PR personnel and people speaking on behalf of companies or organizations; (b) users, including both highly skilled (lay experts) and novice users; (c) experts, including scientific researchers from independent research and development institutions, colleges, and universities; and (d) authorities, including opinion leaders and representatives from law enforcement, politics, and the public service. The maximum number of chaperones in one article was nine. To analyze how chaperones contributed to framing positions, I compared the pro-innovation position with the control position. Table 1 shows the four principal categories of chaperones and how they appeared in popular texts about the Internet.

Table 1. *Enrollment of Chaperones*

	Chaperones, percentage							
Position	Spokes-persons	Users	Experts	Authorities	Total	N	Percentage of articles with chaper-ones	Average number of chaper-ones per article
Pro-innovation	60.1	16.3	12.7	10.9	100	2645	75.4	1.84
Control	36.4	12.9	12.7	38.0	100	1486	81.6	2.10

Frequently, a close connection existed between those who appeared as chaperones within the texts and those who appeared as sponsors. Of the total number of chaperones assuming the two positions, spokespersons were most prominent in the pro-innovation position, whereas authorities were more prominent in the control position (Table 1). The stronghold of spokespersons within the pro-innovation position demonstrates the importance of PR activities and indicates a strong source or content bias. A larger number of stories within the control position, compared with the pro-innovation position, contained chaperones as well as a higher average number of chaperones. This might be linked to the fact that the control position was more dramatic and controversial. Consequently, journalists substantiated their claims by enrolling more chaperones and enrolling them more often.

Both the literature and the stories showed that praise and blame were crucial elements in framing the two positions. In many stories, writers substantiated the pro-innovation position by praising the technology, the actors, and the numerous futuristic expectations (Table 2). Furthermore, at the opposite end, writers substantiated the pro-innovation versus the control position by either blaming the actors and/or the technology for hindering the diffusion of innovations or blaming the actors and/or technology for not controlling undesirable activities on the Internet. Finally, in the last group of stories within both positions, the stories combined the elements of praise and blame. Therefore, also within the pro-innovation position the reader experiences blame, underlining that numerous factors hinder the diffusion of innovations.

Table 2. *Chaperones as Vehicles for Praise and Blame*

	Praise and blame, percentage			
Position	Praise or neutral	Praise and blame	Blame	Total
Pro-innovation	73.3	19.3	7.4	100
Control	4.6	19.5	75.9	100

When stories were told and retold, chaperones were critical in lending credibility to these stories. One example was a story about Internet use in schools. This story covered three researchers reporting their findings, one teacher, and one student. The researchers reported that three of four junior high school students found that the teachers' qualifications were limited in relation to using the Internet. All of the other interviewees confirmed this. Their position was that the teachers needed appropriate qualifications to realize the full potential of the Internet (*Aftenposten*, February 30 2000, p. 20). Within the pro-innovation position, the more the stories included single-minded praise of the technology or of its users, the more they were predominantly supported by internal chaperones (spokespersons and users). The number of external chaperones increased when the stories dealt with both praise and blame. Apart from the obvious reason that internal chaperones were more loyal and, thus, largely limited their support to praise, the stories might have thrived and traveled better with a combination of praise and blame. The pro-innovation position displayed considerable expectations. The solutions lay in the future. The narratives emphasized what would happen and under-communicated what had happened. What had transpired was always more modest than the expectations. This paradox might be described as a trivialization process. Because stories were future oriented, they presented the new technology as a driving force in a positive development toward progress. Resistance to or criticism of new media technology was, therefore, rapidly turned into an attempt to restrict the liberating force of the technology; both content bias and decision-making biases were therefore important in those texts.

Media coverage of the Internet before 1995 was sporadic. In 1995, the three mentioned newspapers placed the Internet on the media agenda. The Internet was high on the media agenda from 1996 to 2000, falling to a lower level after 2000. The popular discourse concerning the Internet did not fluctuate in cycles of hype and disappointment (Fenn 2007), but followed the five stages in the innovation-decision process (Hetland 2012):

1. Knowledge (1995-1996). The public was exposed to the Internet in the trigger year, 1995; the press coverage reached its first peak in 1996 and the media balance was +48. Internet access reached approximately 17% and daily Internet use was approximately 5%.

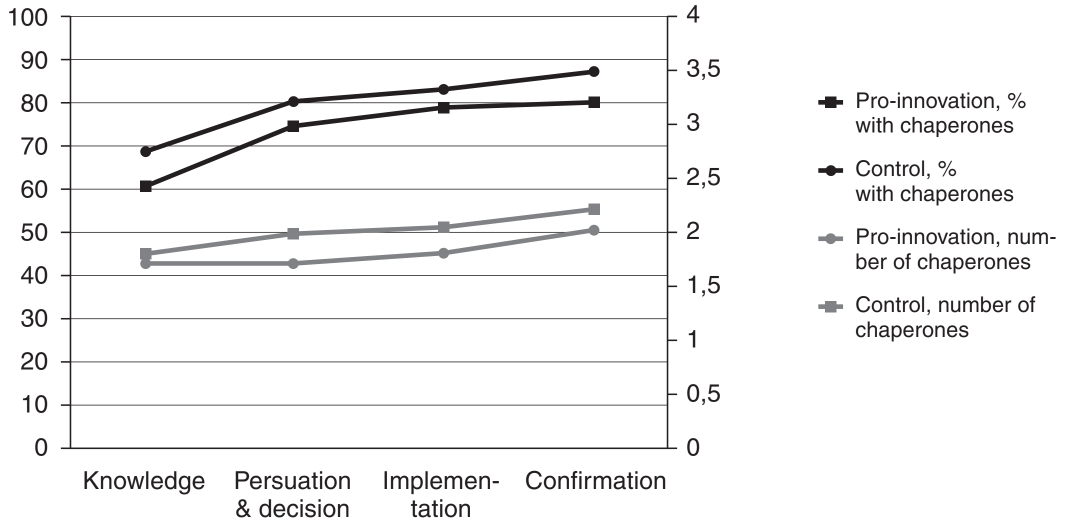
2. Persuasion and decision (1997- 1998). The press coverage was moderate; the media balance was +30. Internet access reached 36% and daily Internet use reached 10%.

3. Implementation (1999-2000). Press coverage had its second trigger year and peaked at a media balance of +54. Internet access reached 63% and daily Internet use reached 27%.

4. Confirmation (2001- 2006). Press coverage fell to a lower level; the media balance was +20. Internet access reached 88% and daily Internet use reached 60%.

During the course of these five stages, the share of articles with chaperones and the average number of chaperones increased within both positions (Figure 1).

***Figure 1.** Articles with Chaperones and the Average Number of Chaperones in Articles with Chaperones*



The growing number of chaperones illustrates an increasing "expertization": journalists seek external voices to comment on or illustrate ongoing activities. This increase might be part of an overall trend of interpretative and investigative journalism. However, it might also be part of the process of diffusion of innovation, where technologies become mature and domesticated. Domesticated technology enables more interpretative and investigative journalism. One is most likely to be experiencing two converging processes, as both interpretative and investigative journalism grow in importance, and more mature and domesticated technologies qualify the same type of journalism. The diversity of chaperones at least makes it more likely that both lay people and experts are represented when journalists try to predict the future. The negotiation process becomes visible in the mediation of science and technology by how chaperones are enrolled in the texts. Contemporarily, as chaperones allow themselves to be enrolled, there is also cooperation that is either poor or nonexistent. Thus, the negotiation process moves along a continuum, from those who resist to those who more than willingly allow themselves to be enrolled (Table 3). In the following sections, I discuss the four situations that manifest a pro-innovation bias.

Table 3. *Manifesting Pro-innovation Bias*

	Resistance	Cooperation
The field of culture	1. Chaperones who do not cooperate; stories are dominated by individual-blame bias.	3. Enrollment of new chaperones; stories are dominated by source- and individual-praise biases.
The field of technology	2. Artifacts that do not cooperate; stories are dominated by the technology-blame bias.	4. Enrollment of new artifacts or properties; stories are dominated by source- and pro-technology biases.

1. Chaperones who do not cooperate. One crucial reason for the absence of cooperation is that actors might have found the costs of cooperation to be excessive. Therefore, the relationship between utility and cost was often problematized in the stories. Potential customers would not pay for something that, in their opinion, entailed negligible utility. Therefore, numerous critical voices focused on the absence of utility. Customers asserted that central actors did not understand their needs. Although news existed about those who reached their target groups on the Internet, experts said that

> for all the others, who are not yet reaching their target groups in this way, it is nevertheless important to start running. If they wait right up until all the others have reached their goal, they will get there too late. (*Aftenposten*, November 20, 1995, p. 22)

Through the "tyranny of urgency," the stories emphasized the significance of cooperation in overcoming all obstacles in question.

In July 1996, *Aftenposten* stated that "[m]en dominate the Internet" (*Aftenposten*, July 7, 1996, p. 27) and that "[m]en are three times more likely to use the Internet than women." The popular image of innovators in the press was closely linked to the traditional "diffusion of innovations" model. The article stated that different information providers had considered more "women-related content" and more "content aiming at children and young people" to engage new user groups. When actors were described, individual-blame bias was prominent in this category of stories. Those who were not innovators were often described in a concerned manner. The position taken in these stories was that this was an important area for action and both content bias and decision-making bias were prominent.

2. Artifacts that do not cooperate. In the hybridization processes that the Internet is undergoing, not all artifacts cooperate. Two factors were central during the years that I studied. The first related to all the successes of the new media technology, which exceeded expectations. The result was an overload, and in the worst case, it was a total collapse. The capacity of the new technology was exceeded by its success. The second factor related to a lack of technological standards. The solution was to develop new technology and to establish technological standards. As an example, one story stressed that before one can begin to market Internet telephony, "the technology ought to be so standardized that we would be able to call as many people as possible." Standards were central and were used to explain the failure to launch different services. Under the heading "Slow start for secure electronic transaction" (SET), Europay confirmed that SET experienced initial problems: "There were several reasons that the system did not take off. We hoped to better collaborate with the banks. We have also experienced technical problems with the client-side certificate distribution" (*Aftenposten*, September 6, 1998, p. 25).

Thus, the technology-blame bias usually focused on the technology itself, on strategic collaborators within the socio-technical systems, and on examples of mismatches between expectations and reality. The technology-blame bias displayed both content and decision-making biases.

3. Enrollment of new chaperones. In the public discourse, it is considered important that many actors, including non-traditional ones, be given the opportunity to participate. The dissolution of various monopolies and the liberalization of the market were seen as fundamental preconditions for generating development marked by innovation. Strategic cooperation between actors in the market rapidly became part of the daily news. Cooperation was established between Internet service providers and content suppliers. The aim was to exploit the existing potential of the market. In addition, news emerged of numerous unexpected alliances. The new technology made old and well-established actors suddenly interested in one another. The user side also mattered. Different forms of cooperation were established between users and suppliers. We heard stories from disabled people who said that their Internet friends did not know they were disabled. Thus, the Internet enabled like-minded people to interact without making disability relevant. In this way, new media technologies were presented as tools for recreating intimacy and interpersonal contact. The feeling of being involved in a revolution was central in this connection. Prime Minister Gro Harlem Brundtland stated the following in February 1996:

> If the number of Internet subscribers increases at the same rate as today, there will be as many Internet users in the year 2003 as the whole of the world's population. Even if such a development is simply hypothetical, this picture illustrates the extent of this revolution at precisely this moment. (*Dagsavisen*, February 9, 1996, p. 9)

Not surprisingly, the source and individual-praise biases were highly prominent among the stories in this category. These biases displayed both content and decision-making biases.

4. Enrollment of new artifacts or properties. A stream of news stories tells of new artifacts being enrolled in networks. One critical argument for new artifact enrollment was the possibility of lowering the prices of existing services. In some cases, users were offered the technology at no cost or for a symbolic payment. This was connected to the fact that central actors wished to overcome the problems associated with an installed base. Thus, it might have been profitable to donate parts of the technology. Aside from the enrollment of modern technology, old solutions received new meanings on the Internet. Electronic newspapers were a central example in this context. In an October 2000 interview, an entrepreneur producing short animated Internet films stated the following:

> Yes, it is expensive to be an innovator, but if we want to be part of it, it is necessary to be early. Over time, the technology will be available to everybody. When that happens, we will be well established with long-term experience as content

> providers… In the near future, we will likely drive along the information superhighway with no speed limit. (*Dagbladet*, October 14, 2000, p. 44)

Source bias, together with pro-technology bias, was prominent within this category. These biases displayed both content and decision-making biases.

Concluding Discussion

Studying science and technology communication through a case study of how the Internet has been communicated in the mass media has been revealing, not least because this new media technology provides rich opportunities to study numerous aspects relating to the PAST model and pro-innovation bias. The selected case provides rich information on how pro-innovation bias plays a critical role in science and technology communication, not the least because the case involves a multiplicity of chaperones. The first research question focused on how chaperones were used to substantiate pro-innovation bias in Internet communication. Bias was understood along three dimensions. Content and decision-making biases prevailed in relation to communicating about the Internet, whereas distortion bias was more difficult to detect because, in this study, the focus was on the texts, rather than how they were produced. Regarding content bias, source bias played the most crucial role in favoring one side rather than providing an impartial presentation. Regarding the decision-making bias, individual praise and blame, as well as praising and blaming technology, framed the understanding of new technology as the key driver toward economic growth and progress.

To summarize, pro-innovation bias in communicating about the Internet manifested the individual-praise, pro-technology, individual-blame, technology-blame, and source biases. Generally, the analysis contributed to a more integrated understanding of how bias was shaped and framed. Pro-innovation bias is prominent in science and technology communication. However, this prominence also reflected that pro-innovation bias was a crucial part of public discourse. Therefore, pro-innovation bias was also a manifestation of Western society's strong pro-growth bias. Many of the economic, ecological, and social challenges confronting us today are caused by both intended and unintended consequences of this bias. Pro-innovation bias is also a critical domestication strategy that is used to predict and shape the future. As such, pro-innovation bias is a fundamental part of the deficit model, as "science boosters tend to see popular science writing as a form of public relations" (Perrault 2013, p. 5) exemplifying a "missionary zeal" approach to science communication.

The traditional media played a crucial role in domesticating new media technologies. Whereas the control position was substantiated by applying four control strategies (Hetland 2012), the pro-innovation position was consequently substantiated by employing five biases, making diffusion of the Internet appear to be inevitable.

The second research question aimed to explore the path from positions to biases. Entman (2010) described a process that progresses from a situation in which the position is framed as one of several possible positions to a slanted presentation, and finally, to a biased presentation. The underlying assumption is that the unbiased position is the ideal position from which one can distinguish the biases. However, Gripenberg et al. (2012) presented strong empirical evidence that pro-innovation bias in technology communication represents the "typical" situation. This is also substantiated by the present study. Generally, a position is turned into a bias by using praise and blame as critical framing strategies. In turn, praise and blame are substantiated by accompanying chaperones who are, therefore, essential vehicles for a specific bias because they often favor the information providers. On a more philosophical level, it is well known that people praise and blame both individual actors and assemblies of actors. People usually only praise inanimate objects because they do not have free will. The present study illustrates that technology might also be blamed for not fulfilling the expectations of chaperones who adhere to pro-innovation bias. In contrast to the control position, the pro-innovation position adopted a more homogeneous framing, thereby contributing to reaching a mutual understanding of the same problem. This mutual understanding is a critical factor in promoting the new media technology.

Pro-innovation bias constrains critical debates about how new technology affects society and about the possible undesirable consequences of the same technology. Perrault (2013) argued that science and technology communication has a twin duty: to inform and educate about science and technology on the one hand, but also to probe and criticize it on the other. Pro-innovation bias prevents the performance of both duties. Therefore, I propose three research pursuits of relevance to future studies on pro-innovation bias in science and technology communication: the framing of public discourse; the integration or separation of consequences; and how chaperones are used to handle complex issues. First, how does pro-innovation bias frame public discourse? Studying the roles of the range of chaperones that accompany pro-innovation bias is critical. How do chaperones lend credibility to pro-innovation bias and how are they selected? Second, how is the public discourse on the desirable and undesirable consequences of science and technology integrated or separated? What hinders a more critical understanding of science and technology in the mass media? Third, how do chaperones, accompanying both the pro-innovation and control positions, contribute to separating complex issues into well-ordered and manageable components?

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Study III

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Internet Between Utopia and Dystopia

The Narratives of Control

Per Hetland

Abstract

The Internet has often been envisioned as a technological utopia, framed by the rhetoric of hope. However, after studying the popular discourse, *three meta-narratives are identified*: utopian narratives containing the *pro-innovation position*; dystopian narratives containing the *anti-diffusion position*; technology-as-risk narratives containing the *control position*. While narratives of anti-diffusion are more or less invisible, narratives of control are surprisingly absent from the scientific discourse about the Internet. The present article sets out to explore narratives of control as they were presented in the Norwegian press during the 1995-2006 period. We have also studied how the expectancy cycles of the Internet fluctuate over time within this period. The study supports two general conclusions: (1) the expectancy cycles for the Internet in the mass media fluctuate in a manner comparable with the stages of the innovation-decision process and; (2) the control position promotes individual, social, technological and institutional control, and is more prominent when the Internet is lower on the media agenda.

Keywords: Internet, innovation, expectations, narratives, domestication

Introduction

Narratives about expectations are significant in the diffusion process of innovations. These narratives utilize resources concerning opportunities and potential risks. They also exert a performative force; they spur different actors into the process of making technology their own, thereby contributing to the domestication processes of innovations. The rhetoric of the Internet is often described as the rhetoric of hope. Mulkay claims that the rhetoric of hope is the dominant science and technology discourse in our culture, while the rhetoric of fear is culturally subordinate (Mulkay 1993, p. 724). However, Bloomfield et al. state that "this subordination is relative rather than absolute" (Bloomfield & Vurdubakis 1995). The rhetoric of hope is prominent in much of the discourses surrounding the development of the Internet, as well as the research into these discourses. For example, in an early study, Johansson studied the rhetoric of technology and computing discourse in Sweden from 1955 to 1995, using policy documents as the empirical corpus (Johansson 1997). Later, Cronehed studied the technology hype by analysing a computer fair (Cronehed 2004), while Lennstrand reports findings from two experiments "gauging the effect of diffusion models on people's perception of speed in this process" (Lennstrand 2001, p. II). A more specialized study was conducted by

Karlsohn; he studied policy documents about information and communication technology (ICT) and education as well as a range of articles from professional educational journals (Karlsohn 2009). A similar but more general study was conducted by Flichy, focusing on a corpus of articles consisting of Internet books, articles from *Wired* and some high-profile magazines (Flichy 2007). The aim of this exercise is to illustrate that the empirical corpus often is strongly biased towards the rhetoric of hope, and the rhetoric of fear is more or less invisible, as it is often absent from or not revealed in the empirical corpus. The control position has been studied earlier in relation to how users produce and distribute information (Bordewijk & Kaam 1986). The issue here, however, is how control is understood when studying how a new media technology is portrayed in the media discourse. My first claim is, therefore, that a more inclusive empirical corpus is necessary to overcome the often very biased descriptions of Internet narratives.

In accordance with the hope-fear dichotomy, Nye argues that new technology is understood using two meta-narratives: utopian and dystopian (Nye 2004, p. 171). However, I claim that those new technological innovations in both the popular and more policy-driven discourse should be better understood using the three meta-narratives or a trichotomy instead of a dichotomy: utopian narratives containing the pro-innovation position, dystopian narratives containing the anti-diffusion position, and technology-as-risk narratives containing the control position. The pro-innovation position implies that an innovation should be diffused and adopted by all members of a social system. The innovation should be diffused as rapidly as possible and neither re-invented nor rejected. Anti-diffusion recognizes innovation (or invention) in fact, but states that for different reasons this innovation ought *not* to be diffused or assimilated by particular user groups or by society in general. The anti-diffusion position is, as the above researchers underline, barely visible in narratives about the Internet. For the most part, the narratives do not reject the innovation, but claim that new technology entails potential risks that must be controlled. The three positions are linked to anticipatory action, thereby creating expectations (Brown, Rappert, & Webster 2000). Over time, these expectations fluctuate. A twofold research question is therefore investigated in the present article: First, how do the expectancy cycles relating to the Internet fluctuate in the mass media? Second, how do the narratives of control contribute to the domestication processes of the Internet?

The next section contains a presentation of the theoretical framework. This is followed by a section on methodology, before the findings themselves are presented. The final section contains a concluding discussion that sums up the findings and points to further research possibilities.

Encountering the Internet

During the 1994-1995 period, the general public encountered the Internet through the *mass media*. The Internet was interpreted, dramatized and given content. Mass media channels are therefore important for creating awareness and knowledge of a new innovation (Nelkin 1995; Rogers 2003). In the mass media, innovations are promoted and changed through different support strategies as conflicts are resolved. An innovation may therefore be both domesticated and re-domesticated (Lie & Sørensen 1996) or re-invented (Rogers 2003). Domestication involves the processes whereby innovations are adapted to everyday life and the processes that involve adaptation of everyday life to innovations (Aune 1996; Silverstone & Haddon 1996). The domestication of innovations in the mass media takes place by establishing frames for interpretation and by appealing to different positions. The positions or morals of the meta-narratives shape the domestication processes.

The stories of the Internet, as they have been told in the Norwegian press during the 1995-2006 period, are central to this study of domestication. Spigel undertook a parallel study of how the introduction of television was represented in different types of magazines (Spigel 1992). A premise for her study was that new media technology is introduced to the general public through old and well-known mass media, and an analysis of the magazine representations would therefore say something about the agenda-setting process. The stream of Internet stories in a number of media may be seen as a "mega-text", which socializes sections of the public into specific understandings or expectations: "the 'mega-text' lives on, then, in the audience's interpretive repertoires" (Jensen 1995 p. 111), until it become obsolete or irrelevant.

In order to study how technology communication in the mass media contributes to domestication processes, I have chosen to study a technology that later became an everyday technology. Yet at the same time as journalists play an important role, members of the public are also active participants in shaping the technological narratives. A variety of actors consequently influence the agenda-setting process (Dearing & Rogers 1996). In a discussion about the threat society and the media, Nohrstedt claims that "when a risk is politicized, it tends to be formulated as a threat" (Nohrstedt 2010, p. 26). Threats, therefore, exploit people's uncertainty and anxiety. This distinction is interesting and gives the media an important role, elucidated by the concepts of "mediation" and "mediatization". While, according to Nohrstedt, "mediation" implies dissemination of information, "mediatization" implies "something more, namely that the problem or danger is created *in and by* the media" (op. cit. 41). The different narratives and their accompanying positions may therefore also be examples of mediatization processes, in and by the media.

To study the popular narratives about the Internet, I have used the media package model that stems from William A. Gamson and his studies of political themes such as social welfare policy and affirmative action (Gamson & Lasch 1983; Gamson & Modigliani 1987). In connection with such themes, a particular use of concepts is established. From a large inventory of possible reference frames, expressions, metaphors, paradoxes and so forth, a smaller repertoire is selected. The purpose of the model is to analyse how this repertoire is used to describe particular aspects of a phenomenon. It is normal to say that media packages consist of two main constituents: *frames* and *positions* (Gamson & Modigliani 1987, p. 143). According to Gamson and Lasch, metaphors, exemplars, catchphrases, depictions, and visual images are framing devices, while roots, consequences and appeal are reasoning devices for a more general position (Gamson & Lasch 1983). However, the selection of facts, context, examples and sources is also important to the framing process (Reese 2001).

The media package model is normally used to describe a group of individual packages within a policy question. The policy questions that Gamson et al. have chosen are marked by two characteristics: (1) they are clearly delimited, and (2) they are the objects of controversies. My aim, however, is to test the model on a larger empirical corpus, that is to say the "total" coverage of the Internet as it appears in the Norwegian press. This has a number of implications. In the first place, the investigation will lack a unifying theme. Second, the Internet is a new media technology and does not necessarily represent a particular controversy with clear adherents and opponents. Instead of controversies, one can therefore find more investigative strategies. Here, the journalists explore different interpretations within the various themes.

Research Method and Media Coverage

In order to gain a more detailed understanding of the introduction of new media technology, I have chosen the presentations given by the mass media. For this purpose, three large Norwegian newspapers were selected to provide as broad a description as possible of how the narratives about the Internet were presented to the general public. Daily newspapers are probably the most important source of information for the majority of people when it comes to material on science and technology during the period studied. According to Ramberg, 74% of the Norwegian public in 1999 and 58% in 2004 stated that they frequently read news about science and technology in newspapers (Ramberg 2004). In the same period, the Internet as a source of information increased from 18% to 33%.

Large portions of the public have engaged with the Internet, both regarding presentations given by the mass media and through practical actions. That is, they have started using the Internet. In Norway, Internet access grew from 8-9% in 1995, to 88% in 2006, while daily use grew from 3-4% in 1995 to 60% in 2006.[1] The Internet is therefore embedded within Norwegian society. The purpose for selecting the 1995-2006 period was to ensure that it covered (a) the years when the Internet was both high and low on the agenda of the mass media, and (b) all important stages of the diffusion process of the Internet. In an earlier study only the first three years was included (Hetland 2002), thereby lacking the later stages of the diffusion process.

The database consists of 2772 newspaper cuttings about the Internet from the paper editions of the following newspapers: *Aftenposten* (the morning edition) (1334), *Dagbladet* (813) and *Dagsavisen* (625). The important point was not to compare the three newspapers, but to select three newspapers covering the breadth of the Norwegian press both politically and journalistically. In 1995/1996, 40.2% of the population over the age of 13 years read one or more of the three newspapers included in the investigation (in 1996/1997, 42.2%). When it came to what was required for an article to qualify as an 'Internet article', I used criteria corresponding to those Bader used in her case study of articles on research (Bader 1990). She had, as a criterion, that roughly half the article should discuss the object of her study. I chose as a criterion that the Internet should be a central theme in the article. This meant as a rule, that at least half the article took up one or more sets of prospects or problems concerning the Internet. In addition, the selection of articles was performed according to the following criteria: a) the article should consist of at least 200 words and b) the Internet should be mentioned in the headline or in the intro-text. Media coverage of the Internet before 1995 was only sporadic. In 1995, the three newspapers studied placed the Internet on the agenda. As Figure 1 illustrates, the Internet was high on the media agenda from 1996 to 2000, falling to a lower level after 2000.[2] By including all articles that satisfied certain criteria, it was also possible to combine a more qualitative textual analysis with a quantitative approach to explore changes over time.

Narratives about the Internet

Creating meaning out of new media technology reaffirms that the introduction of new technology always entails ambivalence. Media-technological ambivalence is often articulated as normative dichotomies. Technology, for example, is presented as good or evil: it makes freedom or control possible, one loves it or hates it, it is reliable or unreliable, or one feels oneself to be included or excluded. Perceived dichotomies are, therefore, common and the middle alternatives are often ignored. The advantage of the Internet is that it is a technology that affects many people first as members of a public audience and, as time passes, also as users – the Internet becomes an everyday technology. As far as everyday technologies are concerned, I have chosen to focus on a technology that "took the public by storm" once it was made available to the general public. I have, in other words, picked out a *success story*.

The dominant position of the meta-narratives is important for understanding the domestication processes. Expectations usually have a temporal pattern (Borup, Brown, Konrad, & Lente 2006). However, in spite of the dot.com hype, the popular discourse of the Internet does not fluctuate in cycles of hype and disappointment (Fenn 2007). The expectancy cycles for the Internet fluctuate in a manner comparable with the five stages in the innovation–decision process: *knowledge*, *persuasion*, *decision*, *implementation* and *confirmation* (Rogers 2003, p. 199). Two important factors enable the stages to be described in a more systematic manner. First, the agenda-setting intensity (the volume of media coverage as measured by the number of articles), and second, the media balance between the pro-innovation position, on the one hand, and the control and anti-diffusion positions, on the other (measured as the difference between the percentage of pro-innovation articles and the percentage of control and anti-diffusion articles). In the twelve-year period studied, the pro-innovation position was dominant in 68.7% of the stories, the control position was dominant in 31.3% of the stories, while the anti-diffusion position was more or less absent from the press reports. So on average, the media balance was +37.4. As already mentioned, the journalist appeals to a certain public, and there are reasons to believe that the Norwegian public in general are rather optimistic or pro-innovation biased when it comes to new technologies. One measure of this optimism is given by the Eurobarometer 2010. In 2010, Norway was included for the first time, and the Norwegians are, according to this survey, the most optimistic nation among 32 European countries with regard to eight selected technologies (ICT, biotechnology, space exploration, solar energy, nuclear energy, nanotechnology, wind energy, and brain and cognitive enhancement) (Gaskell et al. 2010). In spite of this pro-innovation bias in Norwegian society, which may compress the diffusion process compared to other countries, the Norwegian media coverage about the Internet also represents Internet narratives in other countries. Many of the stories are either imported from other countries or inspired by events abroad.

A high positive media balance is symptomatic of a period in which all relevant actors are enrolled to promote the technology, while a low positive or negative media balance signifies a more reluctant or mature period. Using the data presented in Figure 1, describing the volume of media coverage during the diffusion process together with the media balance, we can identify five stages in the expectancy cycles describing how the discourse evolves:

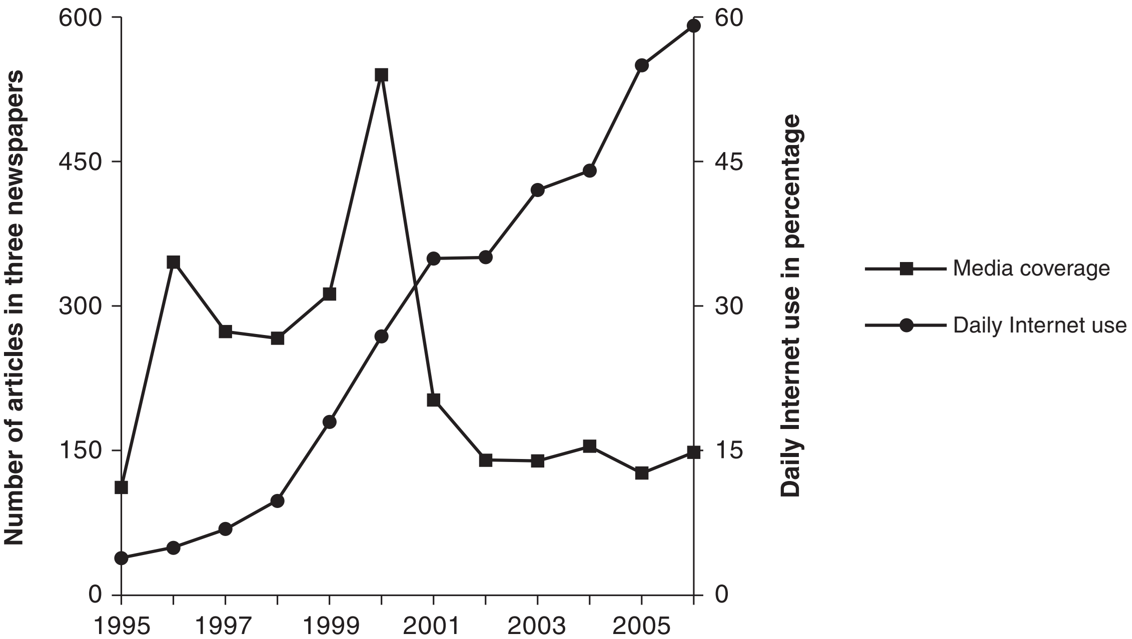
1. Knowledge (1995-1996). The public is exposed to the Internet in the trigger year, 1995, and the press coverage reaches its first peak in 1996; the media balance is +48. Internet access reaches about 17% and daily Internet use is about 5%.

2. Persuasion and decision (1997-1998). Press coverage is moderate; the media balance is +30. Internet access reaches 36% and daily Internet use reaches 10%.

3. Implementation (1999-2000). Press coverage has its second trigger year and peaks at a media balance of +54. Internet access reaches 63% and daily Internet use reaches 27%.

4. Confirmation (2001-2006). Press coverage falls to a lower level; the media balance is +20. Internet access reaches 88% and daily Internet use reaches 60%.

Figure 1. *Media Coverage and Daily Internet Use*



During the twelve years studied, we can conclude that the higher the Internet is on the media agenda (the stages of knowledge and implementation), the more prominent is the pro-innovation position, and over time, when the technology is more mature, the control position becomes more noticeable. The fact that the control position grows in importance during the domestication processes shows that the three dimensions of domestication described by Silverstone and Haddon (1996) – *creating the artefact*, *constructing the user*, and *catching the consumer* – do not constitute a linear process. The domestication processes during the confirmation stage are both characterized by protests and unruly users, exploiting the space for *interpretive flexibility* (Pinch & Bijker 1984), and new attempts to delimit this flexibility (Oudshoorn & Pinch 2003). The domestication processes lead to two important questions; (1) which aspects of new technology are easily domesticated and become "cold" during the diffusion process and (2) which aspects are difficult to domesticate and will remain "hot" even after most potential users have started to use the technology (Callon 1998)?

Domestication Processes

In the following section, the three main domestication processes – (1) pro-innovation, (2) control, (3) anti-diffusion – are explored. I will concentrate, however, on the control position, as this position is the least developed in the literature.

The pro-innovation position

The pro-innovation position is full of positive expectations and is closely linked to more utopian understandings of development. The solutions lie in the future. The narratives place weight on what is going to happen and do not communicate well what has happened. The things that have happened are always more modest than the expectations. This paradox may be described as a trivializing process. The fact that the stories are future-oriented also means that they look upon the new technology as a driving force of positive developments. Resistance to, or criticism of, new media technology is rapidly turned into an attempt to restrict the liberating force of the same technology. Pro-innovation is the most dominant position in science and technology communication. In classical innovation models, new technology was looked upon as a set of established facts or machines, and the role of the public was limited to that of being adopters or rejecters.

The control position

In the first place, ICT has increasingly become an enabling, generic technology that is embedded in other technologies to manage, monitor and regulate technological functions and processes. Second, ICT connects technologies together in increasingly integrated technological systems, and connects people and organizations in new ways. In contemporary society, important societal functions become dependent on electronic communication, which increases various forms of vulnerability. Communication can be interrupted or disturbed by failure in technological systems, through program errors, misuse or deliberate sabotage, and also as a result of mishaps that are ultimately due to human error. The whole risk problem, thus, illustrates that the Internet can also be regarded as "the wilds of nature". The Internet provides the dark sides of Western culture with new arenas in which to unfold, such as criminal activity in general, political activism outside the democratic tradition, or sexual expression and acts outside what is allowed and accepted. As a rule, these actions are met with various forms of social or technological control systems. The control position takes its point of departure in the notion that technology implies risk and its users may be ungovernable. Both users and technology must be regulated and controlled, i.e. domesticated in order for technology to serve the community. When the problems have been solved, the technology will become domesticated and apparently trivial (until the problems arise again). While invention is the process by which a new idea is discovered or created, adoption is a decision to make full use of an innovation. Rogers (2003; pp. 181) defines re-invention as "the degree to which an innovation is changed or modified by the user in the process of its adoption and implementation". Up to the 1970s, re-inventions were looked upon as rare. As a rule, re-inventions were treated as "interference" in diffusion research. Gradually people have come to see re-invention as an important process. In current research dealing with invention and re-invention, the focus has been shifted to the co-construction of users and technology (Oudshoorn & Pinch 2003). The control position may, therefore, be seen as an important element in the co-construction of users and technology.

The control position involves a variety of control measures. How this control might be exercised varies from one media package to the next. The factors that contribute to giving form to the control position are linked to: (a) the delegation of responsibility and (b) the point of time in the process when control should be exercised. Control can be performed by individual and/or social regulations or delegated to humans and/or non-humans (e.g., technology) (Latour 1992). Individual and/or social regulations imply that a single individual, or an individual organization, is responsible for keeping this wilderness under control. Delegation to technology or institutions means that technology and/or control bodies are established to keep an eye on the activity on the Internet. The timeframe is also important. Is this control to be proactive or reactive? Is it to prevent undesirable activities on the Internet before they take place (ex-ante), or is this control to be primarily exercised after the undesirable activities have taken place (ex-post)?

In the group of media packages under the control position, control activities are categorized into four ideal situations indicating where the focus is directed: (1) individual control, (2) social control, (3) technological control, and (4) institutional control (see Table 1). In the stories, one obviously finds combinations of these control situations. However, most of the stories focus on one type of control.

Table 1. *Four Control Situations*

	Control in a Time Perspective	
Responsibility for Control	Proactive	Reactive
Individual and/or social self-regulation	(1) Focus on individual control	(2) Focus on social control
Delegated	(3) Focus on technological control	(4) Focus on institutional control

How control is to be implemented and how far the actors are to go in the exercise of this control activity is the object of ambivalence in the stories. On the one hand, forms of control can be adopted to prevent undesirable activity. On the other hand, the exercise of control may imply "throwing the baby out with the bath water" [3]. Here, the four control situations are presented in general:

1. Individual control. Individual control entails individuals drawing their own line within the area that is covered by freedom of expression, statutes, and regulations. Furthermore, individual control also entails delineating responsibility in relation to those who are not mature enough to exercise this control on an individual basis. It is stressed that parents must use "sound common sense" and stay well informed of what their kids are up to on the Internet and keep an eye on their activities. One reason for the fact that individual control is emphasized so strongly has its background in the notion that "technology cannot be controlled". The Internet breaks down the barriers of censorship and other barriers and what remains is individual control. A good example of how self-control is presented is the story of the Norwegian Broadcasting Corporation's journalist, whose voice was so well known to Norwegians who listened to her radio programme at 9 o'clock every morning. She became totally addicted to the Internet and practically disappeared into cyberspace, but after a few weeks, she said to herself "this simply cannot continue". She then made her own traffic rules.

In the struggle between good and evil, it is not only "the good citizens" who exercise self-control; the "villains" also protect themselves with various forms of control measures. The exchange of information and services is a risky activity for those concerned. The stories stress how the actors involved build up networks characterized by confidence and secrecy. Getting inside a sphere where people exchange unlawful pornography, software and other items requires building up the necessary trust among those within the sphere of exchange (Bohannan & Bohannan 1968, pp. 220-239). Establishing spheres for co-action and exchange is their most important strategy for risk control. The users split their activities up in spheres where different forms of control are exercised with respect to access and participation. Seen in this way, the establishment of spheres of trust is an important domestication strategy.

2. Social control. Social control takes its point of departure from the view that all responsible members of society ought to engage in ensuring that the Internet becomes a place for "free and open public dialogue". This is done in part by teaching one's fellow human beings how they should behave on the Internet. Netiquette is an example of this. The same is true of the use of "flaming". However, just as important is the fact that one should commit oneself to preventing unwanted activities on the Internet. A number of organizations and individuals engage in activities whereby they infiltrate the communities that should be combated (e.g., paedophile groups who exchange contacts and material). People who tip off the police in such cases are presented as "heroes" in press reports. This also provides the basis for various campaigns to get people to inform the police. The threat of displaying details of sex offenders on the Internet, of exposing them to public scorn, is put forward as one of the options one ought to use. There are a number of examples of this kind of "lynch law". Almost without exception, this is considered praiseworthy, even by the traditional control authorities. There are reports both of computer viruses being sent to bases containing child pornography and of their lines being blocked with music. "The police cannot use such methods, but in the struggle between good and evil, there's no doubt who has my sympathy", says the leader of Interpol's working group to combat sexual abuse of children. A number of measures also entail new scripts being written into the technological solutions. Control is delegated to technological control systems.

3. Technological control. A central belief among many actors is that all problems created by new technology also have a technological solution. The Internet is no exception. Control can be delegated to new technology. Particular views of what the user should or should not do are built into the technology. It is the same in the stories that focus on technology as an instrument of control. Parents can delegate their parental responsibility to various control programs. Filtering is, however, not without problems, and readers are told how a great deal of useful information can easily disappear in the filtering process. "It is quite simply not possible to make a 'naughty! naughty! filter' that does not throw the baby out with the bath water", is one conclusion. The security routines are becoming increasingly better; encryption programs are taken into use and the "holes in the system must be filled". Various virus programs are designed to combat the activities of hackers. Secret computer agents and electronic watermarks are among the means being adopted to stop the unlawful distribution of music. In addition, various persons are refused access to the Internet by Internet providers. The providers develop different traffic rules.

One side of technological control is characterized by ambivalence. The actors behind unwanted activities have the same ability to use technological control. To prevent criminal activities, bans are imposed on the use and/or sale and/or exportation of encryption programs, for example. The authorities try to prevent criminal actors from using control technology for their own purposes.

4. Institutional control. Institutional control is primarily reactive. It is the law and regulations that take effect when they are broken, together with the control bodies, that are to safeguard law and order. There are constant reminders emphasizing that statutes and rules have not been adapted to the new technology. They do not keep pace with developments. Among other things, the national anchorage of statutes is a problem – "computer signals cannot be inspected at the border". It is therefore claimed that we are "powerless in the face of the new information technology" without international co-operation; because in situations of conflict, a number of the new entrepreneurs threaten to move offshore. At the same time, it is stressed that the police and security authorities must have new powers, new competence and not least, increased resources.

The Anti-diffusion Position

In contrast to the pro-innovation position, we find the anti-diffusion position. In popular discourse, there are few, if any, examples of total rejection. This position emerges in "letters to the editor", however they have not been included in the present article. When it comes to the anti-diffusion position, there is very little empirical material. In connection with the Internet, the anti-diffusion position is presented either as a temporary solution to a problem where one lacks good solutions, or it is a position that "others" are spokespersons for. When the daily papers describe "machine stormers", it is with amazement. The press offers little understanding for the position.

Conclusion

The Internet took the public by storm and the diffusion rate has been high. The present exploratory study supports two general conclusions.

First, expectations are significant for the diffusion of innovations. The higher the Internet is on the media agenda (the stages of knowledge and implementation), the more prominent is the pro-innovation position. At the other stages, where the Internet is lower on the media agenda, the control position increases in importance. Hypes such as the dot.com hype are important for two reasons: they frame expectations and spur diffusion. Consequently, the hype is most visible during the implementation stage.

Second, technological innovations in both popular and more policy-driven discourses can be understood through three meta-narratives. Utopian narratives are prominent in modern society; they signify progress and hope. In this respect, the narratives about risk and control are an important counterpart to the utopian narratives. Winner claims that technological development is most productive when the breadth of possibilities is neither foreseen nor controlled (Winner 1977, p. 98). Technology always does more things than we planned. This fact is a part of general knowledge to such a high degree that it becomes part of our intentions.

Beck claims that "in advanced modernity, the social production of *wealth* is systematically accompanied by the social production of *risks*" (Beck 1992, p. 19). We initiate technological development projects in the hope that unplanned consequences will arise, not least in the form of other actors actively participating in the development process with their own inscriptions. *Positive side effects* are a latent expectation or an implicit desire in all plans for innovation. In the same way, *negative side effects* are looked upon as a necessary evil that we are obliged to put up with. Any intention contains a hidden "non-intention", which is just as much in our calculations as the immediate goal we have in view. This interplay between intention and non-intention demonstrates that the pro-innovation and control position are two sides of the same coin. They are both equally important in the domestication processes, and the expectations are important in order to "mobilise the future into the present" (Brown & Michael 2003).

But which aspects of new technology are easily domesticated and become "cold" during the diffusion process and which aspects are difficult to domesticate and will readily remain "hot" even after nearly all potential users have started utilizing the technology?

People are often not aware of the problems before the media dramatize them and give them content. Mediatization of an issue "implies that its representation is changed into a form that suits media interest best, and that journalists as professionals are best at, namely to get public attention through emotional messages, dramatic angles and visual images" (Nohrstedt 2010, p. 46). The narratives of control are an interesting example of how risks are politicized, and how the media not only formulate threats, but also solutions. Nohrstedt claims that late-modern society "has become obsessed with the fact that our lives are not entirely safe and under our control" (op. cit. 18). The Internet narratives substantiate that even when problems or dangers are created in and by the media, the media are also searching for control of the same problems and dangers. The rhetoric of fear is, therefore, balanced by the rhetoric of control. In this manner, not only are the problems and dangers created in and by the media, but so are the solutions. The media are therefore important actors in domesticating new technology.

The narratives about risk and control are not only an important counterpart to the utopian narratives, they are also an important element in the media dramaturgy. Hence, the mass media and their sources are important actors in defining and understanding risk in modern society. The present study of the Internet in the mass media substantiates that risk is almost always understood as controllable. If one is unable to control the risks identified, this is always a result of weak control strategies and never because the technology is uncontrollable. This is in line with the fact that "risk management concentrates on normal procedures and regards extremes as inconsequential" (Beck 2009, p. 51). If the extremes were perceived as significant, the dystopian narratives containing the anti-diffusion position would have been more prominent in the media discourse.

During the diffusion process, some aspects of the new technology are easily domesticated and become "cold" during the process. Almost all the problems and dangers described in this twelve-year period are domesticated except for one: the users. Users are always able to find new approaches that circumvent newly invented and often institutionalized control measures.

Some limitations of the present study are obvious: the Internet is a success story in which the media are both mediators and users. Mediatization implies, therefore, that the media often create problems and dangers they have self-interests in solving. The control position may be more prominent than if the technology studied had been a technology not used by the media. A follow-up study could involve a more comparative investigation of a technology that is more foreign (and threatening) to both the media and the readers. Would such a technology be portrayed in a manner that makes it necessary to modify the claim that a trichotomy is more interesting when studying technology expectations than a dichotomy is?

Notes

1. Access figures from tns Gallup. A percentage of the total population 12 years or older. Daily use from Norsk Mediebarometer 2006, and SSB. Percentage of the total population aged 9 to 79.
2. When it was possible to do so, the articles were collected from electronic sources, a) Aftenposten for the whole period, b) Dagbladet after 1.1.1998 and c) Dagsavisen after 1.2.2002. For the missing periods, the collection was done manually. We do not have a full overview of the total population, but it is possible to use Aftenposten as an indicator. For this newspaper, all articles were coded in the electronic database according to their topic, and the selected articles represented 32% of the total population. In Aftenposten in the 1995 to 1999 period, 47% of all the articles met the selection criteria for this study. This proportion declined to 27% in 2000 to 2006. Perhaps the main reason for this was the increase in the proportion of articles with fewer than 200 words. These made up 37% of all articles in the first period, and 48% in the second. The second reason for this is the 'Internet' as the selection criteria. During the period studied, 'Internet' is increasingly replaced by either a) the short version 'net' and/or b) more specific terms. A smaller control study of these articles gave no new information. It is therefore reasonable to assume that we have identified both the diversity and the changes in the period studied.
3. Some more illustrative quotes from the newspaper stories have been included without citing the source of every quote.

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Study IV

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Public Communication of Technological Change: Modest and Less Modest Witnesses

Per Hetland

Abstract

When journalists popularize a highly topical new technology, such as the Internet, they situate their popularization within technological expectations; when researchers popularize it, they situate their popularization within both a retrospective and prospective understanding of technological change. Following this, journalists are inclined to appeal to emotionally involved users or pioneers, and researchers are inclined to appeal to responsible citizens. Hence, journalists immodestly dramatize the future by boosting a new technology or turning its risks into threats, while researchers acting as 'modest witnesses' pour oil on troubled waters, indicating scepticism with the journalistic approach. Consequently, the technology popularization field is structured in two dimensions: from public appreciation of technology via public engagement, to critical understanding of technology in public and from expectation-based argumentation, to research-based argumentation.

Keywords: Modest witness, popularization, technological change, expectations, Internet

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Introduction

Science, technology and public enlightenment are crucial elements of the modern project. As a forerunner of the modern project, academia includes education, scientific research and the public communication of science and technology (PCST) as its three most prominent assignments. The third assignment, PCST, refers to all science and technology 'mediation, interpretation, dissemination and explanation activities – the range of efforts, among others, to inform, sensitize and mobilize the public' (Schiele & Landry, 2012: 34). Professional communicators, such as journalists, public relation officers, museum curators and teachers, play crucial roles mediating science and technology to its various publics. However, sometimes researchers choose a direct route, presenting scientific research to its various publics via, for example, feature articles, textbooks or public lectures (Bucchi, 1998; Bucchi & Trench, 2008; Cheng et al., 2008; Fleck, 1935/1979; Lewenstein, 1995). Thus, this paper sets out to explore how researchers compared with journalists portray technological change when they popularize research about the Internet.

While science and technology journalists look for news values to attract their publics' attention or 'increase relevance and comprehensibility' for publics of non-scientists (HP Peters, 2013: 14107), it seems that most researchers communicating their research act as 'modest witnesses' to calm exaggerated expectations (Allan et al., 2005; Dunwoody, 1999; Gunter et al., 1999; Haraway, 1997; Shapin, 1984; Shapin & Schaffer, 1985). There is much evidence to indicate that these differences are embedded in the respective occupational sub-cultures:

> The professional identity strategies deployed by scientists such as requiring journalists to adhere to scientific norms and discourse are firmly grounded in the material practices, literary style and social technologies of Boyle's 'modest witness'. These contrast sharply with journalists' attempts to deal creatively with esoteric knowledge in the interests of democratization, editorial approval and organizational constraint. (Reed, 2001: 295)

Consequently, one may claim that these differences are part of two different 'professional projects' depicted in the two faces of witnessing (JD Peters, 2001): direct experience of a sociotechnical practice, and discourse about the practice to publics not present. While researchers are scientific witnesses observing sociotechnical practices, journalists report on sociotechnical practices experienced by others. However, very few scientists 'have "seen for themselves" or "directly witnessed" the experiments, the proofs, or even the raw data that support scientific claims. Scientific testimony, then, is usually a double-mediation' (Leach, 2011: 183–184).

Within science and technology journalism in Norway, the Internet has been popularized according to two cultural master frames or master narratives: utopian master narrative that contain the pro-innovation position (Hetland, 2015) and technology-as-risk master narrative that contain the control position (Hetland, 2012). These two master narratives are well known in PCST (Perrault, 2013). However, seldom are the master narratives dominating science and technology journalism compared with the master narratives popularly used by researchers as authors. A study of how climate science is presented in Norwegian newspapers compared the master narratives of journalists with those of researchers and found that while journalists dramatize, researchers try to avoid over-dramatizing (Ryghaug, 2006). Researchers find popularization important; however, they are troubled by the journalists' preoccupation with sensationalism and being overly dramatic (Carlsen et al., 2014; Gunter et al., 1999; Petersen et al., 2009; Ryghaug, 2006).

The dominant view of popularization from the 1990s stated that it involved at best ‘appropriate simplifications’ for a lay public (Hilgartner, 1990; Suerdem et al., 2013). PCST is perhaps the area in which the linear communication model is most clearly reflected. This strong position of the linear model is likely linked to the scientist’s role as teacher and motive of educating the public (HP Peters, 1995). ‘Obviously, experts in many cases want to take the translator role on themselves while journalists assume this role to be theirs’ (HP Peters, 1995: 43). However, the relationship between science and technology and the media is changing. The importance of the media in techno-science is intensifying, even if the media may have less influence on techno-science than on other parts of society. Consequently, the techno-sciences' media connection also has important repercussions (Rödder et al., 2012).

Techno-scientific issues that the public experiences as transformative will typically appeal to the public and to different stakeholders and will most likely be used to test established boundaries. This is especially true when the techno-scientific innovation reconfigures the human communication environment. The public's sensitivity to different techno-scientific issues may also vary greatly. Some issues are 'hot' even before they are placed on the mass-media agenda (Callon, 1998; Epstein, 1996). In a discussion about the ‘threat society’ and the media, Nohrstedt (2010) claimed that 'when a risk is politicised, it tends to be formulated as a threat' (26). Threats therefore exploit people's uncertainty and anxiety. This distinction is interesting and gives the media an important role, elucidated by the concepts of 'mediation' and 'mediatization' (Ampuja et al., 2014). According to Nohrstedt, while 'mediation' implies dissemination of information, 'mediatization' implies 'something more, namely, that the problem or danger is created *in and by* the media' (2010: 41, emphasis in original). Consequently, the media play an important role in the production and circulation of knowledge and interpretations of science and technology (Hjarvard, 2013; Väliverronen, 2001). One may even claim that the media have become an obligatory passage point for researchers that aim for visibility (Goodell, 1977; Latour, 1987). The different master narratives and their accompanying positions may therefore also be examples of mediatization processes in and by the media. People are often not aware of problems or opportunities before the media dramatize them and give them content. Mediatization of an issue 'implies that its representation is changed into a form that suits media interest best, and that journalists as professionals are best at, namely to get public attention through emotional messages, dramatic angles and visual images' (Nohrstedt, 2010: 26). This discursive practice also represents a move away from 'reasoned argument' (Davies, 2014).

The public communication of scientific and technological knowledge will be studied through the following research question: how do researchers compared with journalists portray technological change when they popularize research about the Internet? The first part of the paper is a theoretical discussion that provides an overview of popularization and the implications of retrospective and prospective understandings of technological change, including technological expectations; it aims to combine the two through framing theory. The second part discusses the methodology and then analyses the case of popularization when researchers write in the mass media about a new technology, such as the Internet, focusing on researchers' feature articles in two national newspapers in Norway. The last part of the paper summarizes the analysis and links it to the broader discussion on PCST.

Theoretical and Conceptual Issues

Concerning popular science rhetoric, Perrault (2013) claims that science and technology are popularized according to three different models: public appreciation of science and technology (PAST), public engagement with science and technology (PEST) and critical understanding of science in public (CUSP). The PAST model is characterised by a one-way flow of information from the scientific sphere to the public, in which science is a black box, reading is uncomplicated, knowledge is boosted and a deficit exists only on the reader's side. The PEST model conceives of PCST as a conversation open to dialogue; however, this model still separates science and society and locates the centre of gravity in science. The CUSP model of PCST considers all the elements of science-in-society, including their interactions, to be worth scrutinising. The CUSP model offers four advantages: first, it has a 'relational' focus; second, expertise is multiple; third, it focuses on the twin duties of PCST to inform and educate while probing and criticising; and fourth, it matches the reality of the public's views of science, which combines public enthusiasm and public criticism (Perrault, 2013:

12–17). These three models imply three different roles for science and technology popularizers: boosters, translators and critics. In this context, the CUSP model is of special relevance. Modern society increasingly relies on researchers as experts. Peters states that researchers as public experts combine two interesting aspects: researchers as (policy) advisors and researchers as public communicators (HP Peters, 2014). Expert advice may take the form of public dramas (Hilgartner, 2000) or technological dramas (Pfaffenberger, 1992). Pfaffenberger claims that a 'technological drama is a discourse of technological "statements" and "counterstatements"' (1992: 285). Through this means, experts provide both general knowledge and advice in order to enable rational decision-making (HP Peters, 2014).

As mentioned above, Internet journalism has used two master narratives: utopian master narrative that contain the pro-innovation position (Hetland, 2015) and technology-as-risk master narrative that contain the control position (Hetland, 2012). The former has been dominant over the 12-year period studied (from 1995 to 2006); the pro-innovation position characterized 68.7% of news stories, while the control position characterized 31.3% of news stories. The pro-innovation position was promoted through either praise or blame, while the control position was promoted through individual, social, technological and institutional control. The master narrative of control are an interesting example of how risks are politicized, in that the media not only formulate the threats but also their solutions. The same is true for pro-innovation master narrative; the media not only formulate opportunities, but also promote them. A third master narrative would have been possible: dystopian master narrative containing the anti-diffusion position. This master narrative is well known from the study of other technologies, such as nuclear power or genetic engineering (Bauer, 2015; Bloomfield & Doolin, 2012). In a study of how journalists portray the Internet it was, however, not possible to find this master narrative in its pure form (Hetland, 2012). When it appeared, it was a position for which 'others' were spokespersons, such as more totalitarian regimes.

The three master narratives are linked to anticipatory action, thereby creating expectations (Brown et al., 2000). Expectations usually have a temporal pattern (Borup et al., 2006), which is well illustrated by the popularization of the Internet (Hetland, 2012). Expectations are important in order to 'mobilise the future into the present' (Brown & Michael, 2003), and there is even a business in promoting technological expectations (Fenn, 2007; Pollock & Williams, 2010). However, while expectations are future-oriented, influencing the shaping of technology and innovation, the scientific discourse of technological change tries to understand what has happened or might happen. Technological change is either understood as continuous, characterized by an on-going evolution, or as discontinuous, characterized by smaller and larger revolutions (Basalla, 1988;

Bragesjö et al., 2012; Kuhn, 2012; Rogers, 2003). Thus, while the journalists often situate their arguments within a prospective understanding of techno-science with strong elements of what might be called 'folk theories' (Brown et al., 2000; Green, 2004; Rip, 2006), researchers will usually situate their arguments within a scientific discourse. This paper will study how retrospective and prospective understandings of technological change influence the roles of researchers as popularizers and expert witnesses. Expert witnesses do not mediate sensory experiences acquired by presence; they mediate the results of intellectual work (JD Peters, 2011).

To study how researchers portray their and/or others' research about the Internet, the model that William A. Gamson and his colleagues (Gamson & Lasch, 1983; Gamson & Modigliani, 1987) constructed was adopted. The purpose of the model is to analyse how this repertoire is used to describe particular aspects of a phenomenon (see also Hetland, 2012, 2015). The model has two principal constituents: frames and positions (Gamson & Modigliani, 1987). Metaphors, exemplars, catchphrases, depictions and visual images are framing devices, whereas roots, consequences and appeals are reasoning devices for a more general position (Gamson & Lasch, 1983). Chaperones – spokespersons, users, celebrities, witnesses, experts and authorities – are enrolled in the text to support claims (Hetland, 2015; Morgan, 2011). This paper is concerned with two crucial master narratives within PCST that are used on a wide array of techno-scientific issues with wide cultural implications. One may even claim that they represent two well-embedded cultural narratives (Ihlen & Nitz, 2008). The two different understandings of technological change are dialectic. As Gamson and Modigliani (1989) stated, 'There is no theme without a countertheme' (6). This counter theme or counter frame attempts to undermine or redefine the interpretative framework (Benford & Snow, 2000). While many of the framing devices are important for understanding popularization, the reasoning devices for a more general position are important for understanding the researchers' roles as expert witnesses. The core frame is essential to establish a relational focus with the reader and to inform and educate. The core position outlines the role of expertise, which may be a multifaceted rather than a unitary construct. In this respect, the root analysis will represent the underlying approach to technological change. The core position will also represent the expert advice offered by researchers. In this regard, contextualisation and the production of socially robust knowledge are important elements of the core position (Gibbons, 1999; Nowotny et al., 2001).

Consequently, while the journalists often situate their popularization of technology within narratives of expectations, technology popularization by researchers is often situated within a more general discourse on technological change, making the role of the modest witness a guarantor of scientific validity

(Haraway, 1997). This guarantor role also makes the modest witness vulnerable if the claims are proven false (Haran & Kitzinger, 2009). Witnessing is about taking risks, since 'Witnessing is seeing; attesting; standing publicly accountable for, and psychically vulnerable to, one's visions and representations. Witnessing is a collective, limited practice that depends on the constructed and never finished credibility of those who do it …' (Haraway, 1997: 267).

Journalists use researchers as expert witnesses to comment on on-going events in a complex society. Usually, the journalists act as the initiators (Wien, 2013). Presently in both in Denmark and Norway, researchers from the social sciences and humanities are the dominant expert witnesses in the media (Carlsen et al., 2014; Wien, 2013). An earlier study from Norway showed that in 1966 PCST was dominated by the natural sciences. By 2006, however, there was a more equal distribution between different academic disciplines (Andersen & Hornmoen, 2011). A meta-analysis of studies on the media's coverage of science found that scholars mostly analyse media coverage of the natural sciences and neglect social sciences and humanities (Schäfer, 2012: 658). On the other hand, studies indicate that the gap between the humanities and social sciences and the media is much smoother than the gap between the natural sciences and the media (HP Peters, 2013). Research about the Internet in Norway involves a broad array of disciplines; thus, we will at least avoid the bias of focusing only on science in the media (Trench & Bucchi, 2010: 2). Public attention to science and technology – or rather the various media's attention to science and technology – fluctuates over time. This fluctuation varies according to changing societal contexts and endogenous factors in the operations of techno-science (Bauer, 2012); issue-specific fluctuations are also linked to the domestication processes of specific technologies (Hetland, 2012).

Data and Method

This paper examines popularization when researchers write in the mass media about a new technology, such as the Internet, compared with journalists' popularization. The journalists' portrayal of technological change is presented in two earlier articles (Hetland, 2012, 2015). Consequently, the present presentation of data and method concerns researchers' feature articles in two national newspapers in Norway: *Aftenposten* and *Dagbladet*. *Aftenposten* is Norway's largest newspaper and has been described as having an independent conservative orientation. *Dagbladet* is Norway's second largest tabloid newspaper and has been described as being liberal. Each day, both newspapers have a feature article written by an author not affiliated with the newspaper. The features are long, in-depth articles in which the author may address an interesting topic in about 6,000 characters (including spaces). Of the feature articles selected for this study, 58.1% were from *Aftenposten*, while 41.9% were from *Dagbladet*. The two newspapers publish an estimated[i] 5–15% of the feature articles they receive every day. These newspapers were selected because they have national coverage aimed at the general public and allow the longest feature articles. All relevant feature articles on research about the Internet during the period studied were retrieved. The study covers 86 feature articles from 1995 to 2012. The author wrote one of the feature articles; however, it was not included among those selected for more detailed study.

A previous study of 85 feature articles written by researchers from the University of Oslo in the period from 2002 to 2003 indicates that about 80% of the feature articles have 'research-based argumentation' (UiO, 2004: 9). The remaining feature articles were mainly related to university or science policy. Research-based argumentation in its more popular form is a type of argumentation that, among other things, incorporates one's own or others' research into the text to support the arguments (Latour, 1987). Although the feature articles were connected to current issues, they were marked by the researchers' disciplines (Løvhaug, 2011). Thus, for the present study, feature articles with research-based argumentation were selected.

The requirements for qualifying a feature article as communicating research about the Internet applied criteria corresponding to those Bader used in her case study of research articles (Bader, 1990). Her criterion was that roughly half the article should discuss the object of her study. For this study, the criterion was that the Internet should be a central theme in the feature article. This meant that, as a rule, at least half the feature article took up one or more sets of prospects or problems concerning the Internet. Studies of Norwegian PCST for the period from 1998 to 2000 have estimated that each university faculty member wrote an average of 2.1 self-reported popular articles and made 1.4 self-reported contributions to public debate (Kyvik, 2005). However, during the selection of feature articles for further study, it was more or less impossible to distinguish between popular articles and contributions to debate, since most of articles were a combination of both. If shorter letters to the editor had been included, it would have been easier to identify contributions to debate that were not also popularizations (Hetland, 2002).

Eighty-six digitized feature articles were collected from the database Atekst/Retriever and coded with the help of HyperRESEARCH, a program for Computer Assisted Qualitative Data Analysis (CAQDAS). HyperRESEARCH is useful for organizing, managing and analysing a textual corpus of this size. It is crucial to remember that the thematic focus of the selected feature articles is a result of both the messages that the researchers wish to convey and the editors' selection process. In this paper, the focus will be on the actual texts. Each feature article was coded several times to test hypotheses and facilitate a repeating comparison of the texts gathered (Hesse-Biber & Dupuis, 2000). Writing up the two presentations 'Technological Change as Continuous' and 'Technological Change as Discontinuous' enabled the sorting of cases and selection of typical and illustrative text elements for the analysis. In Norway, the concept of PCST includes communication of the social sciences and humanities. The author did all translations from Norwegian to English.

During the period studied, three large research programmes from The Norwegian Research Council framed much of PCST activities deriving from information and communication technology (ICT) research. These programmes have been crucial in setting the agenda for communicating research about the Internet and its relevance to Norwegian society. The first programme was the Social and Cultural Preconditions for ICT (1998–2002). Among its objectives was 'to develop knowledge and expertise improving public policy and the policy of industry concerning new ICT' (NFR, 2003: 4). The second programme was Communication, ICT and Media (2003–2007). This programme called for research to be 'action-oriented and contribute to policy making and public debate, providing input to the regulation, organization and coordination of ICT, telecom and media policy' (NFR, 2002: 8). The third programme was Core Competence and Value Creation in ICT (2005–2014). One of its objectives was to produce 'research results that are used by trade and industry and that benefit the development of society' (NFR, 2010: 5). All together, these three programmes have funded close to 400 projects, thereby strongly influencing the agenda of research about ICT and the Internet and, consequently, PCST within the same field.

Technological Change Communicated

The number of feature articles varied over time. Figure 1 illustrates the timeline pattern of feature articles communicating research about the Internet.

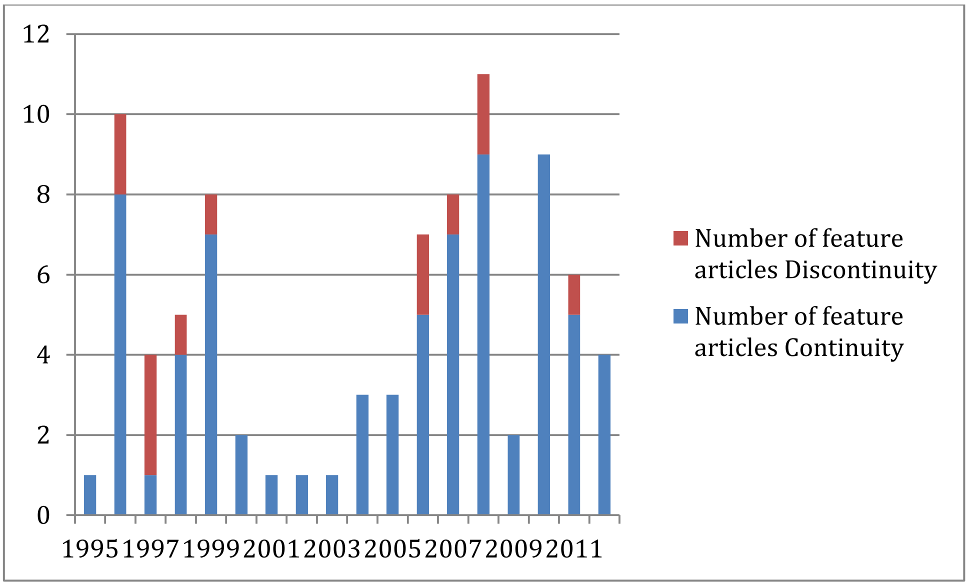

Figure 1. Number of feature articles from 1995 to 2012.

Two waves are identified. The first wave indicates the novelty of the Internet, while the second wave indicates the arrival of two new topics: social media and gaming. However, this paper aims to study master narratives not issue-specific narratives.

Popularization is done by presenting stories using a wide variety of elements. Some stories may contain all of these elements, and all stories contain some of these elements. The 86 feature articles have one or several authors and a total of 104 authors (counting repeat authors every time they appear). Of the total group of authors, 22.1% are from the science, technology, engineering and mathematics (STEM) disciplines, including medicine; 68.3% are from the social sciences and humanities; and 9.6% are from law. Furthermore, 80.8% are men, while 19.2% are women. Finally, 77.9% are from the higher education sector, including all universities and university colleges, while 22.1% are from the institute sector or other independent institutions. Chaperones are enrolled in the texts, and each feature article has an average of 3.6 chaperones. The chaperones mostly consist of references to scientific texts, in addition to research projects, policy papers, politicians, 'the man on the street' and other participants in the public debate. Policy and politics are made relevant. However, it was clear from the first reading that, in general, researchers are rather soft-spoken when it comes to giving policy advice.

In the following sections, this paper will examine how the popularization is handled when technological change is understood first as continuous and second as discontinuous. The feature articles are classified into one of these two understandings depending on how the authors framed technological change in the actual texts. About 85% of the feature articles framed technological change as continuous, while about 15% framed technological change as discontinuous.

Technological Change as Continuous

The first feature article in the sample that discussed the Internet was published in December 1995. Under the heading 'The Internet Is Far from Indispensable' (*Aftenposten,* 13.12.1995: 15), the two authors, both from the Department of Informatics at the University of Oslo, set out to 'dispel the myth that if you as an individual are not connected to the Internet, you will be left behind in society'. Authors adhering to continuity contrast their understanding with the understanding of technological change as discontinuous. One well-known participant in this debate stated in his feature article that 'In many comments, it may seem as if one perceives the Internet as a kind of volcanic land mass that blows up in international waters, a terra incognita where no law prevails, a kind of cybernetic counterpart to the lawless, Wild West. This is incorrect' (*Aftenposten*, 27.09.1996: 15). Within this understanding, the Janus face of technology is highlighted. On the one hand, the Internet represents new digital divides and facilitates different sorts of addictions and criminal acts. On the other hand, it is represented as important to use the Internet and to allow it to become a part of our literacy and institutions. The actors who use the Internet are understood as democratic participants, and there is a clear distinction between actors and artefacts. Some actors constitute a threat to democracy and to other users who follow social norms and Norwegian laws and regulations. However, these rules also apply to 'villains' and the 'addicted'. New technology and digital literacy are increasingly used to regulate and control activities on the Internet and to handle different types of risks and challenges. All in all, it is the social life of 'real life' that is important within the continuity perspective.

Within this frame, it is important that all citizens participate and have access to the public sphere and are not 'duped by experts' fuzzy speech' (*Dagbladet*, 10.12.1996: 42). Open access to information is therefore vital. Since participation in public dialogue is important, several contributors emphasized that we are in no hurry to innovate because 'as long as we try to be the very first in technological change, we have no way to take a break, and we end up as slaves instead of innovators' (*Dagbladet*, 25.08.1998: 3). The importance of expertise is often highlighted in the continuity argument, describing various challenges such as different types of addictions, crime, violence, parental regulation and control, access to information, information overload, commercialization, old and new monopolies, intellectual property rights and user-unfriendly solutions. This view emphasizes the need to develop our expertise to handle these challenges both as users and as a society. Criticising the technophiles is crucial, but public authorities do not do enough to face these challenges and to understand and solve the problems. On the one hand, the 'Internet amplifies, makes invisible and promotes the power of the cultural elites' (*Dagbladet*, 27.11.1999: 52), while on the other hand, our politicians 'confess a lack of knowledge' (*Dagbladet*, 19.04.2005: 38). New solutions should be user friendly; however, they are often the opposite. For example, the government is criticized for making its new public information service a 'flop'. One author claimed that the government 'should find its place on Facebook' where the users are (*Dagbladet*, 13.10.2007: 48).

This view understands the risk of the Internet along a continuum from 'the Net is not as dangerous as many believe' (*Aftenposten*, 02.01.2004: 12) to 'the threat of a massive cyber-attack represents in many ways the quintessence of a global risk society' (*Aftenposten*, 13.12.2004: 8). Innovation, policy and politics are often introduced as conflicting issues such as freedom and/or control, intellectual property rights and/or open access, and information and/or knowledge. Often, the author does not provide any concrete answer and instead appeals for more debate and more democracy. Society may also lack the necessary knowledge (or research) to make good decisions. Sometimes, the author provides more explicit policy advice, such as the need for more user-friendly technology, the need for more parental involvement, the importance of skilled use of cryptography and the improvement of digital literacy. However, the policy advice provided is rather general and allows for a wide range of options. Underlying these proposals is the possibility of concretizing the policy options through a democratic process. Each feature article of the continuity type has an average of three chaperones enrolled in the texts.

Technological Change as Discontinuous

Authors adhering to discontinuity contrast their understanding with the understanding of technological change as continuous. Within discontinuity, opposing views are examples of technophobia that 'permeates Norwegian society, and makes us unable to meet the challenges of the digital revolution' (*Dagbladet*, 29.02.1996: 34). Young people play an important role within this understanding, as they represent change and the future, and although they may become seduced and addicted, they generally represent positive values and constitute a 'media lab for the future' (*Dagbladet*, 17.02.1997: 41). Here, technological change is understood as a series of revolutions. The revolutionary aspect means that the frames of reference and rules change significantly. According to one author, 'Modernity's relatively stable representation of identity is no longer adequate when the subject is played out in cyberspace. It is not fruitful to adopt an extremely optimistic or pessimistic attitude.… Information technology is decisive and penetrating – but the man on the street uses information technology in his own way' (*Dagbladet*, 15.03.1996: 34). Enrolment of actors is done by statements such as: 'We are becoming citizens of the new Net community. We are all cyborgs (a mixture of human and machine) in love with our prostheses: computers, the Internet, and virtual reality', and 'Those who can navigate the electronic highways will be the winners in the information society' (*Dagbladet*, 29.02.1996: 34). Consequently, the boundaries between actors and artefacts become blurred, and the artefacts become prostheses for the actors. Opposing actors are perceived as 'Gutenberg's agents', promoting out-dated understandings. Within this framework, social life unfolds in cyberspace, and the users make their own rules.

Within this framework, the users are the experts who acquire their expertise by being active on the Internet. They 'are not only innovators, but cultural shepherds' (*Aftenposten*, 22.07.1998: 11). Expertise is constituted by use and activity. To understand technology use, one must look to young people. New types of expertise are crucial, and young people are the forerunners in this respect. The researcher's role is to interpret the challenges we are facing, and the establishment is the target of criticism. ICT research is too technically oriented, and we lack competent people to handle the interface between users and technology. It is therefore important to partake in the development of the new society 'by speculating about the kind of society that emerges ... [as] there is less danger of being overwhelmed when the questions arise in their full potential' (*Aftenposten*, 31.08.1997: 11). The different publics are not only users, but also producers within this new regime, and new skills are becoming more important. Statements such as, 'We must learn to navigate the culture's digital field' (*Dagbladet*, 29.02.1996: 34), 'the man on the street uses information technology in his own way' (*Dagbladet*, 15.03.1996: 34) and 'learning in the information society should be oriented towards a communicative competence and emphasize transformation, change and complexity' (*Dagbladet*, 17.02.1997: 41) imply the responsibility and creativity of users and indirectly imply the importance of the users' 'digital literacy'. The incentive is that new skills and competence might create competitive advantages. Young people are innovators and are often made into pioneers in a (post)modern society in which participation is important. The authors approach to innovation is marked by statements such as 'www might be a killer application' (*Dagbladet*, 15.03.1996: 34). An average of 6.9 chaperones are enrolled in the text of each feature article of the discontinuity type.

Discussion

This paper set out to explore how researchers compared with journalists popularize Internet issues. The most important conclusion is that researchers situate their popularization in research-based argumentation framed by two opposing understandings of technological change, while journalists situate their popularization in argumentation framed by two opposing understandings of technological expectations. So while most researchers emphasize 'facts' as modest witnesses, journalists emphasize expectations, as media witnessing is not only about reporting on observations, but also about interpreting them. These two different 'world views' also lead most researchers to emphasize continuity while most journalists emphasize what is going to happen. Consequently, researchers' communications about research are quite modest and strongly influenced by continuity. Most researchers seem worried about the narratives promoted by journalists (and some of their colleagues) and many see it as their mission to present a more sober picture of technological change. Their modesty is primarily not gained by what they know, but by all they know they don't know. However, some of the researchers adopt more 'journalistic approaches' in their popularization activities, particularly regarding the understanding marked by discontinuity. This might, however, also represent a move away from purely 'reasoned arguments' and towards a more engaging discursive practice (Davies, 2014). In general, it seems that while journalist dramatize, researchers try to avoid over-dramatizing (Carlsen et al., 2014; Ryghaug, 2006). However, this is a too simplistic portrayal of the difference. Following the earlier theoretical discussion, the findings might be illustrated as in Figure 2.

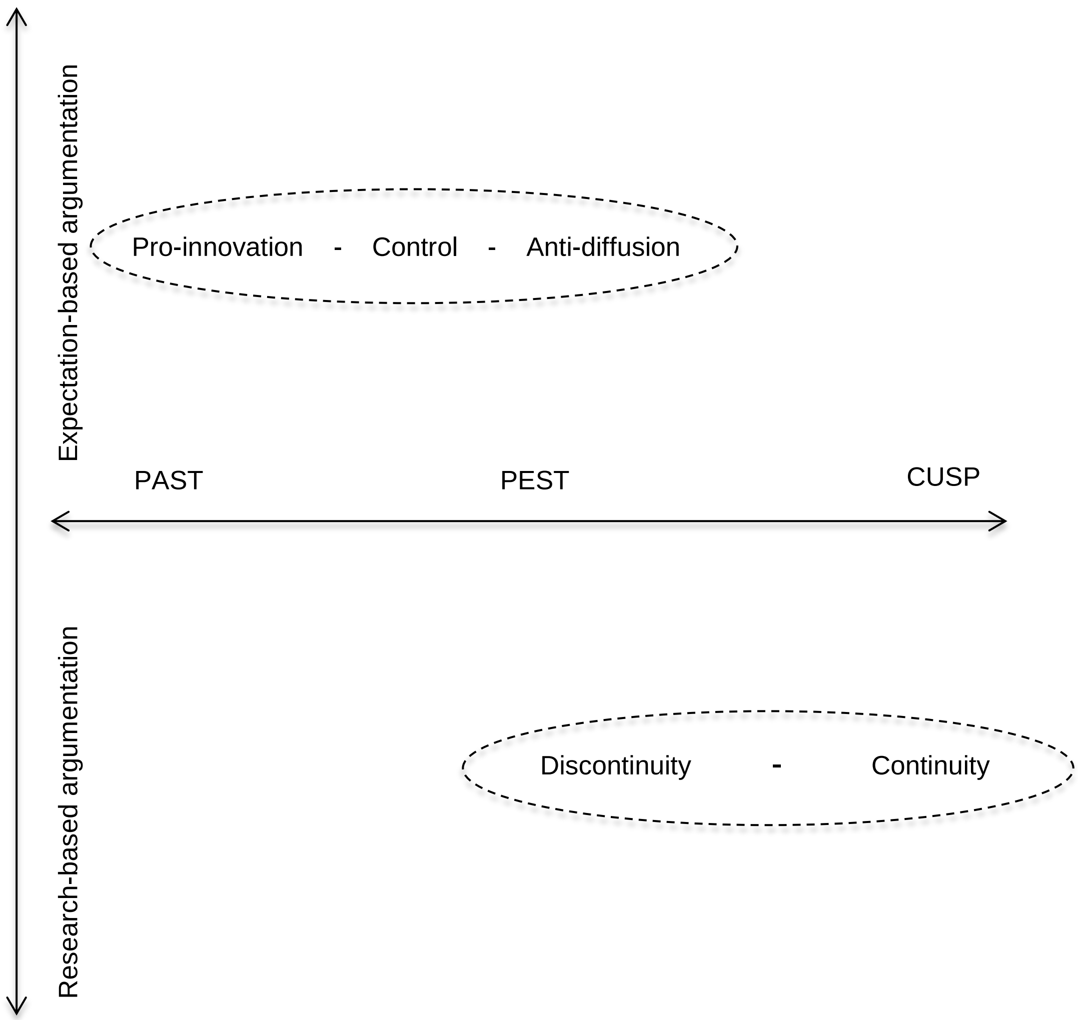

Figure 2. The technology popularization field.

The technology popularization field is structured in two dimensions: (1) from public appreciation of technology (PAST) via public engagement (PEST) to critical understanding of technology in public (CUSP) and (2) from expectation-based argumentation to research-based argumentation. While most journalists' contributions are situated closer to expectation-based argumentation, most researchers' are positioned closer to research-based argumentation. Within the trichotomy of pro-innovation, control and anti-diffusion, most journalists position their contributions close to the PAST-model (the pro-innovation position), while some journalist position their contributions closer to the PEST- and CUSP-models (the control position). Along the dichotomy of discontinuity and continuity, most researchers position their contribution closer to the CUSP-model (continuity), though some researchers position their contribution closer to the PEST-model (discontinuity). One may consequently claim that mediatization processes are primarily driven by the media and not researchers.

Most researchers attempt to curb the mediatization processes and do not aim for visibility for its own sake (Goodell, 1977); they are primarily concerned with communicating both reliable and socially robust knowledge (Nowotny et al., 2001). Consequently, the role of modest witness seems to be a crucial part of the professionalization of the research profession, and the 'authority of the modest witness paradoxically stems from the appearance that authorship itself disappears' (Leach, 2011: 189). The strong standing of the role of the modest witness also makes the CUSP-model the natural choice in science and technology communication. Including law, 77.9% of the researcher/authors are from the social sciences and humanities, and this certainly does not reflect the number of active researchers within the field. Either social sciences and humanities are more likely to be selected by editors, or they are simply more active in popularizing research and partaking in public debate. Another possible interpretation is that the modest witness has an even stronger stance within the 'hard sciences', and that being silent is the ultimate expression of this modesty. The fact that the social sciences and humanities, including law, are more active in science and technology mediation, interpretation, dissemination and explanation activities is an important development in recent years. When it comes to communicating every-day technology compared with science, one aspect of witnessing may easily be overlooked. Both journalists and researchers are witnessing the diffusion of a new technology into society, and at the same time they are using the technology in question. This double perspective on witnessing may frame which questions are asked (Hetland, 2002) and how the two faces of witnessing are put into play.

The two dominant understandings of technological change direct PCST along two different trajectories, and, as Pfaffenberger (1992) claims, we experience a discourse of technological 'statements' and 'counterstatements' (285). The most important distinctions between the continuity and discontinuity frames are found in their rhetorical approach toward technological innovations and their diffusion. While continuity emphasizes Internet participants as users and citizens in a deliberative democracy, discontinuity emphasizes them as pioneers and producers contributing, collaborating or co-creating the new future. While continuity most clearly allows for a more critical understanding of technological change, discontinuity is usually positioned closer to public engagement with technology when it comes to understanding technological change. Green (2004) outlined a model of the rhetorical theory of diffusion of innovations that emphasizes the number of justifications and the level of 'taken-for-grantedness' supporting technological claims. Over time, the number of justifications decreases while the level of taken-for-grantedness increases (Green, 2004: 656). One interpretation of this might be that when the 'revolution' and 'transition' become facts, what remains is normal science and puzzle-solving (Kuhn, 2012). However, this model must be understood in a given context. If, in their own view, the insiders promote an approach to diffusion of innovations that is controversial, the need for justifications is stronger. The discontinuity approach is more radical than the continuity approach, and resistance to it may be experienced as stronger. Insiders will therefore use stronger rhetorical tools to justify their claims by referring to more chaperones supporting the claims made. Thus, those arguing for continuity enrolled an average of three chaperones per feature article, whereas those arguing for discontinuity enrolled an average of 6.9 chaperones per feature article. A similar difference was found between the master narratives of pro-innovation and control in journalists' articles (Hetland, 2015), although it was not as distinct as the difference between the researchers' texts. Especially those arguing for discontinuity present the readers of feature articles with arguments supported by a network of actors and artefacts. The chaperones bear witness to the claims made by both researchers and journalists.

As previously mentioned, utopian master narratives containing the pro-innovation position characterized 68.7% of the journalistic stories, and the technology-as-risk master narrative containing the control position characterized 31.3%. The dichotomy in researchers' portrayal of research about the Internet was instead marked by how to understand technological change. About 85% of the feature articles characterized technological change as continuous, while about 15% characterized it as discontinuous. The third master narrative, the dystopian master narrative containing the anti-diffusion position, was not found in this study among either journalists or researchers. The conflict between continuity and discontinuity is most apparent when a new issue-specific frame arrives; consequently, discontinuity flourishes when it can ride a new wave of innovation. Researchers that adhere to continuity use discontinuity as their counter frame, emphasizing that the competing master narrative represents a problem and/or misunderstanding and vice versa. Thus, the rhetoric used in diffusion of innovations may also be perceived as an important element in what Rogers (2003) called the knowledge and persuasion stages. At the 'knowledge stage', the individual is 'exposed to the innovation's existence and gains an understanding of how it functions', while at the 'persuasion stage', the individual forms a 'favorable or unfavorable attitude towards the innovation' (169). Apparently, the role of the *less* modest witness is more easily played both by journalists (Hetland, 2012) and by researchers at the knowledge stage, while the role of the modest witness is played at all stages and increases in strength towards the confirmation stage.

Competing for grants from The Norwegian Research Council, researchers may see the role of a modest witness as important for success as professional researchers, because feature articles not only communicate downstream (towards the more 'popular' publics), but also upstream (towards fellow researchers and the actors shaping the scientific research agenda). According to

Haraway (1997), the modest witness offers epistemological and social power to those who embody it, including recognition and ultimately public funding for research. However, 15% of the feature articles were framed in a less modest way. One reason for this may be that there is no consensus among researchers about the importance of the modest witness. Some researchers may perceive it as important to be less modest, simply because they find what they describe as 'technophobia' problematic, they see the new technology as decisive and believe it is important to partake in the development process in a more radical manner. As with the rationale behind the modest witness, one can also claim that being a less modest witness might pay off for those competing for research grants and research contracts from other public entities as well as the private sector. This is especially true since the field of Internet and ICT research both involves more funding by actors outside the traditional academic arena as well as a greater variety of funding options within The Norwegian Research Council.

Finally, another aspect of popular science that 'troubles' some of the authors is underlined by Fleck's (1935/1979) understanding of 'textbook science', as '*[c]ertainty, simplicity, vividness originate in popular knowledge*. That is where the expert obtains his faith in this triad of knowledge. Therein lies the general epistemological significance of popular science' (115, emphasis in original). Popular narratives may consequently be perceived as a battle between different views about what's going to count as valid knowledge. Thus, some researchers are troubled by researchers acting as modest witnesses, since the role of modest witness also might exemplify a conservative element within present academia. 'Modesty' implies a diminishment of the revolutionary aspects of technological change and the fact that some technological innovations are disruptive. Researchers adhering to both continuity and discontinuity focus on the twin duties of PCST to inform and educate while probing and criticising (Perrault, 2013). However, the polarised framing of continuity versus discontinuity hardly informs and enlightens readers about Internet innovations and their consequences.

The two different understandings of technological change also guide the need for expertise along two different trajectories. Within the continuity frame, the need for expertise is perceived as less urgent. Policy advice is therefore often limited to encouraging debate and an active deliberative democracy. Within the discontinuity frame, users' roles are perceived as more important in shaping a new technology. Yet here also researchers are rather soft spoken about specific policy advice; in this respect they also adhere to the ideal of the modest witness. Being a witness is about taking risk, and this is most apparent when giving policy advice – thus both group of researchers minimize risk taking. Reading the three research programmes' emphasis on policy development, the space for being less modest is most likely larger than either group of researchers has taken on-board.

The CUSP model aims to inform and criticise; however, sometimes the critical approach creates barriers to a more informed learning process. Consequently, the critical approach must be matched with a more constructive approach that gives the reader a better understanding of technological change in general.

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[i] Personal communication with the two editors.

Study V

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The User Paradox in Technology Testing

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FAGFELLEVURDERT ARTIKKEL

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English abstract

Technology testing provides arenas for interaction between users and producers. In the experiments potential user needs and user-values regarding new technology are communicated to facilitate invention and diffuse innovation. This article provides a framework for discussing how users contribute to both the knowledge and policy construction processes when participating in technology testing.

Keywords: Quasi-experiments, technology testing, users, participation.

Introduction

The sociology of testing has identified a paradox; even if users are paramount for performing the tests, their contributions are often "black boxed" (Hetland, 1996; Pinch, 1993; Woolgar, 1991). In the early 1990s, Ann Brown and Alan Collins introduced "design experiments" as a new approach for studying learning phenomena in quasi-experimental settings (Brown, 1992; Collins, 1992). I will claim that, in spite of this very important turn in the sociology of testing, the user paradox is still unresolved. In this article, I will therefore examine some experimental approaches studying learning phenomena when information and communication technology (ICT) is introduced, my aim being to contribute to an opening of the black box. Much of the experimental activity has had a quasi-experimental design since its aim has been to evaluate the effectiveness or impact of learning interventions, to design innovative learning environments, or to evaluate technology policy changes. The different experimental approaches are closely linked to the idea of the social laboratory. Callon et al. claim that laboratories may be understood as a process of translation in three stages: 1) in the first stage, the complex world is translated into the laboratory, reducing the world's complexity to a manageable scale; 2) in the second translation, the laboratory is transformed into a machine for producing inscriptions, making possible their discussion, interpretation, and mobilization in learned controversies; 3) in the third translation, the laboratory results are transported back into the complex world (Callon, Lascoumes, & Barthe, 2009). In a quasi-experimental design, the distinction between the three stages may be more blurred. Three interrelated questions are asked in this article. The first is how are users understood in different quasi-experimental traditions when it comes to user participation in the knowledge construction process? The second is how are users understood in different quasi-experimental traditions when it comes to user participation in the policy construction process? And the third is how do these understandings influence how the experimental lessons are transformed into policy and practice?

Methods

Interestingly, many relevant journal contributions have little, if anything, on the methodological issues that concern the paradox studied. Furberg formulates the problem as follows: "A negative aspect of writing articles for journals is that most journals have a very strict word limit. This often implies that the restricted amount of words is more likely to be used on the actual analyses of data instead of reflecting on the applied methods" (Furberg, 2010:64-65). Since this article aims at reflecting on the experimental method, I have partly tried to identify methodological reflections in the literature and partly applied my own framework to restudy some significant activities and approaches.

Experiments and user participation

In my own research, I have followed experimental activities for close to thirty years. In the first period, I was surprised by the willingness to invest in large-scale policy experiments, without really trying to analyze what one really learned from them. I therefore set out to analyze why many of the experiments gave such a modest return (Hetland, 1996). Learning is an important part of quasi-experiments. It may seem unnecessary and tautological to stress this point. However, as I will return to later, opportunities to profit from the learning process are often misused or neglected. What is usually the problem with many quasi-experiments is not necessarily the failure of a specific technological design or solution, but rather that the focus shifts from the learning process to a more blurred vision of new inventions and a superficial application of the diffusion of innovation perspective. This is a problem for both researchers, who do not learn how the framing of research limits the possibilities for efficient policy measures, and for the users since one of the lessons that they may derive from the project is not to participate in this kind of project again. Increasingly, public engagement with science and shaping policy is perceived as important for the knowledge and policy construction process as such, and for the dissemination and implementation activities thereafter. In Norway, the participation principle has lately become part of Norwegian science and technology policy (Hetland, 2010).

However, tests do not simply report on pre-existing facts, but, more importantly, are also mechanisms for defining and producing the traits and capacities that the tests supposedly measure. Technology testing has revealed some of the potential of new communication systems but has also illustrated that users tend to prefer the medium that experimenters suggest would be most effective for the purpose in question. We therefore experience that technology testing is an important part of the shaping of technology, making our images into reality. This may partly be understood as what Rosenthal has called the "experimenter expectancy effect" (Rosenthal, 1963). This means that the results of experiments tend to come out in a way that favours the experimenter's expectation of how they ought to come out however much he or she tries to avoid bias.

The experimenter's expectation bias also influences the explanation of failures. One way, which is usually taken by scientists who have come up with negative results, is to say that negative results illustrate that it is necessary to change how we framed the test, not necessarily what we tested. Failures, therefore, do not necessarily tell us anything about the technology, but primarily something about the test. When one discusses the long range of quasi-experiments, it is important to bear this in mind. With technology testing, the experimenters strive to make the technology comply with their expectations embedded in the tests as to how the technology should and should not perform. When the technology does not perform according to the experimenters' expectations, the experimenters often look for external reasons for the failures, not explaining the problematic construction of their own images.

Inspired by what Callon et al. (Callon, 1999; Callon, et al., 2009) call the double delegation, and Bucchi's (Bucchi, 2009) aim to map public participation in science and technology, I will offer a map of how to understand participation in different experimental traditions. The first delegation, according to Callon et al., implies secluded research, and the second delegation delegative democracy. To open up both science and democracy, Callon et al. call for experimental activity in hybrid fora. The different experimental approaches are not necessarily hybrid fora; however, I find it useful to view them with respect to the double delegation. The first axis of the diagram (see Figure 1), therefore, plots the extent to which participants in the experiments contribute to the knowledge construction process; while the second axis of the diagram plots the extent to which participants in the experiments contribute to the policy construction process. The mapping does not indicate intrinsic qualities of the different methodological traditions, but rather my interpretation of how some key authors perceive these approaches. This is important since, where end-users have an active role to play, their function is usually, according to Hartley, one or more of the following: to act as "guinea pigs"; to perform research and development (R&D) and undertake innovation; to become informed about IT; to be the primary subject(s) under study (Hartley, 1987). Similarly, Brown states that, in strictly controlled laboratory settings, the learned theorist is prepared to work with "subjects" (like rats or children!) (Brown, 1992:141). This is a shortcoming that design experiments are designed to overcome; she, therefore, contrasts laboratory contexts with classrooms. Rasmussen has a slightly different approach to participation and shows how the pupils took part in the activities and how "teachers authored the pupils' locus of agency to pursue their interest and to redefine the task" (Rasmussen, 2005:182). She describes and analyzes participation with three concepts: authoring, positionality, and improvisation. The three concepts are of central importance; "otherwise participation as a metaphor for learning can easily become the same as 'going with the flow', and empty jargon that offers little insight into the selections that individuals make, what they do, the dynamics that people in interactions create and how paths are formed" (op. cit. 225). According to Rasmussen, authoring shows how social practice is constructed and maintained; positionality shows the dynamic of social interactions and how this relates to participants' joint construction of knowledge and understanding; and finally, improvisations increase analytical sensitivity toward change (op. cit. 224). The freer the participants are to play out authoring, positionality, and improvisation, the stronger their participation in the knowledge and policy construction processes.

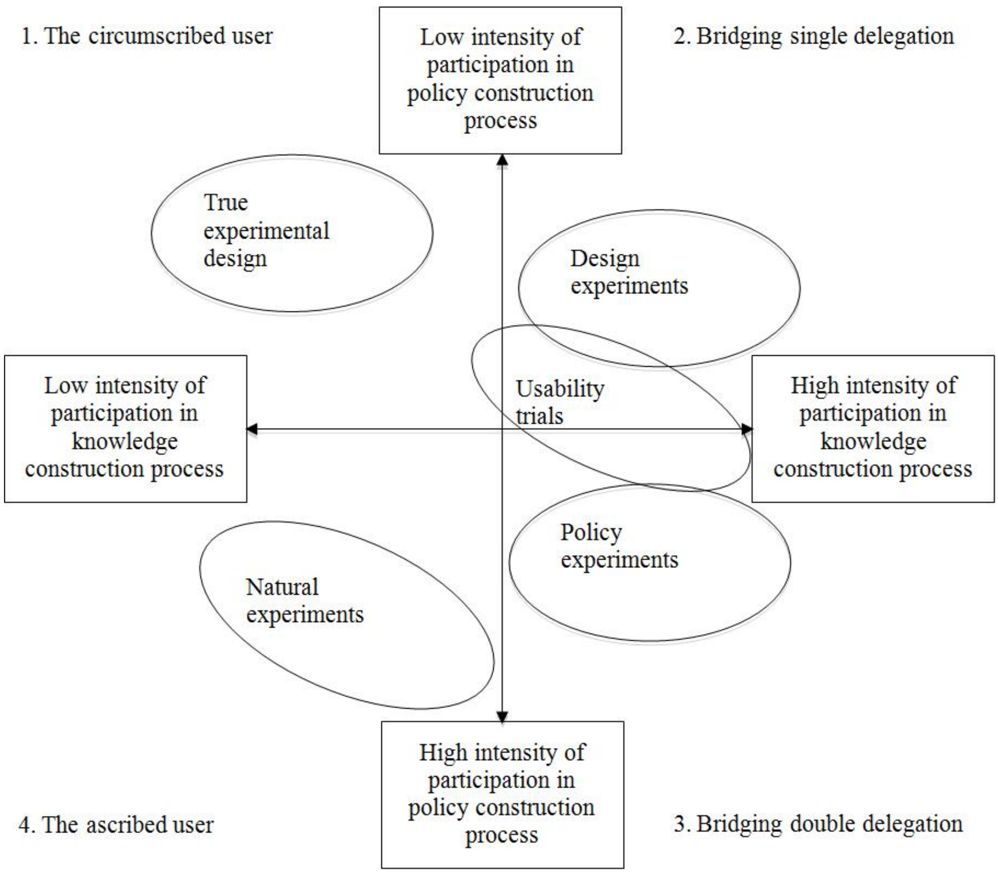

Figure 1. A map of user participation in experimental activity

In the upper left quadrant, titled "the circumscribed user" (Akrich & Latour, 1992), one finds true experimental design, with strict limitations for the participant to play out authoring, positionality, and improvisation. The researcher or experimenter controls the knowledge construction process, and the distance between research results and policy and practice is possibly never overcome. In the upper right quadrant, titled "bridging single delegation," the participants are increasingly involved in the knowledge construction process; however, they are, to a very limited degree, involved in the policy construction process (at least not in the context of the experiment). With this, the participants are given opportunities to handle the first delegation. In the lower right quadrant, titled "bridging double delegation," the participants are increasingly involved in the knowledge construction process and in the process of policy construction. With this, the participants are given opportunities to handle the first and second delegation. In the lower left quadrant, titled "the ascribed user" (Akrich & Latour, 1992), there is no planned experimental activity; however, users partake in the activity of the setting through an attribution process whose origin is in the setting itself (the ascribed user may take an active part in the policy construction processes later on).

1. The circumscribed user

True experimental design in the social sciences is in many respects similar to laboratory traditions in the natural sciences. When Callon et al. claim that laboratories may be understood as a process of translation in three stages, the authors refer to laboratories working in a true experimental design tradition. We already know from more anthropological studies of laboratory life that research within this tradition may be messier than was thought at the outset (Knorr-Cetina, 1981; Latour & Woolgar, 1979; Law, 1994). In an informative article about the relationship between experiments and laboratories in science, Knorr-Cetina emphasizes that there are at least three features of natural objects that a laboratory science does not need to accommodate. Firstly, it does not need to put up with the objects as they are; it can substitute all of its less literal or partial versions. Secondly, it does not need to accommodate the natural object where it is, anchored in a natural environment. Laboratory sciences bring objects home and manipulate them on their own terms in the laboratory. Thirdly, a laboratory science does not need to accommodate an event when it happens; a laboratory science does not need to put up with natural cycles of occurrence but can try to make them happen frequently enough for continuous study (Knorr-Cetina, 1992:117). With this "liberation" from nature, laboratories are able to create their own world, and thereby enhance the symbolic value of the laboratory.

The laboratory as a symbol is recognized not only by social scientists but also by the politicians who promote technology testing. In the way in which technology testing is set up, the tests involve negotiations and translations of interests of political as well as cultural relevance. Because of this heterogeneous mixing network of humans and non-humans, facts and artefacts, fiction and reality, technology testing is an analytical challenge to social science. Testing is, therefore, an important area upon which to focus because testing can be seen as the attempt to specify formally and identify how the technology will perform, is performing, or has performed. Thus, testing is a test case of the new sociology of technology (Pinch, 1993). True experimental design is commonly used in the physical sciences; for the social sciences, experimental designs can be more difficult to set up. However, they are used extensively in some disciplines or traditions.

2. Bridging single delegation

Callon claims that there is a great divide between specialist and non-specialist, and that it is important to find a way to bridge this gap (Callon, 1999). Ann Brown was trained as a "classic learning theorist prepared to work with 'subjects' (rats, children, sophomores), in strictly controlled laboratory settings," however exploring innovative alternatives to this classical approach circumscribing the user (Brown, 1992:141). At the same time, Collins identified a need "for approaches to the study of learning phenomena in the real world rather than the laboratory" (Collins, Joseph, & Bielaczyc, 2004:16). Therefore, feeling the need for a new approach, Ann Brown (1992) and Allan Collins (1992) coined the term "design experiments". In relation to educational research, Brown understands design experiments as an "attempt to engineer innovative educational environments and simultaneously conduct experimental studies of those innovations" (Brown, 1992:141). In other words, they contrast design experiments with true experimental design. Design experiments have some fundamental limitations, since "they are carried out in the messy situations of actual learning environments, such as classrooms or afterschool settings, there are many variables that affect the success of the design, and many of these variables cannot be controlled" (Collins, et al., 2004:19). According to Collins et al., "design research should always have the dual goals of refining both theory and practice" (op. cit. 19). They also underline that they use design experiments to get the detailed picture needed to guide the refinement of a design. Large-scale studies of educational interventions (often policy experiments) are interesting but are seldom tied to any particular design, according to Collins et al. (op. cit. 21). Some authors recognize that design experiments draw upon traditions such as action research, however, claiming that design experiments do so while "retaining the benefits and minimizing the drawbacks of an experimental approach to educational research" (Gorard, Roberts, & Taylor, 2004:580). Krange and Ludvigsen call Brown's (1992) interpretation of design experiments the 'mainstream interpretation' (Krange & Ludvigsen, 2009). They "argue that this line of interpretation is similar to laboratory-oriented experiments, in that …, the context is taken into account without actually being included as part of the unit of analysis" (op. cit. 269). They propose building the context into the premises of the analysis and argue "the importance of considering design experiments, at least on some occasions, as historical and situated" (op. cit. 276). Krange, in her PhD dissertation, states that, if necessary, she will go "beyond the borders of the design experiment and include the longer historical lines in which this is a part" (Krange, 2008:68-69), and claims that "neither the processual orientation nor the situation-specific interactions is sufficiently elaborated within the design experiment tradition" (op. cit. 70).

Several of the design experiments are influenced by Vygotsky and his ideas about double stimulation as a basis for formative interventions. Engeström argues that "double stimulation is radically different from such intervention approaches as the *design experiments* currently discussed in educational research. Double stimulation is, above all, aimed at eliciting new, expansive forms of agency in subjects. In other words, double stimulation is focused on making subjects masters of their own life" (Engeström, 2007:363). He criticizes the mainstream interpretation of the methodology of design experiments as "basically a linear progression of six steps" (op. cit. 368), and in response to these limitations, he proposes the change laboratory as an application of double stimulation. In line with this proposal, the researcher also becomes an interventionist. The study of interventions is, therefore, important, strongly influenced by the socio-cultural perspective on learning, cognition, and development. This shift of focus, from design experiments at large to interventions, is interesting. On the one hand, authors often discuss design experiments in general; on the other, interventions are in focus when being more specific. I understand this shift as an expression of the dual role of the researcher and interventionist, and the need to delimit the research activity. One may say that interventions have acquired the same crucial role in this approach as crises have acquired in the actor-network approach. Experiencing crisis, according to Akrich and Latour, allows the setting to be described; "if everything runs smoothly, even the very distinction between prescription and what the actor subscribes to is invisible because there is no gap, hence no crisis and no possible description" (Akrich & Latour, 1992:261). Crises and problems are, therefore, our most important gateways to understanding what is going on. While Akrich and Latour perceive crises as happening more or less haphazardly, formative interventions are planned crises to spur subjects to master their own lives. However, the strong focus on more specific interventions may lead to the neglect of some important features of the overall experimental setting and later limit the transformation of experimental lessons into policy and practice. One may claim that the 'design experiment' tradition, be it mainstream interpretations or alternative interpretations, includes the participants in the knowledge construction process; however, understanding how experimental lessons are transformed into policy and practice is still a challenge.

Parallel to design experiments, usability trials were performed by technology and service providers. Usability trials were favoured for a number of reasons: they were cheap and easy to manage, and growing privatization and the entry of a competitive market made secrecy more important and made it necessary to focus on specific design issues (Hetland, 1996; Pinch, 1993; Woolgar, 1991). I have first-hand knowledge of two examples, a usability trial with distance education in rural Norway (Hetland, 1999) conducted by Norwegian Telecom and a usability trial to aid the visually impaired to communicate using the Internet (Hetland, 2002) conducted by the Norwegian Central Information Service. In the first trial, it became clear that metaphors are important framing devices. If you frame distance education as 'the virtual classroom,' this will guide what is tested and what is not. The metaphor 'the virtual classroom' is from the same field as the solutions with which one is working; the metaphor, therefore, leads to a concentration on incremental innovations. Norwegian Telecom argued that it was necessary to focus on incremental innovations since the users would not buy a product that they did not recognize. In the second trial, one experienced the difference between hot and cold situations (Callon, 1998). In cold situations, it is easy to identify actors, interests, preferences, and responsibilities. In hot situations, most things are subjects of controversies, and these controversies are an expression of the fact that the participants have no stable basis of common knowledge and insight upon which to agree. Quasi-experiments in hot situations are, therefore, demanding activities for experimenters and participants, and the lessons learned from these situations are perhaps best understood as a contribution to a more informed policy discussion between different stakeholders. With the above-mentioned experiment as a starting point, the Norwegian Central Information Service managed to embark on an important policy process concerning universal design. However, as Woolgar illustrates, usability trials may also configure and thereby shape the user whom they need for the test (Woolgar, 1991). Usability trials may, therefore, also be looked upon as tests in which not only the technology but also the inscribed users are tested. This is because the manufacturers cannot be sure that the users will be able to do what is required of them. So "what is at issue in such tests is not so much the projection from 'test' to 'actual use' of the machine, but the projection from test to actual use of the user!" (Pinch, 1993:36). Or, one might add, "The manufacturers' perception of users as consumers" (Mallard, 2007). My claim is that usability trials may give the users possibilities similar to design experiments; however, the tradition is less rigorous and does not have the same aspiration to refine theory.

3. Bridging double delegation

Callon claims that the double delegation experiences crises. We therefore need strategies to bridge the double delegation. During the 1980s, an important methodological concept was 'field trials' (Mathisen, 1987). Since several of the field trials were large undertakings involving a heterogeneous set of activities with the aim of shaping technology policy, many of the field trials were actually 'policy experiments' (Rondinelli, 1993). Rondinelli understands policy experiments as a "messy" undertaking that shall "facilitate continuous learning and interaction, allowing policy-makers and managers to readjust and modify programs and projects as more is learned about the conditions with which they are trying to cope" (Rondinelli, 1993:18-19). Policy experiments are usually perceived as playing four different roles in the innovation process (Hetland, 1996; Miles, Rush, Turner, & Bessant, 1988; Rondinelli, 1993):

1. They can be *explorative experiments*. Their most important benefits derive from the acquisition of knowledge. They help the researchers define problems, or more useful ways of coping with the problem of "needs," exploring different possibilities for interventions, and, finally, showing how experiments at a later stage should be operated. The most characteristic feature of explorative experiments is, therefore, their usefulness at a very early stage of learning: when we know the least about all the possible implications and by experimentation enhance our knowledge and thereby lower the risk of innovating.
2. They can be *pilot experiments*, raising public and industrial awareness, stimulating debate and open policy-making. Thus, pilot experiments can perform important functions (Rondinelli, 1993:99): they can test the applicability of innovations in places with conditions similar to those under which the more explorative experiments were performed, they can test the feasibility and acceptability of innovations in new environments, and they can extend an innovation's range of proven feasibility beyond the experimental stage.
3. They can be important *demonstration experiments* in the dissemination and diffusion of the uses and implications of information and communication technologies. The main purpose of demonstration experiments is to show potential adopters how they may benefit from the innovations. Thus, although demonstration projects may evolve from explorative experiments and pilot projects, these experiments might also be designed especially to promote the adoption of a specific innovation.
4. They can be typical *replication or dissemination experiments* to disseminate tested methods, techniques, or models through replication, or full-scale implementation of a specific technological solution.

As mentioned earlier, Krange and Ludvigsen (2009) criticized design experiments for not including the context as part of the unit of analysis. Studies of policy experiments face a similar challenge. I will propose frame analysis as one possible strategy (Goffman, 1986). Actors do not act in a vacuum; they act in a context. Frames are, therefore, the context that one applies to organize involvement as well as meaning: any frame imparts not only "a sense of what is going on" but also "expectations of a normative kind as to how deeply and fully the individual is to be carried into the activity organized by the frame" (op. cit. 345). The frame represents clusters of rules that help to constitute and regulate activities, defining them as activities of a certain sort and as subject to a given range of sanctions. Perception is organized, he claims, into natural and social frameworks. The natural frameworks identify occurrences seen as undirected, inanimate, and unguided. The social frameworks provide the background for understanding events that incorporate the will, aim, and controlling effort of intelligence, a live agency, the chief one being the human being (Bateson, 1973). Goffman, therefore, includes the inanimate and the animate, the natural and the social in the creation of frames.

A frame thereby provides the rules and principles that guide our understanding of meaning in experienced events. Framing as constitutive of, and constricted by, encounters therefore "makes sense" of the activities in which participants engage, both for themselves and for others. The framing of a test setting implies a selection of some aspects of a perceived situation to make them more salient in a test, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or policy measures for the problem described, and thereby organize involvement in the inscription-translation-reinterpretation of technology. During the activity, participants will not only obtain a sense of what is going on but will also be engrossed, caught up, enthralled, or disappointed. These feelings and experiences will be transmitted to other actors. However, "Involvement is an interlocking obligation. Should one participant fail to maintain the prescribed attention, other participants are likely to become alive to this fact and perforce involved in considering what the delict means and what should be done about it – and this involvement necessarily removes them from what they themselves should be involved in" (Goffman, 1986:346).

When it comes to the framing of test settings, we may experience multiple sets of frames during the process. However, to facilitate and simplify the discussion, I will concentrate on the problem of divergent framing – be it conflicting, competing, incompatible, or compatible framing. In a study of four large policy experiments from the 1980s and early 1990s, Hetland concluded that "the framing of tests is essential to the understanding of how tests are constituted, the framing of actors is essential to the understanding of how actors are introduced to tests, participate in tests and finally mediate their experience" (Hetland, 1996:184). Since these policy experiments include experimenters and participants with not necessarily shared frames of reference (op. cit. 195), Hetland, therefore, looks into the issue of divergent framing and argues that divergent framing influences how actors are enrolled in tests (op. cit. 191-193) and how tests find their resolution and closure (op. cit. 199-201). The issue of divergent framing and the following negotiation and interpretation processes led Hetland to call the policy experiments hybrid communities; hybrid because the groups involved were heterogeneous, including experimenters, participators, politicians, technicians, and other internal and external actors. The experiments were also hybrid because they involved a heterogeneous set of problems and solutions in a variety of domains. The term communities was used because the experiments entangled a diverse set of actors and technology in a web of activities with changing involvement. Hetland claims, "Experiences with hybrid communities during the past 30 years have led to two fundamental discoveries. Firstly, that the anticipated results from hybrid communities were difficult to achieve. Secondly, that technology policy is not primarily founded on experience with hybrid communities, but is experimental in its very nature, and hybrid communities should thereby be looked upon as an active part of technology policy" (op. cit. 201).

Graphically, the results of a successful innovation process in the classical diffusion of the innovation model are presented as an S-shaped diffusion curve, and the adopter categories encompass the innovators, the early adopters, the early majority, the late majority, and, finally, the laggard (Rogers, 2003). The crucial issue for anyone who wishes to promote an innovation is, according to this theory, to activate the early adopters and early majority. The S-shaped diffusion curve illustrates this by "taking off" at about 10 to 25 percent adoption. However, the quasi-experiments here described are situated along the whole spectrum of the S-shaped curve. As the S-shaped diffusion curve also illustrates the increase of knowledge about an innovation, the chosen quasi-experiments apparently embody decreasing uncertainty. See Figure 2.

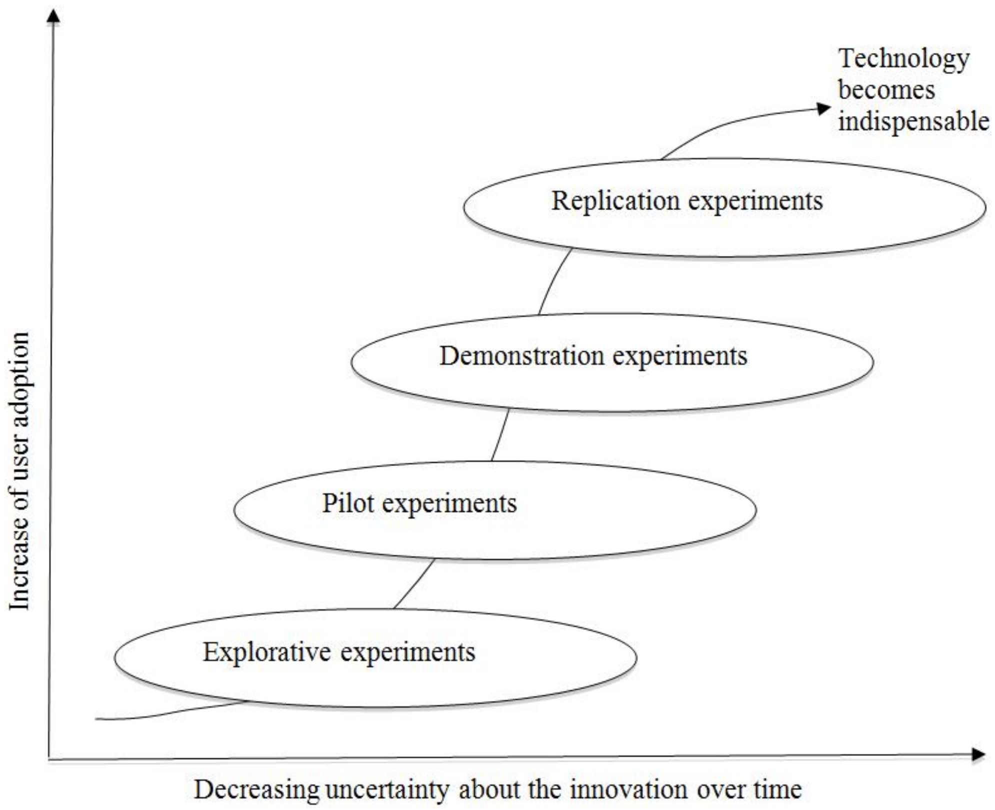

Figure 2. The arrangement of experiments (Hetland 1996:16)

Hetland concludes that not only are the artefacts translated but also the experiments. “This implies that there is a strong ‘push’ towards the end of the diffusion curve where technology becomes indispensable. By this ‘push’ the logic of the different experimental stages is easily corrupted” (Hetland, 1996:210). This push is partly a consequence of divergent framing, since the participants and the experimenters may have conflicting interpretations of what the experiments are aiming for and how to interpret the lessons learned. This leads also to a counterintuitive claim: technology push-strategies are the strategies “least” concerned with technology as such. Furthermore, when one sets out to test technology within a strategy of demand-pull, one ends up testing the ability for “inside” recruitment of new allies. The next counterintuitive claim is, therefore, that demand-pull strategies are the strategies “most” concerned with technology as such (op. cit. 226).

Possibly the largest policy experiment introducing new information and communication technology into Norwegian schools is Project Innovation in Learning, Organization and Technology (PILOT). One hundred and twenty schools were involved in the project between 1999 and 2003. This project was initiated by the Ministry of Education and Research, and the research activities were coordinated by the National Network of IT-Research and Competence in Education (ITU). (As of 2010, the ITU is part of the National Centre for ICT in Education.) This large project was originally framed as action research; however, the main aim was to encourage the participating schools to develop pedagogical and organizational approaches to the use of ICT in learning, and to participate in the dissemination of the experience gained. Innovation, diffusion, and the development of policy were important dimensions (Erstad, 2004). The summative report provides policy recommendations in general, at the national level, and concerning school development at the local level. In the book *Digital Literacy in the School* (Erstad, 2005), Erstad provides an introduction aimed at students, teachers, and school leaders. What makes PILOT extremely complex is its aim of compiling the exploration, pilot, demonstration and replication experiment into one large policy experiment lasting only four years. Even if the project may be considered as successful within this frame, it is a risky venture. One problematic issue in this policy experiment is the tendency toward a pro-innovative bias. To avoid such a bias, Rogers proposes five research strategies (Rogers, 2003:106-118). However, I will claim that the pro-innovation bias is primarily in the framing of the total activity, not that research does not examine unsuccessful innovations, rejection, or re-invention.

Building on the experience with PILOT, the Ministry of Education decided in 2004 to establish a national program for school development with ICT called 'Learning Networks' (Erstad, 2009). Until now, about 550 schools have been or are involved. In his discussion of the preliminary findings, Erstad elaborates on two issues: knowledge creation and networking. Central to the idea of knowledge creation or knowledge building is "the creation or modification of public knowledge, knowledge that lives in the world and is available to be worked on and used by other people" (op. cit. 95). A specific methodology called 'dialogue conferences' was used in the former project PILOT. "This was organised as meeting points where teachers from different schools met to present experiences of school development using ICT, reflect on these together by writing and talking, and making strategies for future developments that are brought up again at future meetings face-to-face. In between the meetings they collaborated online. Reports from the participants indicated very positive outcomes of such 'dialogue conferences'" (Lund, 2004 cited in Erstad, 2009:98). In 'Learning Networks,' this was an important tool for allowing the participants to reflect upon their actions.

The strength of policy experiments is their ability to include the participants in knowledge and policy construction. The problematic issues are primarily a tendency to pro-innovation bias and divergent framing. I will return to these issues in the final discussion.

4. The ascribed user

"Natural experiments" occur more haphazardly. That is, the assignments of treatments are made by "nature," not by "experimenters". Some of these natural experiments happen regularly and are, therefore, targets for a regular system of evaluation; for example, air transportation accidents are evaluated by different National Transportation Safety Boards. Other natural experiments have a more irregular occurrence, and if important enough, they are evaluated by the respective authorities. The aim of these evaluations is to improve technological solutions and, if necessary, the relevant policy. In Norway, there are several interesting examples within the field of ICT, studying breakdowns caused by fires or natural catastrophes. Within education, one may claim that natural experiments occur when people respond, for example, to policy interventions, regulations, or socio-economic circumstances. In these kinds of "experiments" the participants may be involved in the policy construction process.

Conclusion

In the previous text, I have outlined how user participation is understood in different experimental approaches. The third question, how these understandings influence how the experimental lessons are transformed into policy and practice, is still unanswered. This question is important, since if anything like a national schoolyard should exist, it is littered with experiments that never found resolution and closure. In this article, I have used a socio-cultural perspective or the translation model inspired by Callon and Latour. The translation model explains innovations as temporary interpretations of nature, technological potentials, strategies of competitors in the market and of the different interests. I will therefore first conclude that the chosen experimental approach is also an important element in transforming lessons into policy and practice. I will claim that the more opportunities users have to play out authoring, positionality, and improvisation, the more included they are in the transformation process from the experimental phase to policy and practice. In other words, the choice between different experimental traditions is also a choice that influences the diffusion of innovations. This conclusion is in line with Rich's understanding of knowledge utilization (Rich, 1997). Rich argues that utilization "is a process – a series of events which may or may not lead to a specific action by a particular actor at a given point in time" (Rich, 1997:17). Utilization is therefore viewed as a process rather than an outcome. "Use" however, has several connotations as Rich outlined, and he distinguishes between 1) use (information has been received and read), 2) utility (some user's judgment that information could be relevant or of value for some purpose), 3) influence (information has contributed to a decision, an action, or a way of thinking), and 4) impact (information was used and it led directly to a decision or to action) (Rich, 1997:15). These distinctions are of course significant when thinking of utilization as a process as opposed to an outcome. In a study of utilization of Norwegian research, three explanatory factors were prominent. The users had to evaluate the results as compatible with their own experience, they had to trust the quality of the research, and, finally, they had to be active stakeholders in the projects (Brofoss & Wiig, 2006). Henceforth, experimental types of interventions may be a communication strategy for speeding up the diffusion of an innovation. Very often, one perceives the innovation as dropped into a container spreading through certain channels over time among the members of a social system. This epidemic and often pro-innovative approach imagines diffusion as a shift of the demand curves caused by the spread of information from early adopters to late adopters who are made aware of the innovation by the use by early adopters. However, when entities connect to form a chain or network of action or things, they "translate or change it to become part of a collective or network of coordinated things and actions" (Fenwick & Edwards, 2010:9). The experimental activity is therefore best understood as a translation process building networks. The durability and extension of those networks are essential for the success or failure of an experiment and the dissemination process. Durable networks also imply that the actors have compatible framing of what is going on, since divergent framing easily will lead to disintegration. Finally, it is important to bear in mind that experimental activity within technology-push or a pro-innovation-strategy requires strong networks of social actors to facilitate the transformation from the experimental phase to policy and practice.

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Study VI

Hetland, P. (2011a). Science 2.0: Bridging Science and the Public. *Nordic Journal of Digital Literacy*, *6*(Special Issue), 326–339.

Science 2.0: Bridging Science and the Public

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English abstract

"Science 2.0" is still evolving; basically, it is an ongoing, "natural" experiment about a potentially novel way of participating in knowledge construction processes based on Internet applications. The topic of this article is scientific culture and organisation that interact with communities of interests outside of institutions, based on analyses of systematic biology and the mapping of biodiversity. The focus will be on the convergence of professionals and so-called amateurs involved in the production of new knowledge.

Keywords: Science 2.0, citizen science, apomediation, boundary infrastructures

Introduction

Collaborative technologies provide new possibilities for doing science and including amateurs in knowledge production. These possibilities may cause exaggerated expectations (Selwyn, 2009). Nevertheless, expectations are important for shaping the future (Brown, Rappert & Webster, 2000). Parallel with the development of collaboration technologies, policy is an important driver towards stronger emphasis on networking, sharing and communication. The participation principle is, for example, an important part of Norwegian science and technology policy. Web 2.0 and later Science 2.0 are now depicted as being novel modes of organisation and culture in scientific communities (Waldrop, 2008). Eysenbach suggests a framework of five major aspects or themes to describe Medicine 2.0 (Eysenbach, 2008): 1) Social Networking, 2) Participation, 3) Apomediation, 4) Collaboration and 5) Openness. Apomediation is a new socio-technological term that was coined to characterise the 'third way' for users to identify trustworthy and credible information and services. *Apo* comes from the Latin for 'stand by', and apomediation describes the fact that when you access information on the Internet, you can bypass the gatekeepers or any middlemen, and it allows you to go directly to the source of information, even if it is not a (previously considered) 'expert' source. The expert 'stands by' you.

This article aims to contribute to the understanding of scientific development, public participation and the possibilities for co-production of scientific knowledge, and to explore how collaborative technologies influence how we understand social networking, participation, quality assessment, collaboration and openness in science. This may be studied as a bottom-up process following in the footsteps of scientists and amateurs, or as a top-down process following the shaping of new boundary infrastructures for doing science. In order to have the possibility to include both strategies, I have chosen systematic biology and the mapping of biodiversity in Norway. Systematic biology and the mapping of biodiversity is a growing field in Science 2.0 (Hine, 2006, 2008). Over time, several constituencies of stakeholders have developed, and their activities have converged such that we may now have a new mode of knowledge production that can form the basis for an exploratory study of Science 2.0, possibly a paradigmatic case. At the same time, systematic biology and the mapping of biodiversity have engaged amateurs for as long as the disciplines have existed. Few branches of biology have felt the hand of amateurs like ornithology (Mayfield, 1979). Mayfield (1979) underlines that "Perhaps the most important contribution of the amateur, and assuredly one that will not dwindle in the years ahead, is the nurture of young scientists" (p. 170). Amateur activities among children and teenagers often lay the foundation for a later scientific career; and, of course, "Fieldwork is fun, and the public is not always able to distinguish what is purely recreational" (p. 168). The often symbiotic relationships between amateurs and professionals have also given us analytical concepts like boundary objects (Star & Griesemer, 1989). The word 'amateur' has its roots in Latin (*amator* – lover) and is used for persons practising an activity without having this as a livelihood. In everyday language, the concept is often applied to lay people or those who are self-taught. In keeping with the Latin origins of the amateur concept, amateurs may have training in the subject up to degree level. That which distinguishes them is the work that they undertake in connection with, for example, the natural history collections, and which is not their paid profession. An alternative concept can thus be 'voluntary'. In this connection, it is important to be clear about the fact that the non-governmental organisations (NGOs) in natural history organise both amateurs without any formal schooling or work association, and those with a formal education and relevant employment. That the latter group can, nevertheless, play a particularly active role in the NGOs is related to the fact that they have frequently commenced their career as amateurs and where they later have not clearly defined the boundary between professional and hobby activities. The word 'amateur' also signals a certain passion and the strength of this passion is well described by Richard Conniff in his colourful history of the early naturalists (Conniff, 2011). Within natural history, there are both 'broad' and 'narrow' amateur communities in Norway. Concerning vascular plants, this may amount to several thousand individuals, while with lichens there are possibly only 30 or so. These interest groups are important within their field of natural history in three ways: first, they make a considerable contribution of new objects to natural history collections; second, they contribute new information and quality assessment of older information in the existing parts of the collections; and third, they are important contributors of new information through the newly established Species Observation.

The changes in the relationship between the expert and different publics, policy, administration and civil society mean that knowledge and values must be renegotiated, and that expertise is both real, substantive and relational (Callon, Lascoumes, & Barthe, 2009; Collins & Evans, 2007). The Internet is one of many new arenas in which this clearly comes to expression. For the university museums, this signifies that the relationship between science and the public is changing, and that the traditional authority of science must be legitimised in a different manner than hitherto. Collaborative technologies may be used to shape hybrid spaces with heterogeneous actors and agendas, and collaboration activities may be facilitated by the development of *boundary objects and boundary infrastructures* (Bowker, 2000; Bowker & Star, 1999; Star, 2010; Star & Griesemer, 1989). These terms help us to establish a theoretical process-oriented perspective on how negotiations and competition for different interpretations and practices within a given 'hybrid space' take place. Boundary objects refer to elements that link various groups and interests together. Star and Griesemer (1989) define boundary objects as temporary agreements by different actors and groups on how to relate to a given situation. They describe how a standardised method in natural history for collecting, conserving, marking and describing finds, functioned as a boundary object between amateurs and researchers in what was a research subject among researchers and a subject for hobby activity, exercise of an occupation or nature conservation among groups of the public. In other words, they establish agreement about what are points of contact in common. Boundary objects are negotiated agreements that contain different interests but, at the same time, open up for slightly different practices. In this way, boundary objects permeate borders at the same time as the established practice is continued. Scientific infrastructures represent "regimes and networks of boundary objects (and not unitary, well-defined objects), boundary infrastructures have sufficient play to allow for local variation together with sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics, and so forth) to be applied" (Bowker & Star, 1999, pp. 313-314) and thereby help scientists, amateurs and administrators to cooperate across disciplines and organisational boundaries. Cyberscience, E-Science and Science 2.0, therefore, become a manifestation of scientific culture articulated in the face of a new technology (Hine, 2008, p. 34). Bowker argues that this layering of boundary objects creates a form of irreversibility or path dependency in the infrastructure for two reasons: "first because the infrastructure is *performative*; and second because the infrastructure is *diffuse*" (Bowker, 2000, p. 648). To analyse the processes that facilitate the building of boundary infrastructures, and thereby the scaffolding of Science 2.0, I will introduce the concept of bridging. Bridging activities and boundary objects are essential for understanding how Science 2.0 develops over time. The concept of bridging helps us to establish a theoretical process-oriented perspective on how negotiations and competition for boundary infrastructures take place.

Based on these concepts, the research problems can be formulated as follows:

What characterises participation in knowledge production and collaboration in respect of systematic biology and biodiversity in Internet-based hybrid spaces? How does apomediation play out to identify *trustworthy and credible information and services given multiple voices operating in Internet-based hybrid spaces? Finally, how do the interfaces used to stimulate collaboration function as bridging devices between different user groups and stakeholders?*

Methods

On behalf of the University Museums Commission, appointed by the Norwegian Ministry of Education and Research, a colleague and I evaluated the university museums' work in digitalising their collections (Hetland & Borgen, 2005). Fifty people were interviewed, some of them several times. About half of them worked with natural history, while the other half worked with cultural history. More detailed references to the empirical material are given in Hetland & Borgen. Later in 2010, I conducted follow-up interviews with important natural history experts at the Global Biodiversity Information Facility (GBIF) both in Norway and at the international GBIF Secretariat at the Natural History Museum in Copenhagen, The Norwegian Biodiversity Network (SABIMA) and The Norwegian Biodiversity Information Centre (NBIC). The follow-up interviews have been selected for studying critical issues in the process of building boundary objects and boundary infrastructures and the role of apomediation in this respect.

Technoscience may be described as building networks and we have followed scientists, amateurs and policy actors at work; how do they enrol or exclude actors and resources building boundary objects and boundary infrastructures through problematisation, interessement and the definition of obligatory passage points (Latour, 1987). Latour call this the translation model. The translation model offers methods and concepts to open up the innovation process. The research questions were analyzed by following important and often controversial issues in the interviews combined with document studies of the same issues, what kind of transformations do these issues undergo later in the hands of others and finally how are these controversies resolved. During the process we have followed how various groups and interests are linked together, building boundary objects and boundary infrastructures while establishing routines for quality assessment.

Mapping of biodiversity: The Norwegian case

In Norway, natural history museum collections are the backbone of taxonomic and bio-geographical research. They comprise: a) documentation of previous scientific work and enable us to understand the current position of the subject; b) research material selected by a large number of individuals over a period of two hundred years, material that no individual short-term project could replace today; and c) they provide a large biological diversity database where the determination of species and related information may be revised when necessary or possible. Digitalisation of the museum collections was an important precondition for more flexible use of the same collections. Five approaches to digitalisation of the collections can be identified, facilitating Science 2.0: 1. *Digitalisation as a researcher-driven activity*. The first attempts to digitalise the collections commenced in the 1970s. What characterised the individual projects was the fact that they were supervised by researchers who recognised the great demand for digitalisation within their own field (Hetland & Borgen, 2005, pp. 15-16). 2. *Digitalisation as an employment-driven activity.* Early in the 1990s, unemployment in Norway was high, and in this connection, the University of Oslo launched a digitalisation project as a contribution for enhancing both employment and skills (Hetland & Borgen, 2005, pp. 16-30). Over time, more than 1,000 man-years have been used in the digitalisation of museum collections. 3. *Digitalisation as an administrative and dissemination-driven activity.* Administrative and dissemination-driven activities have been organised by adopting two approaches: a. *The Museums Approach*. The challenges facing the university museums were first outlined in the Green Paper NOU 2006:8 entitled *Knowledge For Everybody.* This was followed by Parliamentary Report no. 15 for 2007-8, *Talking Artefacts – The University Museums.* Finally, this provided the basis for proposing the National Digital University Museum. b. *The Biodiversity Approach.* The NBIC was established in 2005 as a joint bank for biological diversity in Norway, and a national information source for natural species, varieties and populations. Several activities have commenced in close association with the NBIC, not least Species Observation in collaboration with the NGOs that have organised themselves into *The Norwegian Biodiversity Network* (SABIMA). This is an umbrella organisation with the objective of working to strengthen the protection of biodiversity in Norway. With more than 18,500 members, the ten NGOs embrace both professionals and most skilled amateur biologists in Norway. However, among the approximately 8,000 information providers, over 60 per cent of the observations are made by the 100 most active observers. Other services provided by the NBIC include the Red List Database, the Alien Species Database, Species Maps, Species Names and the Habitat Database. 4. *Digitalisation as 'megascience'.* The Global Biodiversity Information Facility (GBIF) was an initiative introduced by the OECD Megascience Forum Working Group. The Norwegian GBIF-node was established in 2005. GBIF-Norway and the NBIC provide access to over 12 million records from almost 30 information providers, including all the important scientific institutions, NGOs and some private companies, through the service Species Map. More than 6.2 million of these records are registered through Species Observation, mostly carried out by amateurs (all figures are from September 2011).

All types of systematisation establish a form of path dependency. The potential for change is reduced and it becomes difficult to include new functions that require another form of systematisation without considerable extra resources. The need for new methods by which to systematise the museums' collections became manifest when changes and new subject traditions arose in the border zone with the old. A good example is the emergence of ecology as a new discipline. Other challenges are seen in the increased interest in interdisciplinary and multidisciplinary approaches. In retrospect, it may be said that the superior rationale of digitalisation processes is linked to the need to rapidly be able to use the collection for an increasing number of new purposes, many of which had not been previously considered. These new possibilities have also established a basis for formulating new needs within research, administration and dissemination and, not least, for identifying important gaps in our shared knowledge. In the following, I will look at how social networking, participation, apomediation, collaboration and openness influence how hybrid spaces are shaped and the importance of boundary objects in this respect.

Social networking and participation

Historically, the first attempts to digitalise collections arose from a tradition whereby the individual curator had a personal relationship with the collections, or as one of the curators stated: 'That which was the forerunner to the compilation of a database was to obtain an overview of one's own collection. You may indeed emphasise *own* – "They are my collections and I must know what I have in my own collections such that I can inform others who want to know what I have".' Increasingly, other actors were involved and the emphasis on "my collections" slowly changed. One of the curators was a role model for the amateur community, and they frequently used his databases as models reflecting how they prefer to see them. On occasions, they found that this did not work as expected, and that they required this or that particular function. They communicated this to the curator. The next day, he had worked throughout the night and changed the programme, and the new function was incorporated. The amateur community were amazed at how concerned the curator was with user-friendliness and his ability to listen to others' suggestions.

Digitalisation, therefore, increased the amateur community's interest in participating in a major national project, and the emerging databases functioned as boundary objects between the museums and the amateur community. The aforementioned curator functioned as a broker between the museum and the amateur community, not least because of his central position in the network, and his willingness to devote time to the development of both solutions and relations. Later, this central position also made it possible for him to take an important role in the GBIF's activities. So, even if the different activities evolve around the boundary object, the different network relations are not symmetrical, but include both interactional as well as structural diversity, and strong as well as weak ties.

Collecting new objects is a central activity of the amateur community. For example, the vascular plant collection at the Natural History Museum in Oslo receives some ten thousand new objects each year, of which seven thousand come from amateurs. The fact that 'collecting' is central to the amateur community is associated with the fact that the 'discovery' aspect in the role of the researcher is that which initially arouses an interest in the natural sciences. The Swedish Species Information Centre coordinates the so-called "Swedish Taxonomy Initiative" and produces *The Encyclopaedia of the Swedish Flora and Fauna*. This encyclopaedia is also popular among Norwegian amateurs and when the first volumes of butterflies arrived, the number of members in the Norwegian Entomological Society increased 15 per cent during the first summer, and several ornithologists started to collect butterflies alongside bird watching. Digitalisation has provided the opportunity to discover 'new territory' and to develop one's own interests. One informant stated: 'The fact that data is accessible on the web is a strong motivation for collecting, and it is stimulating to make new finds, especially when one knows from the accessible information that a particular find is an important find. Many get a "kick" out of locating "unexplored terrain" by mapping existing finds and discovering areas where no previous finds have been made of a particular species.' Digitalisation has thus established a new arena for revealing the contribution of the amateur community. It is, nevertheless, important with this type of motivation that feedback is provided to the collectors. Should amateur individuals feel that the museums have appropriated their items and overlooked their origins, then much of the motivation is invalidated. This can also be a factor influencing which museum the collector comes to regard as 'his' or 'her' museum. There are several examples of collectors attaching themselves to a specific museum where they feel that they have established the best dialogue. This dialogue depends on mutual respect and trust; there are now examples of amateurs who both registered their specimens in Species Observation and thereafter handed the specimens over to the museum. On some occasions, amateurs have experienced a reluctant attitude towards their observations from the museum, an attitude that may extend the gap between the two communities. Boundary objects may be both abstract and concrete. Star and Griesemer first noticed that "specimens of dead birds had very different meanings for amateur bird watchers and professional biologists, but that "the same" bird was used by each group" (Bowker & Star, 1999, p. 297). I will claim that for a boundary object to work well, this presupposes that each group respects the different communities of practice.

At the outset, direct contact between the different curators and amateurs was an important element in both networking and participation. The NGOs aimed for a mutual database for both scientists and amateurs. However, they were not completely satisfied with the registration system chosen by scientists; they, therefore, argued that the NBIC should copy the very successful Swedish

Artportalen.se, which now has almost 30.4 million observations. Both before and simultaneously with this initiative, several other actors had identified similar needs. Artportalen.se is fairly easy to use, but does not cater for all the needs of the scientists. In 2007, the Minister of the Environment, Helen Bjørnøy, decided to implement a solution that "should increase public participation in biodiversity mapping". The new service was launched in May 2008. The most important change that came with Species Observation was that the strong network between amateurs and scientists now also includes the conservation authorities. Species Observation has been a remarkable success and since May 2008, more than 6.2 million observations, made mostly by amateurs, have been registered. For the amateur community, administration and policy actors Species Observation is now an obligatory passage point. The NGOs consequently regard the NBIC as a very important measure, and they have also obtained a place on the board of management. For the individual observer, Species Observation also makes it possible to produce personal digital field notes. What distinguishes the Norwegian and Swedish solution from several other similar solutions is that the information providers have "ownership" of their own observations, and almost all information is accessible for everybody free of charge according to the EU Inspire Directive. Amateurs, NGOs, independent research institutes, researchers at museums and universities and, not least, planning authorities use the report possibilities. At present, Species Map is the most important report service and it is made an obligatory passage point for the planning authorities by Section 8 of the Norwegian Biodiversity Act, which states that the public authorities must base their planning decisions on scientific knowledge. The service is also an important learning resource at universities and schools. As an illustration; among those people accessing the Swedish Artportalen.se, about 15 per cent report observations, while 85 per cent only use the different services. Four 'moments' of translation are recognised in the attempts by these initiators to impose themselves and their definition of the situation on others: (a) problematisation: the initiators sought to be indispensable to other actors by defining the nature and the problems of the latter and then suggesting that these would be resolved if the actors negotiated Species Observation as the obligatory passage point; (b) interessement: a series of processes by which the initiators sought to lock the other actors into the roles that had been proposed for them in the shaping of Species Observation; (c) enrolment: a set of strategies in which the initiators sought to define and interrelate the various roles they had allocated to others; and (d) mobilisation: a set of methods used by the initiators to ensure that supposed spokespersons for various relevant collectivities were able to represent those collectivities properly.

The amateur communities are rather skewed when it comes to interests in natural history. Among the more than 6.2 million observations in Species Observation, one finds 87.8 per cent birds, 0.5 per cent other vertebrates, 2.1 per cent insects and invertebrates and 9.6 per cent plants. Skewing of data collection and management efforts is central to how we understand the world around us. Bowker discusses several reasons for skewing among scientists (and their financial supporters) like the species being very small (viruses); being the exotic other (Antarctic bryozoans); having been already studied (beetles); being disliked (parasites); being charismatic or non-charismatic species (pandas or weeds) (Bowker, 2000), and surely many more reasons may exist. When amateur communities form in natural history, it is reasonable to assume that skewing will grow out of interests linked to charismatic species; attractive species; species that are easy to observe; species being the exotic other, and I would add; species that live close to human habitats; species with a large variety; species with high aesthetic value (colourful); species with dramatic behaviour (like migration); species that are part of cultural history (useful or dangerous); and species that encourage community building and the display of social status in a community. Interestingly, the establishment of Species Observation has, over time, reduced the skewing of reported observations. Ornithology is an interesting example of community building, mostly consisting of boys and men. Professional ornithologists long ago labelled ornithology the "scientia amabilis" (Mayfield, 1979, p. 168). Mayfield also describes how in 1888, teenagers' interest was already instrumental in establishing The Wilson Ornithological Society. The original registration system in Artportalen.se is especially well suited to the registration system used by ornithologists since they were instrumental when constructing the registration system. The revised version of Species Observation, therefore, aims to cater for a larger number of needs to better mobilise all relevant collectivities.

Apomediation and collaboration

Right from the time when Carl von Linné established the Latin binomial nomenclature, researchers throughout the world have worked with the system of species. The work on giving species scientific names has, therefore, been carried out for more than 250 years. One consequence of this self-organised activity is that the same organism could have been described under different names, and that the understanding of these names varied over time and space. Tidying up and further development of this is taxonomic research. When the collection was digitalised, it was important to establish a structure that related the different names to each other. Thus, if a former name was used when registering, then this name is stored, but it is stored in relation to the modern name used today – the 'correct' name. As an example, it can be mentioned that in the species thesaurus for Norwegian vascular plants, some 19,000 names are registered for approximately 3,000 Norwegian vascular plants. Updated species thesauri and taxon registers are thus important for quality assessment of the digitalised material. Work on digitalisation has manifested the need for a national standard in this field, which the Global Biodiversity Information Facility and the NBIC are now following up, which, again, is part of the work conducted on international codes of biological nomenclature. The standard will be an important tool for the research community, administrative institutions and NGOs, and will contribute to increased collaboration and improved communication. One may claim that the "purpose of standards is to achieve orderings of practice at a distance" (Fenwick & Edwards, 2010, p. 85).

Quality assessment, however, has several facets whereby in this connection quality assessment may be regarded as a continual process involving problematisation, interessement, enrolment and mobilisation. Quality assessment of the scientific collections may be divided into three main aspects: 1) quality assessment of the actual digitalisation process, 2) quality assessment of the professional decisions and descriptions, and 3) quality assessment through new information. Regarding the first aspect of quality assessment, professionals with first-degree knowledge have read the proofs. Regarding the second aspect of quality assessment, curators have neither the capacity nor the possibility to assess everything included in the collections. First, the collections are very large, such that quality assessment at this level would scarcely be possible on account of the volume. It is emphasised that this would be a never-ending task. Second, possibly only a few individuals have the specialist knowledge required. The third form of quality assessment occurs when the material is subjected to taxonomic revisions or research projects, broadly understood (including those undertaken by the amateur community). In this event, the material will be quality assessed by those working on this, and where new information will normally be added. One example is the Red List project involving mosses. Those working on the project discovered that the most important thing that they could do was to assess the quality of the information in the collections. An assessment was made of the Red List mosses and it was revealed that the material had an error level of about 25 per cent. Assumedly, this is one of the highest levels of error frequency. A far lower error percentage is expected for lichens, but, at the same time, it is important to make users aware that errors do occur. At the bottom of the search page of the Lichen database, it is consequently stated: "We do not guarantee a correct classification of the material, nor correct information on the labels. For a critical use of the database, please contact the person responsible for the database". Another important point in relation to material included in later research projects is associated with lending routines. Several museums have developed good lending routines such that 'first of all, you receive an overview of what we have; you determine what you will borrow; you are given a list of what you have borrowed; you are obliged to return the material by the agreed date; you are obliged to apply for and receive approval if you plan to do anything with an object (for example remove a leg from an insect); you will receive a reminder if the article is not returned by the agreed date' (Informant). Such routines are essential if one is to follow the history of the object, not least because this type of loan frequently results in systematic revision of the database when new information is included.

Errors may be checked manually and with the assistance of automatic assessment routines. As mentioned, the actual identification is registered manually, but some assessments may be undertaken automatically. For example, checking that the coordinates are placed within the rectangle, which encompasses the municipality, may test the location; second, investigating what appear to be logical inconsistencies or surprising locations. The amateur community can also contribute new information and quality assessment of older information relating to existing parts of the collections. For example, amateurs are involved in the registration of local flora in a number of geographical areas. In this connection, they have been granted access to the scientific databases. Through this activity, they are also contributors to the data. In the Vascular Plants Database, much geographical information is given, particularly that which is familiar to local residents who are thus best able to interpret and confirm and, at the same time, determine the coordinates of the localities. The amateur community thereby makes a major contribution to the database through an interpretation of the geography and coordinate determination. This information is subsequently quality assessed. The other area to which amateurs make an important contribution is related to time and the individual collector. Who has found the item and when? 'Amateurs can relate data from the individual localities. They know in detail where they have gone from day to day, and can immediately recognise inconsistencies. They know, for example, that an individual could scarcely have found items at two localities wide apart on the same day at the end of the 1800s' (Informant).

Quality assessment or validation of information in Species Observation differs somewhat from the scientific model. The different NGOs together with the NBIC have organised validation with the help of national coordinators and a network of experts, and the costs are shared between the different actors. Three coordinators handle the largest species groups. One coordinator handles birds, one all other zoological observations and one botanical observations. Red List observations are given priority. The validation activity has three levels. First, openness encourages self-control; people do not want to expose excessive ignorance. Second, they can ask for help from fellow observers to validate their observations and comment on pictures, etc. The third is the more formal validation. The coordinators validate some observations themselves; a network of experts validates the rest. The experts are mostly highly skilled amateurs with a high standing within the specific community, good performance and publishing activities in the NGOs' journals. In addition to biological skills, all experts have to have a certain level of digital literacy. Also, professionals like retired professors etc. are active as experts. For every observation, the experts will state if it is validated or if more information is needed. Pictures are important in this process. An observation that fails the quality assessment will not be removed, but will only be available for the owner. They try to avoid validating the observer, which is a strategy with a long history in some of the NGOs. If an observation is accepted, the owner cannot change or remove the observation without consent from the organisation. So far, no observations have been removed. A referee system by means of which at least two experts shall validate the same observation, is used only for birds. One reason for this is the difficulty in finding enough experts in all species groups. Even the large community of bird watchers has problems finding enough experts. In this respect, Species Observation is a greater success than expected. There are some examples of assumed fraud; when one and the same person has an unlikely number of rare observations, that person will then be contacted for closer examination. Not only recent observations are included in the database; old diaries and inventory lists are also included. This is very interesting since historical data will make it possible to observe changes over time. Finally, quality assessment is also ensured by the educational activities of the NGOs and the NBIC.

One reason why the amateur community, for some species, might have a higher number of skilled experts than the scientific community is the fact that systematic biology in many respects has a higher standing among amateurs than among professional scientists. However, the rising concern for biodiversity is also positioning "systematics as a strategic science" and thereby increasing its status (Hine, 2008, p. 96). After this short span of time, Species Observation has already been made an obligatory passage point for nearly all reporting activities among the NGOs and the system of quality assessment is important, both for locking the actors into specific roles and for the enrolment of new users. The importance of digital literacy also concerns the observers, and some amateurs prefer to work in the traditional modus operandi; collecting specimens and handing them over to the museums. The different amateur communities also have different experiences with digital tools. Interestingly, Species Observation has made it easier for amateurs in rural areas to participate and to make them more visible. Some capitalise on this visibility since their activities may be turned into paid contracts later on, or they may receive payment for illustrations. Different ranking lists also encourage visibility. Increased visibility and user-friendliness are, without doubt, important. One species group increased its observations five-fold between the year before Species Observation and the year after. Rare findings are also made more visible, and contributions from the amateur community are made more visible for the scientific community. So far, Species Map is one of the most important bridging devices and, for some species, especially birds, the number of observations is so great that it is possible to study them with more advanced statistical models. Or as one stated when underlining the importance of Species Observation, "the proof is in the maths...".

Openness

In our interviews, we have attempted to register attitudes towards the level of 'openness' concerning both scientific collections and Species Observation. In this connection, we have heard a number of stories concerning previous attitudes where certain curators have regarded the collections as being virtually their own private property. At the same time, our informants have emphasised the fact that digitalisation has established a new form of transparency and that 'closing' parts of the collection has become a far more visible action. Transparency is therefore important to ensure interessement, enrolment and mobilisation. On the other hand, this question is not entirely unproblematic and has been the focus of much discussion. In some instances, the individual researcher or the research community has argued for limited access. One such argument has been the need to protect particularly rare species. Other arguments are associated with need: 'It will never be realistic in my view to put absolutely everything on display. Who else, other than those who are occupied with research, needs to know if all the data from a station comes from Finnmark which has been visited six times in the last six years?'. And concerning ongoing research: 'With regard to non-published material, it is the case that not everyone has access to absolutely everything contained there' (Informant). The last point was also emphasised regarding motivating researchers to enter new material into the databases while simultaneously not wishing to give away 'large data sets free of charge'.

The question of 'ownership' is interesting. 'We have a small in-house problem here – one which concerns "my collections".' For some of the collections, we have proceeded from a systematically structured collection where it was possible to find your animals at a specific location, to a numeric system. The fact that you can no longer find 'your collection' is something that is alien to the classical curator. One is concerned that a distance is established between the individual and the collection' (Informant). Without saying that this applies to all museums in Norway, it is, nevertheless, emphasised by a number of individuals that this refers to cultural differences between different professional areas, and we hear comments such as: 'There is not so much of this in botany; it is just that our collections are organised in a different manner to zoologists. It is here that there is a cultural difference.' Without having systematically investigated these cultural differences, we find at one of the museums involved that, concerning botany, there is a clear difference when the material collected by the researcher is for personal use, and when it is part of the museum's public collection. This boundary is seen in the publication of scientific work which refers to the material and is indicated by data registration, labelling and physical transfer from the researcher's workplace to the herbarium. In addition to possible cultural differences, there are a number of instances where a certain amount of caution must be displayed in respect of researchers' needs. The NBIC has, therefore, drawn up an agreement with the different primary data owners who are to deliver data to the NBIC. Since Norway is a member of the GBIF, there will be increased pressure on public collections to share their information more widely, although it will continue to be legitimate to protect certain information; for example, that relating to vulnerable species, data from ongoing projects and data of questionable quality. Increased acceptance of these underlying values is important for the interessement processes.

There is much to suggest that digitalisation has also resulted in new approaches and attitudes in the amateur community. According to other informants, this type of reporting was far less common previously and secrecy was widespread in many amateur groups. The reasons for this secrecy could be several: first, increased status and/or collector pride – 'This is my place, I know it best; here I can slip away and study my species.' The second reason is 'the need for protection'. Both of these reasons have been discussed in SABIMA, where the current attitude is that 'one desires to be a part of the joint effort in mapping our nation' and that secrecy disenables the individual from playing this part. Secrecy is, however, ensured for some species by delaying observation or making the geographical location less accurate for fear of environmental crime. In this respect, it is important to remember that some of the active amateurs also hide reports because they are afraid of "environmental crimes" being committed by criminals as well as the public authorities. This especially concerns the large predators.

Bridging

One of the most important aspects of collaborative technologies is that the technology facilitates bridging activities and thereby co-exploration. Museum collections have, for many years, been important boundary objects between amateurs, professionals and conservation authorities. The collections have, however, been difficult to access for a growing number of new purposes. The digitalisation of collections has built bridges between a number of more or less well-structured boundary objects in local use. The ability to link boundary objects together into boundary infrastructures, therefore, depends on bridging activities between a heterogeneous set of actors and repositories. In this article, we have identified four steps leading towards a new boundary infrastructure. First, the digitalisation of museum collections was an important premise for facilitating bridging activities. With such a start, the 'privatisation' of collecting activities was challenged, professionals and amateurs met in new arenas and the natural history collections of all Norwegian museums were bridged together. Second, the establishment of the Global Biodiversity Information Facility created a bridge between Norwegian collections and an increasing number of collections around the globe. This has also made standardisation an even more important precondition for scientific collaboration. Third, the establishment of Species Observation created a new opportunity for the amateur community to participate in national mapping activities, and has facilitated new ways of bridging activities between science and the public. With Species Observation, a successful boundary object has been established between the scientific community, the amateur communities and the conservation authorities. The mapping of biodiversity has been made into a huge collaborative enterprise. As Dickinson et al quite rightly emphasise, most large-scale citizen science projects provide long-term monitoring on a geographical scale beyond the reach of ordinary research methods (Dickinson, Zuckerberg, & Bonter, 2010). Fourth, bridging activity between the more science-driven museum collections and the more interest-driven Species Observation has facilitated new services as obligatory passage points for planning authorities.

In this article, we have identified some important processes in building boundary infrastructures. The most important element is to develop boundary objects that facilitate collaboration. Successful boundary infrastructures presuppose two levels of boundary objects. The first level facilitates communication and trust. At this level, one finds the standardisation of names or species thesauri, the EU Inspire Directive and the growing standardisation of assessment routines. These boundary objects are structured through more formal standardisation processes and more informal self-organised processes. This layer of boundary objects also facilitates the management of standardised forms like the Red List or The Alien Species List. The convergence of the aforementioned processes facilitates enhancing the level of trust in the information provided through the boundary infrastructures. The second level of boundary objects facilitates activities that reach out to the different communities or society at large. Important boundary objects are, so far, the Species Maps. Potential boundary objects, which have not yet succeeded, are parallel to the Swedish initiative being established at the National Encyclopaedia of the Swedish Flora and Fauna. As regards Science 2.0, establishing functional boundary objects will, for example, help a group of actors to identify collective needs, while simultaneously adjusting to individual needs and so forth. The boundary objects create a dialogue between various interests, and handle stability and ambiguity concurrently. Bridging different boundary objects then facilitates the building of boundary infrastructures that make Science 2.0 possible. One important aspect, bridging the amateur community and scientists and facilitating collaboration, is the move from the Model-Authoritative to the Model-Democratic (Fischer, 2009). While the Model-Authoritative has weak input filters and strong output filters, the Model-Democratic has weak input filters and strong output filters. Species Observation has a low threshold for contribution by the amateur community, but well organized quality assessment of critical content. So far the assessment routines focus on critical information, since this large information repository grows very fast. Fisher quite rightly points to the fact that large information repositories may be a mixed blessing unless we are able to develop new strong output filters. One of the possibilities he mentions is collaborative filtering, which is already in use for parts of the Species Observation-repository.

Boundary infrastructures, therefore, presuppose two bridging activities. First, standards are important bridging devices between different boundary objects. The standardisation of names or species thesauri, data standards and agreed quality routines makes it possible to exchange information between different sources. Second, new services like the Red List or Species Maps have sufficient consistent structure to allow for the full array of bureaucratic tools (forms, statistics and so forth) to be applied. With this second bridging activity, the boundary infrastructure also opens up for a wide array of possible applications that producers and users might develop further.

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vi / bottom	None	(Addendum) "The author is employed by Department of Education, Faculty of Educational Sciences, University of Oslo"
vii	Added new page	(Addendum) "Norsk sammendrag (translation of English Abstract)"
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